2017
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CHULA ΣNGINEERING
Foundation toward Innovation

BULLETIN

FACULTY OF ENGINEERING CHULALONGKORN UNIVERSITY

BULLETIN 2017

Faculty of Engineering
Chulalongkorn University

FOR USE BY
ENGINEERING STUDENTS
HAVING ID.NO.<u>60X XXXXX XX</u>
UNTIL THEIR GRADUATION

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UNIVERSITY CALENDAR
ACADEMIC YEAR 2017

First Semester

First day of classes	Tuesday, August 15, 2017
Midterm Examinations (if any)	Monday, October 2 – Friday, October 6, 2017
Close of first semester activities	Sunday, December 5, 2017
Last day of classes	Friday, December 16, 2017
Final Examinations	Monday, December 4 – Tuesday, December 19, 2017
Close of first semester	Wednesday, December 20, 2017

Second Semester

First day of classes	Monday, January 8, 2018
Midterm Examinations (if any)	Monday, March 5 – Friday, March 9, 2018
Close of second semester activities	Sunday, April 8, 2018
Last day of classes	Friday, May 4, 2018
Final Examinations	Monday, May 7 – Monday, May 21, 2018
Close of second semester	Tuesday, May 22, 2018

Summer Session

First day of classes	Monday, June 4, 2018
Last day of classes and Examinations	Friday, July 20, 2018
Close of summer session	Saturday, July 21, 2018
Last day of Academic Year	Friday, August 10, 2018

ADMINISTRATION
FACULTY BOARD

Dean of the Faculty :

Assoc. Prof. Dr. Supot Techavorasinskun

Associate Dean

Assoc. Prof. Dr. Kasem   Choocharukul
Assist. Prof. Dr. Jirawat   Chewaroungroaj
Assoc. Prof. Dr. Tawatchai   Charinpanitkul
Assoc. Prof. Dr. Anongnat   Somwangthanaroj
Assist. Prof. Dr. Manop   Wongsaisuwan
Assist. Prof. Dr. Sanphet   Chunithipaisan
Assoc. Prof. Dr. Atiwong   Suchato
Assist. Prof. Dr. Manoj   Lohatepanont
Assoc. Prof. Dr. Pisut   Painmanakul

Assistant Dean

Assoc. Prof. Dr. Thanyarat   Singhanart
Assoc. Prof. Dr. Chotirat   Ratanamahatana
Assist. Prof. Dr. Charnchai   Pluempitiwiriyawej
Assist. Prof. Dr. Chaiyachet   Saivichit
Assist. Prof. Dr. Niphon   Wansophark
Assist. Prof. Dr. Sukree   Sinthupinyo
                Dr. Falan   Srisuriyachai
                Dr. Phannee   Saengkaew
                Dr. Sirikanya Singcuna
                Dr. Sawekchai Tangaramvong
                Dr. Pimporn   Ponpesh

Head of Department of Civil Engineering

Prof. Dr. Teerapong Senjuntichai

Head of Department of Electrical Engineering

Assist. Dr. Komson Petcharaks

Head of Department of Mechanical Engineering

Assoc. Prof. Dr. Pairod Singhatanadgid

Head of Department of Industrial Engineering

Assist. Prof. Dr. Paveena Chaovalitwongse

Head of Department of Chemical Engineering

Prof. Dr. Paisan Kittisupakorn

Head of Department of Mining and Petroleum Engineering

Dr. Thitisak Boonpramote

Head of Department of Environmental Engineering

Assist. Prof. Dr. Khemarath Osathaphan

Head of Department of Survey Engineering

Prof. Dr. Chalermchon Satirapod

Head of Department of Metallurgical Engineering

Assoc. Prof. Dr. Gobboon Lothongkum

Head of Department of Computer Engineering

Assist. Prof. Dr. Natawut Nupairoj

Head of Department of Nuclear Engineering

Assist. Prof. Dr. Phongphaeth Pengvanich

Head of Department of Water Resources Engineering

Assist. Prof. Dr. Anurak Sriariyawat

Elected Members of the Board:

Assoc. Prof. Dr. Sirima   Panyametheekul
Assoc. Prof. Dr. Jaroon   Rungamornrat
Assoc. Prof. Dr. Dawan   Wiwattanadate
Assoc. Prof. Dr. Nopdanai   Ajavakom
Assist. Prof. Dr. Wanchalerm   Pora
Assist. Prof. Dr. Napassavong Osotssilp
Assist. Prof. Dr. Somchai   Kriengkraiwasin
Assist. Prof. Dr. Boonrat   Lohwongwatana
Assist. Prof. Dr. Somboon   Rassame
Assist. Prof. Chate   Patanothai
          Dr. Piyatida   Ruangrassamee

Program Director of International School of Engineering

Assist. Prof. Dr. Witaya Wannasuphoprasit

Program Director of The Regional Centre for Manufacturing Systems Engineering

Prof. Dr. Parames Chutima

Acting Director of Biomedical Engineering Program

Assoc. Prof. Dr.Siriporn Damrongsakkul

Acting Director of Defense Engineering and Technology Program

Assoc. Prof. Dr. Withit Pansuk
Col.Assist. Prof. Dr. Chuan Chuntavan

Director of Center for Engineering Research and Technical Services

Assoc. Prof. Dr. Thanyawat Pothisiri

Registrar :

Assiat. Prof. Dr. Charnchai Pluempittiwiriyawej

FACULTY OF ENGINEERING
OBJECTIVE

It is the objective of the Faculty to educate engineering students both in the fundamental and professional knowledge, and to train the students in the analysis and synthesis of engineering systems. It is expected that our graduates should possess the ability to function effectively both as individual and in a team. Initiative, self-confidence and perseverance are the desired quality in our graduates. It is also our objective to instill the sense of professional and social responsibility and integrity in the students during the course of instruction.

ACTIVITIES

Education :

The Faculty of Engineering prepares men and women for professional careers in engineering and for responsible positions of a technical and semitechnical character in industry, commerce, education, and government.

At present, the Faculty of Engineering offers courses leading to Bachelor, Master, and Doctoral degrees in Engineering, Master degree in Science as well as Graduate Diploma. The curricula are administered by the departments shown below.

Department	B.Eng.	G.Dip.	M.Eng.	M.Sc.	D.Eng./Ph.D.
- Civil Engineering	√	-	√	-	√
- Electrical Engineering	√	-	√	-	√
- Mechanical Engineering	√	-	√	-	√
- Industrial Engineering	√	-	√	-	√
- Chemical Engineering	√	-	√	-	√
- Mining and Petroleum Engineering	√	-	√ (International Program)	-	-
- Environmental Engineering	√	-	√	-	√
- Survey Engineering	√	-	√	√	√
- Metallurgical Engineering	√	-	√	-	√
- Computer Engineering	√	-	√	√	√
- Nuclear Engineering	√	-	√	√	√
- Water Resources Engineering	-	-	√	-	√
- Regional Centre For Manufacturing Systems	-	-	√ (International Program)	-	-
- Automotive Design and Manufacturing Engineering (International Program)	√	-	-	-	-
- Aerospace Engineering (International Program)	√	-	-	-	-
- Information and Communication Engineering (International Program)	√	-	-	-	-
- Biomedical Engineering	-	-	√	√	√
-Defense Engineering and Technology	-	-	√	-	-

Details of the graduate degrees in Engineering can be found in the handbook on Graduate Studies.

Research

The current development in Engineering, Science and Technology is a result of extensive research endeavors worldwide. Recognizing the vast impact of research on engineering education and on the industrial development as a whole, the Faculty of Engineering is determined to drive itself to be a research-oriented one. Faculties are encouraged to engage actively in research activities. Inevitably, engineering students, at one stage of their education at the Faculty, can learn from the research projects in which they participate. A strong emphasis is placed in research because the key element to a better understanding of engineering necessitates that practical work and research be conducted in order to complement theoretical studies. Students also gain 'hands-on experience'. Research is a source of learning and transferring of knowledge by the principles of academic freedom.

Services

The Faculty provides academic services to the public in the form of seminars, training courses, technical conferences, continual education and technical consultancy in all engineering disciplines. The array of equipment at the Faculty of Engineering are also utilized to service small, medium and multi-national industries in Thailand as well as other governmental agencies in the form of material and product testing.

SERVICES AND FACILITIES

Campus

The University compound is located between Phya Thai and Henry Dunant Road in Bangkok, a city of more than eight million people. The Faculty of Engineering occupies a large section on the south of the campus. These include four main office and classroom buildings which house a large library and an auditorium of 600 seats. Other buildings are Department of Civil, Electrical, Mechanical, Industrial, Chemical, Mining and Petroleum, Environmental, Survey, Computer, Nuclear Technology, Water Resources, The Regional centre for Manufacturing Systems Engineering and International office.

Laboratories

The Faculty has well-equipped laboratory facilities for conducting experiment associated with classroom courses in various departments. Facilities of testing according to industrial standards and facilities of testing for student thesis, dissertation, and for faculty research are also provided.

The Engineering Library

Located on the 3rd floor of the Engineering building #3 is our newly renovated Engineering Library, equipped with state-of-the art multimedia system for digital online searching services, modernized study areas and seminar rooms. It also contains a collection of more than 60,000 volumes of technical literatures, text-books, standard books as well as audio visual tape, CD-ROM multimedia and 95 periodicals which cover practically all branches of engineering

Engineering Computer Center

Engineering Computer Center (ECC) was established in 1984 to provide and support computer services and related facilities which concentrate on engineering applications. The ECC provides not only computing facilities for training of engineering students and for research and development in various engineering disciplines, but also some specific engineering applications and professional services to industrial sectors such as Database applications, Computer Aided Design, Finite Element Analysis, Mathematics related applications, System Simulations, etc.

The ECC is one of the largest faculty-level computer center in Thailand. The facilities include various models and sizes of Computer Servers, Engineering Workstations both UNIX and Windows-based, network printing, and Web-based learning facilities. All of these facilities are connected to the Chulalongkorn University Network (ChulaNet) and wirelessly to the ChulaWiFi which provides free internet access to students and personnel throughout the university campus. Chulalongkorn University is a member of the eduroam, a secure, world-wide roaming access service developed for the international research and education community. Every student and staff can connect to the Internet via any eduroam-enabled network when you roam to other eduroam member sites. Please refer to http://eduroam.uni.net.th and http://www.eduroam.org for more details.

Accommodations

Chulalongkorn University provides five dormitories for unmarried students. Two for Thai male, two for Thai female, and one for international students. Private accommodation may also be found in the nearby area.

Scholarships and Financial Aids

A number of scholarships are available for needy students with good academic and behavior records or outstanding in his/her field of study. Financial aids are also provided for students with urgent financial problems.

University Healthcare

The University maintains a clinic where medical care for minor illness and injuries is provided for students free of charge. The Health Center is located at Jamjuree 9 Building. The center is open every weekday from 8.00 a.m. to 4.00 p.m.

Reserve Officer Training Corp (ROTC) Program

Students of Chulalongkorn University are eligible to apply for training in the Reserve Officer Training Corp Program. Male students who do not participate in the program, or have not completed the third year of the program, may apply for deferment of conscription for military service.

ADMISSION REQUIREMENTS

To be eligible for admission to Faculty of Engineering an applicant must meet the following requirements :

1. He/she must hold a Mathayom Suksa 6 (Grade 12) certificate from a High-School or other equivalent which the University recognizes as being acceptable,

2. He/she must have passed the competitive entrance examination held annually by the Commission On Higher Education.

GENERAL REGULATIONS

Registration

Students must register at the time appointed to enroll according to academic calendar in each year. Late registration will be penalized by additional fees.

Student Advisors

Each student will be assigned to a faculty advisor after notification of his/her admission, throughout his/her academic program. The student must consult and seek approval from his/her advisor in all matters of program planning for his/her study before registration.

Grading System

The quality of the student's work will be evaluated as follows :

GRADE	DEFINITION	GRADE POINT
A	Excellent	4.0
B+	Very Good	3.5
B	Good	3.0
C+	Fairly Good	2.5
C	Fair	2.0
D+	Poor	1.5
D	Very Poor	1.0
F	Fail	0.0

In addition, the following letter symbols may also given :

I   (Incomplete)
P   (In progress)
S   (Satisfactory)
U   (Unsatisfactory)
V   (Visitor)
W   (Withdrawn)
M   (Missing)
X   (No report)

Academic Performance Evaluation and Disqualification

One lecture or discussion-hour per week in a semester is equal to one Unit of Credit. Three hours of Laboratory work per week in a semester are also equivalent to one Unit of Credit.

The overall scholastic performance of a student is average and expressed in a semester as a Grade-Point Average (GPA) and annually as a Cumulative Grade-Point Average (GPAX). The GPA is obtained by the sum of the products of grade points and units of credit divided by the total units of credit for which grades A,B+,B,C+,C,D+,D and F in each semester are received. Grades P,S,U,V,W,M and X are disregarded in the computation for GPA.

The grade I (Incomplete) may be replaced if the student completes his/her work of that course with the approval of the instructor within the second week of the subsequent semester. If the work is not done or un-

approved within this limit of time, the grade I will be automatically converted to grade F.

A student may repeat his/her course only for the course which he/she has received a grade D+,D, F, or U. When a course is repeated, the units of credit shall be counted toward a degree only once, but the student's Grade-Point Average will be computed on the total number of credits attempted. To be qualified for graduation, a student must pass all the required courses with the Cumulative Grade-Point Average of at least 2.00. An undergraduate student who receives his/her Cumulative Grade-Point Average less than 2.00 will be classified as on academic probation. This probation can be removed when that student can increase his/her GPAX greater than or equal to 2.00.

An undergraduate student will be disqualified for further registration in the Faculty when

(a) his/her GPAX falls less than 1.50 at the end of any semester except for the first semester, or

(b) his/her GPAX is less than 1.80 for two consecutive semesters during his/her academic probation, or

(c) his/her GPAX is less than 2.00 for four consecutive semesters during his/her academic probation.

(d) his/her GPAX is less than 2.00 or the number of total credits is less than the course's requirement within 16 semesters for four-academic years

Adding or Dropping Courses

A request for adding or dropping courses after registration must be approved by the student's advisor. For the withdraw, the request must be approved by the dean of Faculty as well.

Adding courses can be made within the first two weeks of a regular semester or within the first week of a summer semester.

Dropping courses can be made within the first six weeks of a regular semester or within the first two weeks of summer semester. Any attempt to drop courses after these periods shall be considered as withdraw which these courses will be shown in the student's transcript of record with the letter symbol "W".

Class Attendance

A minimum attendance for class participation of students is 80 percent, otherwise he/she will not be allowed to attend an examination.

Graduation Honors

There are two classes of honors. The first class honors is awarded to graduates who received a Bachelor of Engineering with cumulative grade-point average is equal to or higher than 3.60 in four academic years and never receive grade F and U in any subject. Similarly requirements apply to those who received the second class honors, except the cumulative grade-point average is equal to or higher than 3.25.

Gold medal will be awarded to the outstanding student who has completed all the curriculum requirements with the highest ranking among the

students of the same professional for the same academic year in addition to his/her first class honors.

TUITION AND FEES

Tuition fees :

Regular Undergraduate Programs

Regular semester	21,000	baht per semester
Summer session :	5,250	baht per session

Regular Graduate Programs

Regular semester	31,000	baht per semester
Summer session	7,750	baht per session

<u>Notes</u> : The rates for special programs are set separately. Details may be requested directly from each program.

LIST OF DEPARTMENTS

Code No.	Name
2101	Department of Civil Engineering
2102	Department of Electrical Engineering
2103	Department of Mechanical Engineering
2104	Department of Industrial Engineering
2105	Department of Chemical Engineering
2106	Department of Mining and Petroleum Engineering
2107	Department of Environmental Engineering
2108	Department of Survey Engineering
2109	Department of Metallurgical Engineering
2110	Department of Computer Engineering
2111	Department of Nuclear Engineering
2112	Department of Water Resources Engineering
2163	The Regional Centre for Manufacturing Systems Engineering
2141	Nano Engineering (International Program)
2142	Automotive Design and Manufacturing Engineering (International Program)
2143	Information and Communication Engineering (International Program)
2145	Aerospace Engineering (International Program)

CURRICULUM   INFORMATION

Faculty of Engineering offers the programs leading to Bachelor degrees in Civil Engineering, Electrical Engineering, Mechanical Engineering, Naval Architecture and Marine Engineering, Automotive Engineering, Industrial Engineering, Chemical Engineering, Mining and Petroleum Engineering, Environmental Engineering, Survey Engineering, Metallurgical Engineering, Computer Engineering, and Nuclear Engineering, Nowadays, we provide the international programs in Nano Engineering, Automotive Design and Manufacturing Engineering, Information and Communication Engineering , and Aerospace Engineering. The student is required to select a program of study after he/she has completed his/her second semester, except for international program, and some specific programs.

Common Fundamental Subject   (55–61 Credits)

General Education   (30 Credits)

Social Science*	3 credits
Humanities*	3 credits
Science and Mathematics*	3 credits
Interdisciplinary*	3 credits
English	12 credits
General Education, Special	6 credits
2100111 Exploring Engineering World (compulsory)	3 credits
2100311 Engineering Essentials (optional)	3 credits

*The subject should be chosen from the list approved by General Education Office except English.

Basic Science and Mathematics   (21–24 Credits)

Mathematics (2301107–108, and/or 2301207, and/or 2603284)	6–12 credits
Physics (2304103–104, 2304183–184)	8 credits
Chemistry (2302127, 2302163)	4 credits

Basic Engineering   (14–26 Credits)

Code	Name	Credits
2100301	Eng Practice	2 credits
2103106	Eng Drawing	3 credits
2103213	Eng Mechanics I**	3 credits
2109101	Eng Materials	3 credits
2110101	Comp Prog	3 credits
2102391	Elec Eng I	3 credits

Program Core Courses

Each Program has its area of concentration which is composed of compulsory courses and approved electives. The total number of core course credit of each program is about 74–84 credits.

Approved Electives

Each engineering curriculum offers some approved electives. All elective courses must be chosen from departmentally approved list.

Free Electives

A student has a free selection of courses of 3–6 credits which are offered by any faculty in the University.

The total number of credits for graduation from The Faculty of Engineering must not be less than the amount of the credits which are specified by each curriculum.

Each undergraduate is required to undertake a minimum of six weeks practical training in industry as the part of the course 2100301 Engineering Practice, which is offered for the third year student in the summer session, before graduation. Work in the laboratory is also brought into sharper focus by the fourth year senior project. The engineering project work, which is aimed at providing the student with experience similar to those of practicing engineers, is a compulsory course of all departments.

FIRST YEAR CURRICULUM
COMMON TO ALL ENGINEERING STUDENTS

FIRST SEMESTER

GROUP I   **GROUP II**

COURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS
2103106	ENG DRAW	3	2109101	ENG MATERIALS	3
2301107	CALCULUS I	3	2110101	COMP PROG	3
2302127	GEN CHEM	3	2301107	CALCULUS I	3
2302163	GEN CHEM LAB	1	2304103	GEN PHYS I	3
2304103	GEN PHYS I	3	2304183	GEN PHYS LAB I	1
2304183	GEN PHYS LAB I	1	5500111	EXP ENG I	3
5500111	EXP ENG I	3	2100111	EXPL ENG WORLD	3
		17			*19*

SECOND SEMESTER

GROUP I   **GROUP II**

COURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS
2100111	EXPL ENG WORLD	3	2103106	ENG DRAW	3
2109101	ENG MATERIALS	3	2301108	CALCULUS II	3
2110101	COMP PROG	3	2302127	GEN CHEM	3
2301108	CALCULUS II	3	2302163	GEN CHEM LAB I	1
2304104	GEN PHYS II	3	2304104	GEN PHYS II	3
2304184	GEN PHYS LAB II	1	2304184	GEN PHYS LAB II	1
5500112	EXP ENG II	3	5500112	EXP ENG II	3
		19			*17*

TOTAL CREDITS FOR COMMON TO ALL ENGINEERING STUDENTS = 36
(Except international program)

DEPARTMENT OF CIVIL ENGINEERING

The Department's curriculum is designed to provide the students with broad educational and professional perception as well as to enhance their effectiveness as practitioners and researchers in the field of modern civil engineering, which includes planning, analysis, design and construction of buildings, bridges, foundations, dams, hydraulic structures and transportation facilities. It contains courses in mathematics, related basic sciences, fundamentals of general engineering and specific civil engineering subjects. Besides, the students are required to fulfill selected courses in English, humanities and social sciences so as to broaden their outlooks in their future careers.

Laboratories in various divisions and research units of the Department are set up to supplement classroom works and to facilitate the study of advanced topics.

The Department offers a 4-year undergraduate program leading to the Bachelor of Engineering degree as well as graduate programs for Master and Doctor of Engineering degrees.

HEAD :

Teerapong   Senjuntichai,   Ph.D. (Manitoba)

PROFESSORS   :

Suched	Likitlersuang,	D.Phil. (Oxford)
Teerapong	Senjuntichai,	Ph.D. (Manitoba)
Thanyawat	Pothisiri,	Ph.D. (UI Urbana-Champaign)

ASSOCIATE PROFESSORS   :

Akhrawat	Lenwari,	Ph.D. (Chula)
Anat	Ruangrassamee,	Ph.D. (Tokyo Tech)
Boonchai	Stitmannaithum,	D.Eng. (Tokyo)
Boonchai	Ukritchon,	Sc.D. (MIT)
Jaroon	Rungamornrat,	Ph.D. (UT Austin)
Jittichai	Rudjanakanoknad,	Ph.D. (UC Berkeley)
Kasem	Choocharukul,	Ph.D. (Purdue)
Noppadon	Jokkaw,	Ph.D. (Chula)
Phoonsak	Pheinsusom,	D.Eng. (Tokyo)
Saksith	Chalermpong,	Ph.D. (UC Irvine)
Sorawit	Narupiti,	Ph.D. (Michigan State)
Supot	Techavorasinskun,	D.Eng. (Tokyo)
Tanit	Tongthong,	Ph.D. (Maryland)
Tospol	Pinkaew,	D.Eng. (Tokyo)
Tirawat	Boonyatee,	D.Eng. (Kyoto)
Veerasak	Likhitruangsilp,	Ph.D. (Michigan)
Wanchai	Teparaksa,	D.Eng. (Kyoto)
Wisanu	Subsompon,	Ph.D. (Carnegie Mellon)
Withit	Pansuk,	Ph.D. (Hokkaido)

ASSISTANT PROFESSORS   :

Boonchai	Sangpetngam,	Ph.D. (Florida)
Chatpan	Chintanapakdee,	Ph.D. (UC Berkeley)
Manoj	Lohatepanont,	Sc.D. (MIT)
Pitcha	Jongvivatsakul,	Ph.D. (Tokyo Tech)
Tanate	Srisirirojanakorn,	Ph.D. (UI Urbana-Champaign)
Vachara	Peansupap,	Ph.D. (RMIT)
Watanachai	Smittakorn,	Ph.D. (Colorado State)

LECTURERS :

Sawekchai	Tangaramvong,	Ph.D. (UNSW)
Nakhon	Kokkaew,	Ph.D. (Columbia U.)
Veerayut	Komolvilas,	D.Eng. (Yokohama National U.)

CIVIL ENGINEERING CURRICULUM
FIRST YEAR CURRICULUM
COMMON TO ALL ENGINEERING STUDENTS

COURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS

THIRD SEMESTER

2101252	STAT CE	3			
2101256	CE PROFESSION	3			
2103213	ENG MECH I	3			
2301207	CALCULUS III	3			
5500208	COM PRES SKLL	3			
xxxxxxx	GENERAL EDUCATION	3			
		18			

SIXTH SEMESTER

COURSE NO.	SUBJECT	CREDITS
2101307	RC DESIGN	4
2101312	STRUCT ANAL II	3
2101335	CONS SUPVN	2
2101338	HIGHWAY ENG	3
2101421	GEO ENG DES CONS	3
2112440	HYDRAULIC ENG	3
2108306	FLD PRAC TOPO SURV	1
		19

FOURTH SEMESTER

COURSE NO.	SUBJECT	CREDITS
2101202	MECH MAT I	3
2101253	APP MATH CE	3
2101254	GEOL CE	2
2101302	MAT TESTING LAB	1
2108298	SURVEYING	3
2112346	HYDRAULICS I	3
xxxxxxx	GENERAL EDUCATION	3
		18

SUMMER SEMESTER

COURSE NO.	SUBJECT	CREDITS
2100301	ENG PRACTICE	2
		2

FIFTH SEMESTER

COURSE NO.	SUBJECT	CREDITS
2101310	STRUCT ANAL I	3
2101311	CIV ENG MAT	4
2101321	SOIL MECHS	3
2101322	SOIL MECHS LAB	1
2101337	TRANS ENG	3
2112342	PRIN OF HYDROLOGY	3
2112344	HYDRAULIC LAB I	1
		18

SEVENTH SEMESTER

COURSE NO.	SUBJECT	CREDITS
2101406	STL/TIMBER DSGN	4
2101455	CONS ENG COST EST	3
2101490	PRE-PROJECT	1
xxxxxxx	FOREIGN LANGUAGE	3
xxxxxxx	GENERAL EDUCATION	3
xxxxxxx	ELECTIVE COURSES	3
xxxxxxx	FREE ELECTIVES	3
		20

EIGHTH SEMESTER

COURSE NO.	SUBJECT	CREDITS
2101454	CONST MANAGEMENT	3
2101499	CIVIL ENG PROJECT	3
xxxxxxx	GENERAL EDUCATION	3
xxxxxxx	APPROVED ELECTIVES	3
xxxxxxx	FREE ELECTIVES	3
		15

TOTAL CREDITS FOR GRADUATION = 146

CIVIL ENGINEERING

NAME OF THE MASTER'S DEGREE

   : Master of Engineering
   : M. Eng.

NAME OF THE DOCTORAL DEGREE

   : Doctor of Philosophy
   : Ph.D.

ADMISSION

To be eligible for admission to the M.Eng. program, an applicant must meet two basic requirements:

1. Hold a Bachelor's degree in Civil Engineering or equivalent.

2. Have other qualifications as prescribed by the regulations of the Graduate School or the committee of the program considers acceptable for admission.

To be eligible for admission to the Ph.D. program, an applicant must meet two basic requirements:

1. Hold a Bachelor's Degree in Civil Engineering or equivalent with a minimum of second-class honor (GPA > 3.25/4.00) for Option 3; or hold a Master's Degree in Civil Engineering or equivalent with good academic records for Option 2 and excellent academic records for Option 1.

2. Have other qualifications as prescribed by the regulations of the Graduate School or the committee of the program considers acceptable for admission.

DEGREE REQUIREMENTS

An acceptable thesis of not less than 12 credits, together with 9 credits of core courses plus 15 credits of elective courses are required for the Master's degree.

A student who has fulfilled the requirements of the Master's program with a passing grade point average of not less than 3.00, passing English examination and a minimum of one published technical paper. A period of study of not more than 8 regular semesters will be awarded the degree of Master of Engineering.

An acceptable dissertation of not less than 60 credits for Option 1 and 48 credits of Option 2 and Option 3 together with 12 credits of elective courses for Option 2 for or 9 credits of core courses plus 15 credits of elective courses for Option 3 are required for the Ph.D. Degree.

A student must fulfill the requirements of the Graduate school by passing the English examination and publishing technical papers in international peer – reviewed journals. The maximum period of study is 5 academic years for Option 1 and Option 2 and 8 academic years for Option 3.

COURSE REQUIREMENTS

A student must choose his major area of study from one of the followings:

1) Core Courses 9 credits

Structural Engineering

2101601	Advanced Structural Theory	3(3-0-9)
2101607	Advanced Mechanics of Materials	3(3-0-9)
2101680	Applied Mathematics I	3(3-0-9)

Geotechnical Engineering

2101621	Foundation Engineering	3(3-0-9)
2101637	Advanced Soil Mechanics	3(3-0-9)
2101835	Earth and Retaining Structures	3(3-0-9)

Transportation Engineering

2101660	Transportation Systems	3(3-0-9)
2101661	Transportation Planning and Policy	3(3-0-9)
2101662	Methods for Transportation Analysis	3(3-0-9)

Construction Engineering and Management

2101690	Construction Methods and Equipment	3(3-0-9)
2101692	Analytical Methods in Construction Management	3(3-0-9)
2101870	Construction Project Management	3(3-0-9)

2) Elective Courses 15 credits

Structural Engineering

2101510	Computer Methods for Civil Engineering	3(3-0-9)
2101512	Advanced Concrete Technology	3(3-0-9)
2101603	Theory of Elasticity	3(3-0-9)
2101604	Shell Structures	3(3-0-9)
2101605	Stability of Structures	3(3-0-9)
2101606	Dynamics and Vibrations	3(3-0-9)
2101608	Plate Structures	3(3-0-9)
2101609	Plastic Design of Steel Structures	3(3-0-9)
2101611	Matrix Analysis of Structures	3(3-0-9)
2101614	Behavior of Steel Structures	3(3-0-9)
2101615	Advanced Prestressed Concrete Structures	3(3-0-9)
2101616	Long Span Structural Systems	3(3-0-9)
2101617	Structural Building Components	3(3-0-9)
2101618	Finite Element Method for Civil	3(3-0-9)

	Engineers	
2101619	Seismic Design of Structures	3(3-0-9)
2101654	Engineering for Disaster Mitigation	3(3-0-9)
2101656	Disaster Damage Mitigation and Recovery Management	2(2-0-6)
2101681	Applied Mathematics II	3(3-0-9)
2101799	Boundary Integral Equation Method For Applied Mechanics	3(3-0-9)
2101800	Advanced Solid Mechanics	3(3-0-9)
2101801	Fracture Mechanics	3(3-0-9)
2101802	Inelastic Behavior of Materials	3(3-0-9)
2101803	Nonlinear Analysis in Structural Mechanics	3(3-0-9)
2101804	Behavior of Reinforced Concrete Structure	3(3-0-9)
2101805	Limit State Design of Concrete Structures	3(3-0-9)
2101806	Numerical and Approximate Methods for Structural Engineering	3(3-0-9)
2101810	Fire Safety Design of Structures	3(3-0-9)
2101817	Structural Testing and Evaluation	3(2-3-7)
2101818	Life Cycle of Concrete Structures	3(3-0-9)

B. Geotechnical Engineering

2101524	Computer Programming and Computer Tools for Graduate Research	3(3-0-9)
2101534	Computer Application for Geotechnical Engineering	3(3-0-9)
2101535	Tunnel Engineering	2(2-0-6)
2101624	Elasticity in Soil Mechanics	3(3-0-9)
2101632	Rock Mechanics	3(3-0-9)
2101634	Plasticity in Soil Mechanics	3(3-0-9)
2101636	Interpretation of Field Exploration and Soil Testing	3(2-3-7)
2101639	Special Study in Soil Engineering	3(3-0-9)
2101655	Civil Engineering and Disaster Recovery	2(2-0-6)
2101820	Geo-environment Engineering	3(3-0-9)
2101821	Deep Foundation Design	3(3-0-9)
2101824	Finite Element Method in Geotechnical Engineering	3(3-0-9)
2101831	Engineering Ground Modification	3(3-0-9)
2101832	Engineering Geophysics	3(3-0-9)
2101833	Soil Dynamics and Earthquake Engineering	3(3-0-9)

C. Transportation Engineering

2101551	Pavement Design	3(3-0-9)
2101553	Public Transit Systems Planning and Operations	3(3-0-9)
2101554	Traffic and Parking Studies for Site Development	3(3-0-9)
2101555	Travel Behavior Survey and Analysis	3(3-0-9)

2101556	Air Transportation System	3(3-0-9)
2101557	Planning and Management of Airport System	3(3-0-9)
2101558	Transportation and Logistics System Optimization	3(3-0-9)
2101559	Traffic Engineering	3(3-0-9)
2101560	Sustainable Transportation	3(3-0-9)
2101567	Rail Transport System	3(3-0-9)
2101644	Urban Transportation Planning	3(3-0-9)
2101649	Probability Statistics and Decision for Civil Engineering	3(3-0-9)
2101653	Computer Model in Transportation	3(3-0-9)
2101659	Logistics for Disaster Management	3(3-0-9)
2101664	Transportation Operations	3(3-0-9)
2101665	Highway Design	3(3-0-9)
2101666	Intelligent Transportation Systems	3(3-0-9)
2101667	Logistics System Analysis	3(3-0-9)
2101668	Evaluation of Transportation Project and Policy	3(3-0-9)
2101669	Transport Policy	3(3-0-9)
2101742	Advanced Transportation and Logistics System Optimization	3(3-0-9)
2101840	Traffic Modeling and Simulation	3(3-0-9)
2101841	Special Studies in Transportation Engineering	3(3-0-9)
2101842	Advanced Transportation and Logistics System Optimization	3(3-0-9)
2101844	Road Safety	3(3-0-9)
2101845	Advanced Pavement Design	3(3-0-9)
2101846	Railway Engineering	3(3-0-9)

D. Construction Engineering and Management

2101535	Tunnel Engineering	3(3-0-9)
2101550	Civil Engineering Project Planning	3(3-0-9)
2101580	Construction information Management	3(3-0-9)
2101590	Construction Techniques and Productivity	3(3-0-9)
2101618	Finite Element Method for Civil Engineers	2(2-0-6)
2101621	Foundation Engineering	3(3-0-9)
2101649	Probability Statistics and Decision for Civil Engineering	3(3-0-9)
2101691	Special Studies	3(3-0-9)
2101694	Contracting in Construction Business	3(3-0-9)
2101695	Computer Applications in Construction	3(3-0-9)
2101697	Infrastructure Planning and Management	3(3-0-9)
2101698	Construction Business Management	3(3-0-9)
2101831	Engineering Ground Modification	3(3-0-9)
2101871	Risk Management in Civil and Environmental Engineering	3(3-0-9)

	Systems		2101794	Graduate Seminar in Civil	3(3-0-9)
2101873	Special Topics in Construction	3(3-0-9)		Engineering	
	Engineering and Management		2101811	Thesis	12 credits
2601511	Financial and Managerial	3(3-0-9)	2101828	Dissertation	48 credits
	Accounting		2101829	Dissertation	60 credits
2604501	Financial Management	3(3-0-9)	2101894	Doctoral Dissertation Seminar	0(0-0-0)
			2101897	Qualifying Examination	0(0-0-0)

3) Thesis and Seminar

PROGRAM OF STUDY (CIVIL ENGINEERING)

Year	Semester	M.Eng.	Ph.D. (Option 1)	Ph.D. (Option 2)	Ph.D. (Option 3)
1	1	Core Courses 9 credits Elective Courses 3 credits	Dissertation 10 credits	Elective Courses 6 credits Dissertation 8 credits	Core Courses 9 credits Elective Courses 3 credits
	2	Elective Courses 12 credits	Dissertation 10 credits	Elective Courses 6 credits Dissertation 8 credits	Elective Courses 12 credits
2	1	Thesis 6 credits	Dissertation 10 credits	Dissertation 8 credits	Dissertation 6 credits
	2	Thesis 6 credits	Dissertation 10 credits	Dissertation 8 credits	Dissertation 6 credits
3	1		Dissertation 10 credits	Dissertation 8 credits	Dissertation 6 credits
	2		Dissertation 10 credits	Dissertation 8 credits	Dissertation 6 credits
4	1				Dissertation 6 credits
	2				Dissertation 6 credits
5	1				Dissertation 6 credits
	2				Dissertation 6 credits

COURSE DESCRIPTIONS

2101202   Mechanics of Materials I   3(3-0-6)
Condition: Prerequisite 2103213 or 2103211
Fundamental concepts of stress and strain; axially loaded members; torsion; shear force bending moment in beams; deflection of beams; stresses in beams; composite beams; unsymmetrical bending; buckling of columns; combined stresses and Mohr's circle; failure criterion.

2101252   Statistics for Civil Engineering   3(3-0-6)
Necessity of statistical methods in civil engineering; probability theory; random variables; probability distribution models in civil engineering; statistical estimation and hypothesis testing in civil engineering; applications of regression analysis in civil engineering.

2101253   Applied Mathematics for Civil   3(3-0-6)
Engineers
Condition: Prerequisite 2301207
Introduction to linear algebra, matrices and matrix operations, linear and nonlinear algebraic equations, eigen value problems; Fourier and Laplace transforms, series representation of functions, ordinary differential equations and partial differential equations; introduction to vector calculus, vector fields, differential and integral operators, integral theorems and applications; Introduction to optimization problems; Introduction to numerical techniques and applications in civil engineering.

2101254   Geology for Civil Engineers   2(2-0-4)
A general survey of geology with particular reference to civil engineering; common rock forming minerals; general characteristics and origins of rocks; features of the earth and geological process; structural features of the earth's crust; geology of water supply, reservoirs and dam sites, erosion and flood control; river and harbor improvement; geological factors affecting quarrying, tunneling, landslide, land subsidence, foundations and building materials.

2101256   Civil Engineering Profession   3(3-0-6)
Development of concepts, methodology and processes of civil engineering; relationship between civil engineering and other professions and society; roles and contributions of civil engineering to economics and social developments; concepts of engineering design; fundamental of construction works; project planning; ethics; safety; sustainable development.

2101302   Materials Testing Laboratory   1(0-3-0)
Condition: Co-requisite 2101202
Behavior and testing of common engineering materials such as steel, timber, brick and cast iron.

2101307   Reinforced Concrete Design   4(3-3-6)
Condition: Co-requisite 2101310

Structural behavior in thrust, flexure, torsion, shear, bond and interaction among these forces; analysis and design of reinforced concrete structural components by working stress and strength design methods; design calculations and construction drawings; application of graphs, tables, and computer software in design of reinforced concrete structures.

2101310   Structural Analysis I   3(3-0-6)
Condition: Prerequisite 2101202
Introduction to structural analysis; degree of statical indeterminacy and stability of structures; reactions, shears and bending moments in beams and rigid frames including deflected shapes; analysis of determinate plane trusses; responses of plane structures under moving loads by using influence lines; deflection analysis by method of moment-area and conjugate structures; deformation analysis of structures by virtual work and related energy methods; analysis of indeterminate structures by force method or flexibility method.

2101311   Civil Engineering Materials   4(3-3-6)
Condition: Prerequisite 2101202
Properties of civil engineering materials: cement, concrete, steel, wood, soil, asphalt, rubber, plastic, other synthetic materials, and composite materials.

2101312   Structural Analysis II   3(3-0-6)
Condition: Prerequisite 2101310
Methods of structural analysis; slope-deflection method; moment distribution method; introductory plastic structural analysis; matrix structural analysis; introduction to finite element method in structural analysis.

2101321   Soil Mechanics   3(3-0-6)
Condition: Prerequisite 2101254 or 2106296
Formation of soils; soil classification; soil exploration; water flow through porous media; stresses in soil mass; stress-strain relationship and strength properties of cohesionless soils and cohesive soils; settlement; consolication theory.

2101322   Soil Mechanics Laboratory   1(0-3-0)
Condition: Concurrent 2101321
Soil exploration; index properties of soils; permeability; compaction; CBR; stress-strain behavior of soils; shear strength and one dimensional consolidation.

2101335   Construction Supervision   2(2-0-4)
Construction methods; construction standards; components, methods, and procedures of construction supervision and inspection check list in foundation construction, structural and architectural works as well as infrastructure construction.

2101337   Transportation Engineering   3(3-0-6)
Introduction to transportation engineering; principles and concepts of transportation including transportation

demand and supply; fundamental traffic operations and transportation system analysis; transportation economics, and transportation planning concepts.

2101338 Highway Engineering   3(2-3-4)
Condition: Prerequisite 2101337
Road and traffic systems; highway planning and development; traffic consideration; roadway design; road materials; highway construction and maintenance; highway safety management.

2101406 Steel and Timber Design   3(3-3-6)
Condition: Prerequisite 2101310
Design of timber and steel structures by ASD and LRFD methods; tension and compression members; beams; beam-columns; built-up members; plate girders; connections; design practice.

2101421 Geotechnical Engineering   3(3-0-6)
**   Design and Construction**
Condition: Prerequisite 2101321
Criteria in geotechnical engineering design; design and construction of shallow foundation; design and construction of pile foundation and construction control; design and construction of retaining structures, sheet piles and diaphragm walls for excavation and filling; design of caisson and construction method; slope stability.

2101454 Construction Management   3(3-0-6)
Condition: Consent of Faculty
Construction industry; principles of management; construction organization; contracts and tendering; planning and control tools; feasibility study; cash-flow analysis; construction laws and regulations; safety in construction; construction finance and accounting; construction claims and disputes; arbitration.

2101455 Construction Engineering and   3(3-0-6)
**   cost Estimating**
Condition: Consent of Faculty
Principle of construction engineering, construction materials and methods, construction productivity; principle of cost estimating; approximate and detailed estimating; quantity takeoff; methods of measurement, labor and equipment costing.

2101461 Building Design   3(2-3-4)
Condition : Prerequisite 2101307 or 2101336
Design of reinforced concrete buildings of various types; structural systems; slab systems; frame analysis; interaction of frames and walls; walls; footings.

2101462 Prestressed Concrete Design   3(2-3-4)
Condition : Co - requisite 2101307
Concept and principles of prestressing; properties of relevant materials; prestressing systems; loss of prestress; analysis and design of statically determinate members; flexure, shear, bond, anchorage and bearing; moment-curvature analysis; deflections and camber; design for

anchorage zone reinforcement prestressed concrete piles; introduction to post-tensioned concrete floor systems; construction site visit.

2101464 Bridge Design   3(2-3-4)
Condition: Prerequisite 2101307
Theories of load distribution and application; simply supported bridges in reinforced concrete, steel and prestressed concrete; statically indeterminate bridges; ultimate load method; bridge economy.

2101490 Pre-Project   1(0-2-1)
Necessary skills for conducting project: thinking skills and problem identification, literature review, development of problem solving procedure and methodology, report writing, oral presentation, etc.

2101495 Advanced Topics in Civil   3(3-0-6)
**   Engineering I**
Topics of current interest or new developments in various fields of civil engineering; A complete written report is required by the Department. A final oral examination is optional.

2101499 Civil Engineering Project   3(0-6-3)
Condition: Prerequisite 2101490
Student shall carry out a practical project of interest on problems in various fields of civil engineering. The project is to be proposed by the student group and approved by the instructor and the Department. The work must be completed within one semester. A complete written report and a final oral examination are required.

2101510 Computer Methods for Civil   3(3-0-9)
Engineers
Review of computer programming; elimination methods for linear equations: various decomposition and storage schemes, partial pivoting, errors and ill-conditioning; iterative methods for linear equations: Jacobi iteration, Gauss-Seidel iteration; numerical solution of differential equations; finite difference method; solution of nonlinear equations; emphasis on civil engineering applications.

2101512 Advanced Concrete Technology 3(3-0-9)
Review of concrete technology; improvement of concrete's quality by pozzolanic materials, mineral and chemical admixtures; high-performance concrete; fiber reinforced concrete; polymer concrete; durable concrete and other special concrete; repair and strengthening of concrete structures.

2101524 Computer Programming and   3(3-0-9)
**   Computer Tools for Graduate Research**
Object-oriented programming using C++, event driven and GUI programming, data flow programming for data acquisition and automatic control in laboratory; use of MATLAB and Mathematica, numerical algorithm for linear system, numerical algorithm for non-linear system.

**2101534   Computer Application for   3(3-0-9)
              Geotechnical Engineering**
Computer application for analyzing shallow foundation, slope stability, deformation and stability problems; analysis of tunnel lining and tunnel deformation due to adjacent construction activities.

2101535   Tunnel Engineering   3(3-0-9)
History of tunneling; soil tunneling methods; types of linings and face support; stand-up times and tunnel man's ground classification; groundwater control and soil modification methods; lining behavior and design; ground movements and changes of pore water pressure caused by tunnel construction; field observations, monitoring, and instrumentation; building distortion/damage and relation to ground movements; fundamentals of tunnel engineering related to soil types and construction techniques; design of tunnel lining in various subsoil conditions; applications and techniques of tunnel construction for infrastructure systems.

2101536   Underground Construction   3(3-0-9)
Condition: Consent of Faculty
Soil investigation plans; soil profile; selection of soil properties; construction of shallow foundation construction of deep pile foundation; pile load test; pile integrity test; pilot pile test; blow count test; construction of basement by sheet pile bracing system; construction of deep basement by diaphragm wall system; caisson sinking in soft clay.

**2101546   Introduction to Finite Element   3(3-0-9)
              Method**
Condition: Consent of Faculty
Concepts of weak form of governing differential equation, weight residual method, minimization principle, equivalence between weak and strong forms, weak solution and its uniqueness; Galerkin approximation, space of test and trial functions, basis functions, quality and convergence of approximate solutions; finite element approximation, element-based shape functions, element stiffness matrix and load vector, matrix assembly procedure, treatment of boundary conditions, convergence of finite element solution; introduction to finite element method to two- and three-dimensional boundary value problems; applications of finite element programs to various boundary value problems in civil engineering.

2101550   Civil Engineering Project Planning   3(3-0-9)
Principles of civil engineering project planning; analysis of technical requirements; financial and economic feasibility studies; capital budgeting; social, political and environmental impact assessment; fundamental decision analysis.

2101551   Pavement Design   3(3-0-9)
Principles of highway and airport pavement including pavement types and wheel loads; stresses in flexible and rigid pavements; consideration of properties of pavement components including the design test; methods of design of flexible and rigid pavement for highways and airports; methods of construction and maintenance.

**2101553   Public Transit Systems Planning   3(3-0-9)
              and Operations**
Condition: Consent of Faculty
Components of public transportation system; public transportation planning procedure; technological evolution of mass transit; selection of transit mode; transit station planning; basic operation elements; date collection and analysis; scheduling of service; fare policies; financing and cost structure of transit service.

**2101554   Traffic and Parking Studies for   3(3-0-9)
              Site Development**
Condition: Consent of Faculty
Survey and data collection for traffic studies; traffic forecasting methods; traffic impact studies; point of access studies; vehicular circulation analysis; parking studies; planning and design of parking facilities; legal requirements.

**2101555   Travel Behavior Survey and   3(3-0-9)
              Analysis**
Condition: Consent of Faculty
Dimensions and characteristics of urban travel; travel demand; theories of travel behavior; methodologies of travel survey; experimental design; theory of sampling; analytical methods in travel behavior research.

2101556   Air Transportation System   3(3-0-9)
Condition: Consent of Faculty
Introduction to air transportation; air transportation economics; air transportation supply: network and carrier; air transportation demand; passenger and cargo; air transportation planning and management; air transportation infrastructure.

**2101557   Planning and Management of   3(3-0-9)
              Airport System**
Condition: Consent of Faculty
Preparation of a layout and design of an airport system including studies of a proposed site; surface and subsurface drainage; runway and taxiway; grading plane and earthwork estimates; design of base courses and runway surfaces; accessory structures and lighting; airport operations.

**2101558   Transportation and Logistics   3(3-0-9)
              System Optimization**
Condition: Consent of Faculty
Introduction to modeling and operations research ; linear programming; sensitivity analysis; integer programming; network optimization; heuristics; queuing system; applications of these tools to transportation and logistics problems.

2101559   Traffic Engineering   3(3-0-9)
Condition: Consent of Faculty
Theory of traffic flow, traffic studies, highway capacity analysis, traffic control devices, signal system, traffic system design and operations.

2101560   Sustainable Transportation   3(3-0-9)
Condition: Consent of Faculty
Principles of sustainable transportation; social, economic, and environment components; planning; planning for sustainable transportation system; measures-public transport, non-motorized transport, and other innovative measures; mobility management; evaluation; institutional and regulatory issues.

2101566   Dynamics of Structures   3(3-0-9)
Condition: Consent of Faculty
Analysis of structural systems with single and multi degree of freedom; equations of motions; free and forced vibrations; vibration natural frequencies and mode shapes of systems; numerical evaluation of dynamic response; response spectrum; modal response history and response spectrum analysis; response of inelastic SDF system; building codes on seismic design of structures.

2101567   Rail Transport System   3(3-0-9)
Condition: Consent of Faculty
This course covers the following topics: History of Rail Transport Development, Fundamental and Characteristics of Rail Operation, Rules of Safety, Composition of Rail System: infrastructure, Rolling Stocks, Signaling and Communication, Case Studies of Rail Transport Development in Thailand and Neighboring Countries.

2101580   Construction Information   3(3-0-9)
**   Management**
Condition: Consent of Faculty
Basic concepts of construction information, information flow in construction, construction information models, construction information management, computer programs for construction information management..

2101590   Construction Techniques and   3(3-0-9)
**   Productivity**
Condition: Consent of Faculty
Construction Processes, materials, tools, equipment; construction productivity; modern construction techniques; equipment in building and infrastructure works.

DESCRIPTIONS OF GRADUATE COURSES IN CIVIL ENGINEERING (M.ENG., PH.D.)

2101601   Advanced Structural Theory   3(3-0-9)
Analysis of trusses; frames and arches; influence lines; continuous frame with non-prismatic members: building frames subjected to lateral loads; introduction to matrix analysis of structures.

2101603   Theory of Elasticity   3(3-0-9)
Basic field equations for linear elastic solids, equations of equilibrium, constitutive law, strain-displacement relation, compatibility equations; solutions of two dimensional problems, beams, wedges, disks and rings under various conditions of loading, point load solutions; energy principles, principle of virtual work and complementary virtual work.

2101604   Shell Structures   3(3-0-9)
Membrane theory of shells; rotation and translational shells; general theory of shells; axisymmetrical bending of shells of revolution; cylindrical shell roofs; prismatic shell roofs.

2101605   Stability of Structures   3(3-0-9)
Buckling of concentrically and eccentrically loaded columns; lateral buckling of beams; built-up columns; stability of frameworks.

2101606   Dynamics and Vibrations   3(3-0-9)
Dynamic system modeling; equation of motion; analysis of systems with single and multi-degree of freedom; free and forced vibration; determination of natural frequencies of structures; distributed mass system; response spectrum method; dynamic analysis using numerical techniques; basic principles of non-linear system.

2101607   Advanced Mechanics of Materials   3(3-0-9)
Stress, strain, and displacement relationships; energy theorems; equilibrium and compatibility conditions; plane stress and plane strain problems, beams on elastic foundation; beam-columns, flexure of curve members; torsion of non-circular and thin walled members, shear center; shear flow. Introduction to theorems of limit analysis.

2101608   Plate Structures   3(3-0-9)
Differential equation for bending of plates; axisymmetrical bending of circular plates; orthotropic plates; combined action of lateral loads and in-plane forces; finite element method.

2101609   Plastic Design of Steel Structures   3(3-0-9)
Ultimate load capacity of steel structures; method of analysis for structures in the plastic rang; plastic design of continuous beams, frames, and connections. Secondary design problems to include the effect of shear and axial force upon plastic moment capacity.

2101611   Matrix Analysis of Structures   3(3-0-9)
Review of matrix algebra; matrix procedures for analysis of continuous beams, plane frames, space frames under static and quasi-static loading; stiffness and flexibility methods; techniques for solving large linear equation system; computer application.

2101614   Behavior of Steel Structures   3(3-0-9)

Researches which relate the basic behavior of structural steel members and frames to present design approximations; discussions are emphasized on background, use and limitations of the current specifications.

2101615 Advanced Prestressed Concrete 3(3-0-9)
Structures

Prestressing systems; behavior of prestressed concrete beams; moment-curvature relationship; load-deflection curves; ductility and fatigue; analysis and design of composite members, continuous flexural members, prestressed frames and segmental bridges.

2101616 Long Span Structural Systems 3(3-0-9)

Analysis and design of two-hinge ribbed and lamella arches, ribbed domes, two-way grid systems, space frames, and cable suspended systems.

2101617 Structural Building Components 3(3-0-9)

Analysis and design of structural components for buildings considering various types of construction materials; timber, metal, concrete, and synthetics. The components include floor systems, roof members, tilt-up walls, sandwich panels, precast members, bearing walls, shear walls and light-gauge steel members.

2101618 Finite Element Method for Civil 3(3-0-9)
Engineers

Basic concepts of interpolation; finite element interpolation; introduction to the finite element techniques in mechanics; development of elements from various principles and application of the method to static continuum problems; convergence and compatibility requirement; assemblage of elements and boundary conditions; structure of a typical finite element computer program; introduction to the treatment of dynamics and stability and extension of the method to generalized field problems; application in civil engineering problems.

2101619 Seismic Design of Structures 3(3-0-9)

Elementary engineering seismology; seismic waves; intensity and magnitude; response spectrum and design earthquakes; earthquake codes and analysis; response spectrum analysis; random vibrations; artificial generation of earthquake records; structural design and detailing for earthquake resistance of special structures: bridges, dams, and nuclear power plants.

2101621 Foundation Engineering 3(3-0-9)

Application of soil mechanics principles to stress distribution in earth masses; settlement analysis; bearing capacity of spread footings, piles and caissons; excavation for foundation works, sheet pile, brace cut, anchored wall and cofferdams.

2101624 Elasticity in Soil Mechanies 3(3-0-9)

Vector and tensor analysis, Eigenvalue problem, introduction to continuum mechanics, stress-strain definition for small strain, equilibrium and compatigility equations, stress-strain relationship, stress-strain relationship, stress-strain parameters and invariants, stress function method, energy method and variational principle, Hooke's law, simple elastic model, anisotropic and non-linear elastic model.

2101632 Rock Mechanics 3(3-0-9)

Physical properties and classification of intact rock; theories of rock failure; state of stress in the earth's crust; stresses and deformations around underground openings assuming elastic, plastic, and time-dependent behavior; effect of geologic discontinuities on rock strength; introduction to stability analyses in rock.

2101634 Plasticity in Soil Mechanics 3(3-0-9)

Introduction to plasticity theory, classical plasticity theory, yield surface and flow rule, classical elasto-plastic model, modern plasticity theory, critical state soil mechanics, critical state soil model, advanced soil model, bounding surface theory, multi yield surface theory, conventional method for plastic analysis, limit analysis, limit equilibrium, slip line method

2101636 Interpretation of Field 3(2-3-7)
Exploration and Soil Testing

Site investigation for civil engineering, conventional and geophysics methods; laboratory and field works in soil sampling, classification and testing.

2101637 Advanced Soil Mechanics 3(3-0-9)

Soil classification, index properties, weight-volume relationship, permeability and seepage analysis, stress within soil mass, elastic solutions for stress, shear strength behaviour and Mohr-Coulomb failure criteria, stress paths, deformation behaviour, consolidation theory, secondary compression, settlement prediction.

2101639 Special Study in Soil Engineering 3(3-0-9)

Contemporary topics in soil engineering.

2101644 Urban Transportation Planning 3(3-0-9)

Transportation systems and characteristics of traffic flow in urban areas; planning of urban transportation facilities; mathematical models for prediction of traffic flow; interrelationship of and use and transportation.

2101649 Probability Statistics and Decision 3(3-0-9)
for Civil Engineering

Elements of probability theory; common probability models; probabilistic models and observed data; elementary Baysian decision theory; analysis of independent random process.

2101653 Computer Models in Transportation 3(3-0-9)

Analytical models and practical tools for planning and analysis of transportation supply; computer application in the design and analysis of transportation and logistics networks; planning and analysis of transportation and

logistics network facilities; routing and scheduling of transportation resources.

2101654   Engineering for Disaster Mitigation   3(3-0-9)

Introduction to engineering for disaster resilience; earthquake disasters-case studies and lessons from earthquake disasters learnt; seismic design concept; tsunami disaster-modeling, early warning system, and preparedness: field trips to disaster prone areas.

2101655   Civil Engineering and Disaster   2(2-0-6)
Recovery
Problems and remedy measures of civil works after natural disaster, case studies from various countries, disaster management related to structures damaged by natural disaster, recovery of landslide induced by natural disaster, field trip to some organizations related to disaster recovery management or sites under.

2101656   Disaster Damage Mitigation and   2(2-0-6)
Recovery Management
Mitigation of disaster damage; hazard maps; crisis control: basic principles and management learning for business continuity: structural and non-structural mitigation measures from the viewpoint of the government to that of local communities: disaster recovery: communication and recovery technologies; case studies.

2101659   Logistics for Disaster Management   3(3-0-9)
Characteristics of and issues challenging disaster logistics management. Management concepts and techniques for disaster logistics planning, preparedness, response and recovery operations.

2101660   Transportation Systems   3(3-0-9)
Introduction to transportation systems; importance of transportation in the economy; development of transportation technology; roles of public and private sectors; transportation organizations; transportation system components and functions; types of transportation; modes of transportation; key characteristics of transportation models; intermodal transportation; general and mode-specific policy issues; social, economic, and political issues; careers in transportation sector.

2101661   Transportation Planning and Policy 3(3-0-9)
Policy context and transportation planning; decision making tools in transportation planning; modeling techniques in transportation; introduction to transportation economics; the four-step planning process and its limitation; alternative modeling approaches; transportation planning ethics.

2101662   Methods for Transportation Analysis 3(3-0-9)
Mathematical and statistical methods for transportation analysis; basic probability models and statisticl analysis; introduction to mathematical programming; decision analysis, optimization and simulation.

2101664   Transportation Operations   3(3-0-9)
Techniques in transportation operational analysis, space-time diagram, cumulative plots, queuing theory, traffic flow theory, traffic control, transportation scheduling, operations of transportation terminals.

2101665   Highway Design   3(3-0-9)
Highway design procedures; basic design policies; geometric design and structure standards; cross section; design of traffic interchanges and intersections; highway capacity analysis; analysis of freeway and highway facilities; design of traffic control devices.

2101666   Transportation Systems   3(3-0-9)
The use of advanced surveillance, navigation, communication, and computer technology to monitor, analyze, and improve the performance of transportation systems; enabling technologies; application of technology technology to monitoring, analysis, evaluation, and prediction of transportation system performance and behavior, feasibility studies; human factors and institutional issues.

2101667   Logistics System Analysis   3(3-0-9)
Fundamentals of logistics management, framework for logistics system analysis, logistics system modeling, logistics network design, distribution planning and management, transportation system and operation analysis.

2101668   Evaluation of Transportation   3(3-0-9)
Project and Policy
Basic microeconomics; Applications of microeconomic principles for transportation policy analysis; Evaluation of transportation projects and financing alternative.

2101669   Transport Policy   3(3-0-9)
Major policies concerning the transportation-related aspects of the environment, energy, economic development, community mobility/accessibility, freight transportation, advanced transportation systems, transportation safety and social justice; basic concepts in transportation policy formulation, research design and evaluation of legislation analysis and tracking, decision-making methods, public participatory techniques, transportation policy evaluation principles and methods.

2101680   Applied Mathematics I   3(3-0-9)
Ordinary differential equations; Fourier series; introduction to Fourier and Laplace trasforms; some applications to boundary value problems; vector analysis; matrices and linear equations.

2101681   Applied Mathematics II   3(3-0-9)

Partial defferential equations and boundary value problems; special functions; integral transform, calculus of variations and complex variables with emphasis on civil engineering applications.

2101690   Construction Methods and   3(3-0-9)
               Equipment

Construction method in civil engineering; planning for earthwork construction; construction equipment cost; selecting of construction equipment; calculating of machine power; analysis of equipment productivity such as dozer, scrapers, excavator, truck and hauling equipment, finishing equipment, pile-driving equipment, belt-conveyer, aggregate production, asphalt mix production and placement, concrete equipment, and cranes.

2101691   Special Studies   3(3-0-9)
Individual's problem solving in civil engineering.

2101692   Analytical Methods in Construction 3(3-0-9)
               Management

Analytical methods applied to modern construction engineering and management from both owner's and contractor's views; civil engineering systems modeling and analysis; applications of systems analysis, deterministic and probabilistic models, decision analysis, mathematical programming, optimization techniques, simulation techniques, and computer programs for civil engineering systems simulation; other analytical tools for rational decision making in construction engineering and management from project inception to completion.

2101694   Contracting in Construction   3(3-0-9)
               Business

Fundamentals of contracting in public and private construction projects; different contracts in construction business; rights and obligations of construction contracting parties; provisions regarding payment, quality, time extension; arbitration.

2101695   Computer Applications in   3(3-0-9)
               Construction

A broad range of computer applications in construction with emphasis on construction engineering and management; computer hardware and software components, operating system, programming languages, and information technology; analysis, design, development, and implementation of microcomputer-based systems such as database, spreadsheet, computer aided design and virtual reality technology; the effective utilizations of various construction management software; concepts of decision support system.

2101697   Infrastructure Planning and   3(3-0-9)
               Management

An integrated approach to the planning, construction, operation, and maintenance of infrastructure through an understanding of the performance of infrastructure and life-cycle cost evaluation; approaches the management, available technologies, and decision supporting tools in infrastructure and facility planning and management; economic framework for identifying and analyzing investment and operations options; relevant issues cuch an environment, laws, and regulations.

2101698   Construction Business Management 3(3-0-9)
Construction organization strategic construction business development; marketing plan, operational plan, financial planning and business valuation, quality control and management; construction process improvement.

2101742   Advanced Transportation and   3(3-0-9)
               Logistics System Optimization

Advanced optimization techniques for transportation and logistics networks; strength of mathematical formulation; large-scale optimization techniques: problem decomposition, row-and column-generation, branch-and-price-and-cut, genetic algorithms, and other state-of-the-art techniques.

2101794   Graduate Seminar in Civil   3(3-0-9)
               Engineering

Self studies on the topics provided by the division; oral presentation of the study outcome in conjunction with technical papers as wall as answers to technical questions and comments from the audience; special lectures by guest speakers.

2101799   Boundary Integral Equation   3(3-0-9)
               Method for Applied Mechanics

Description of general boundary value problems and basic governing field equations; development of Green's functions and their derivatives; Integral relations for field quantities; Standard integral equations for state variables and body flux; Singularity-reduced procedure and singularity-reduced boundary integral relations; special cases of cracks and dislocations; Boundary integral equation method, formulation of governing integral equations, boundary and solution approximations; evaluation of kernels, numerical integration, post-process.

2101800   Advanced Solid Mechanics   3(3-0-9)
Review of basic principles of solid mechanics; plane problems in linear elasticity, green's functions for point loads on surface of semi-infinite plane; rigid punch problems; green's function for point load in infinite plane; edge dislocations and cracks, Wiliams asymptotic expansion, stress intensity factors; complex variable representations for anti-plane shear and plane problems; three dimensional linear elasticity, stress functions; representations of displacement field; green's functions of infinite and semi-infinite spaces, rigid punch problem, Hertz problem, Eshelby's equivalent method; introduction to composite media, macroscopic measures of stress and strain, averaging theorem, overall properties of multi-phase media; Somigliana's identity, boundary integral equations for two and three-dimensional linear elasticity.

2101801 Fracture Mechanics 3(3-0-9)

Introduction to fracture mechanics, stress analysis of linear elastic cracked bodies, the stress field theory of fracture, the energy concepts on fracture, numerical and experimental determination of fracture properties, effects of variables on fracture toughness, fracture mechanics design, and elasto-plastic fracture; analysis of simple two-dimensional fracture problems; introduction to fatigue, fatigue crack growth, fracture criteria, and fracture control plans.

2101802 Inelastic Behavior of Materials 3(3-0-9)

Review of basic principles of solid mechanics; introduction to inelastic behavior of materials, aspects of material behavior and evidences from experiments; nonlinear elasticity, total deformation for plasticity, J_2 total deformation theory; incremental theory of plasticity, concept of yield surface, plastic flow rule, consistency condition, J_2 flow theory, isotropic hardening, kinematic hardening; plasticity with nested yield surfaces, plasticity with a bounding surface; formulation of boundary value problems in plasticity, minimum principles, solution of simple BVPs in plasticity; pressure-sensitive materials, time dependent materials; application of inelastic material behavior in finite element analysis, radial return method.

2101803 Nonlinear Analysis in Structural 3(3-0-9)
Mechanics

Finite strain mechanics; total Lagrangian and updated Lagrangian finite element formulation, nonlinear solution methods, large displacement behavior of structures and large displacement analysis of structural problems, finite element formulation of inelastic problems.

2101804 Behavior of Reinforced Concrete 3(3-0-9)
Structure

The behavior and strength of reinforced concrete structures subjected to flexure shear, torsion, axial and eccentric loading; determination of deflections, bond and cracking, review of research and pertinent literature, with emphasis on background, structural models, the performance and criteria approach of present design codes and specifications.

2101805 Limit State Design of Concrete 3(3-0-9)
Structures

Limit state design criteria; structural reliability, structural behavior in flexure, shear, torsion, compression and bond; structural design for slab, frame, column, footing, and others; determination of serviceability limit states for structural performance.

2101806 Numerical and Approximate 3(3-0-9)
Methods For Structural Engineering

Introduction to numerical computing; numerical methods for system of linear equations; numerical methods for linear least square problems; numerical methods for eigen value problem; numerical methods for system of nonlinear equations; method of interpolation: numerical integration and differentiation; approximate method for boundary value and initial value problems; introduction to optimization; applications to structural engineering problems.

2101810 Fire Safety Design of Structures 3(3-0-9)

Fire safety engineering; behavior of natural fires; properties of materials at elevated temperatures; design and detailing of structural elements for fire safety; design of frames for fire safety; assessment and repair of fire-damaged structures.

2101817 Structural Testing and Evaluation 3(3-0-9)

Concept of structural testing and evaluation; destructive and non-destructive testing; structural models and components for testing; full scale testing; testing standards; equipment and measurement techniques; date analysis and evaluation of structural performance.

2101818 Life Cycle of Concrete Structures 3(3-0-9)

Life Cycle and structural performance; importance and necessity of maintenance of structures; concrete deterioration mechanism and its prediction; concrete evaluation; remedial measures; surface repair; strengthening and stabilization; examples of management system for maintenance.

2101820 Geo-Environment Engineering 3(3-0-9)

Solid wastes management, waste compositions, design and monitoring of landfills, contaminant transports, fate transports, and soil remediation techniques.

2101821 Deep Foundation Design 3(3-0-9)

Behavior of pile foundation, estimating pile capacity, driven and bored pile, grouting and non-grouting behavior, pile driving analysis, pile integrity and sonic logging test, pile load test, design of pile foundation, settlement analysis.

2101824 Finite Element Method in 3(3-0-9)
Geotechnical Engineering

Revision of mathematics and continuum mechanics; principles of finite element method, element discretization, displacement functions and isoparametric elements, element equation; numerical integration; direct stiffness assembly method; weighted residual and variational method; boundary conditions; solution methods; non-linear and dynamic problems.

2101831 Engineering Ground Modification 3(3-0-9)

Aspects of soil mineralogy and its composition applied to soil engineering problems; origin and occurrence of soils; non-clay minerals in soil; structure and properties of clay minerals; classification and nomenclature of clay minerals; mineral analysis; relation between soil composition engineering properties; soil compaction, lime/cement-soil mixing behavior, preloading and

prefabricated vertical drain (PVD) techniques, cement grouting, cement columns, geotextile and geosynthetic.

2101832   Engineering Geophysics   3(3-0-9)
Application of elastic wave and electricity in ground prospecting, reflection survey, refraction survey, surface wave method; borehole method, down-hole, up-hole and cross hole; resistivity method for ground prospecting; electro-magnetic prospecting.

2101833   Soil Dynamics and Earthquake   3(3-0-9)
          Engineering
Earthquake mechanisms, earthquake magnitude and energy, strong ground motions, seismic hazard assessment, wave propagation theory, basic soil dynamics, effects of earthquakes in geotechnical aspects: liquefaction, dynamic bearing capacity and lateral earth pressure.

2101835   Earth and Retaining Structures   3(3-0-9)
Slope stability problems; methods of slope stability analysis; slope stability analysis under drained/undrained conditions and with/without groundwater seepage; field stability observations using geotechnical instruments; introduction to earth pressures; lateral earth pressures; lateral earth pressure theories; analysis and design of retaining wall.

2101840   Traffic Modeling and Simulation   3(3-0-9)
Traffic micro-simulation fundamentals; the use of transportation and traffic simulation and modeling software; data collection and preparation; base model development; model calibration; interpretation of outputs; related statistical analysis.

2101841   Special studies in Transportation 3(3-0-9)
          Engineering
Individual's problem solving in transportation engineering.

2101842   Advanced Transportation and   3(3-0-9)
          Logistics System Optimization
Advanced optimization techniques for transportation and logistics networks; strength of mathematical formulation; large-scale optimization techniques: problem decomposition, row-and column-generation, branch-and-price-and-cut, genetic algorithms, and other state-of-the-art techniques.

2101844   Road Safety   3(3-0-9)
Accident characteristics; sources of road traffic accidents; road safety indicators; statistical methods in traffic safety analysis; safety management system; road safety audit; counter measures; current research in road safety.

2101845   Advanced Pavement Design   3(3-0-9)

Advanced theorem of pavement design and method for evaluation of damage caused by heavy wheel load impacts on pavement containing excess water.

2101846   Railway Engineering   3(3-0-9)
Historical development of railways; principles of railway planning; geometric design; track structure; rolling stocks; signaling and operating system; financing and economics of railway development project; construction and maintenance of railway.

2101870   Construction Project Management 3(3-0-9)
Concept of construction project management, planning and scheduling techniques, estimating, and cost control techniques for construction projects; work breakdown structure; progress monitoring ; construction resource management; project risk management; project quality control and quality assurance; new project management techniques.

2101871   Risk Management in Civil and   3(3-0-9)
          Environmental Engineering Systems
Fundamental concepts of risk, risk management process, risk analysis, risk response, risk monitoring and evaluation, risk management tools and techniques, reliability of civil and environmental engineering system, risk benefit assessment, acceptable risk, risk management system, applications and case studies in civil and environmental engineering systems.

2101873   Special Topics in Construction   3(3-0-9)
Fundamental concepts of risk, risk management process, risk analysis, risk response, risk monitoring and evaluation, risk management tools and techniques, reliability of civil and environmental engineering system, risk benefit assessment, acceptable risk, risk management system, applications and case studies in civil and environmental engineering systems.

2101811	Thesis	12	Credits
2101828	Dissertation	48	Credits
2101829	Dissertation	60	Credits
2101894	Doctoral Dissertation Seminar	0(0-0-0)	
2101897	Qualifying Examination	0(0-0-0)	

DEPARTMENT OF ELECTRICAL ENGINEERING

The undergraduate curriculum is designed to provide students with a broad and firm foundation in physical science and electrical engineering, which is essential for an electrical engineering pursuing his/her career as a practitioner or researcher.

Electrical engineering courses begin in the sophomore year with electric circuits, electrical machines and electromagnetic. During the junior year, the students have to study further fundamental subjects related to electrical power, electronics, communications, and control systems. Courses in engineering mathematics are also included in the curriculum to strengthen the students ability in analysis. During the senior year, students can select their specialization by taking subjects from the approved elective list as well as the Electrical Engineering Project.

Laboratory works in various disciplines of electrical engineering are included in the curriculum. The objective of these courses is to develop the students' skills in operating test equipment, resourcefulness in solving practical problems, and ability to analyze test results.

The Department of Electrical Engineering offers two graduate programs leading to the degree of Master of Engineering and the degree of Doctor of Philosophy.

For Master degree, the applicant must hold a Bachelor's Degree either in Electrical Engineering or in related fields of study and must also meet the requirements of the Graduate School.

The program consists of 36 credits, of which 3 are required core courses in applied mathematics, 9 are major requirement, 6 required elective courses in related fields, and 18 are thesis:

The major requirement consists of 11 strategic research areas (SRA) namely: Advanced Control and Optimization Biomedical Engineering Embedded Systems and Robotics High Voltage Engineering Microwave and Lightwave Communications Multimedia and Signal Processing Nanoelectronics and Photonics Power Electronics Power and Energy Systems Telecommunications and Information Networking Smart Grid and Renewable Energy

For Ph.D. Program, the applicant must meet one of the following requirements :

1. The applicant who holds a Bachelor's Degree in Electrical Engineering must obtain the second honor degree or the minimum 3.25 grade point average and must also meet the requirement of the Graduate School.

2. The applicant who holds a Master's Degree in Electrical Engineering must obtain good or excellent in master thesis and must also meet the requirement of the Graduate School.

Moreover, each student has to pass the following requirements in order to achieve his or her study :

1. For the applicant who holds a Master's Degree with more than 3.5 grade point average, must take credits from the seminar and listed elective courses with the approval of the major advisor.

In addition to fulfilling the course requirement, the student is required to submit a thesis of 60 credits, satisfactorily pass an oral examination and one part or more of the thesis has been accepted to be published in international journal.

2. For the applicant who holds a Master's Degree with grade point average less than 3.5, is required to pass at least 12 credits from the listed elective courses with the approval of the major advisor and the seminar courses.

In addition to fulfilling the course requirement, the student is required to submit a thesis of 48 credits, satisfactorily pass an oral examination and one part or more of the thesis has been accepted to be published in international journal.

3. The applicant who holds a Bachelor's degree is required to pass 24 credits from the listed elective and the seminar courses with the approval of the major advisor.

In addition to fulfilling the course requirement, the student is required to submit a thesis of 48 credits, satisfactorily pass an oral examination and one part or more of the thesis has been accepted to be published in international journal.

HEAD :

Komson   Petcharaks,   Dr.Sc. Techn.
                         (Swiss Federal Inst.
of Tech Zurich)

PROFESSORS :

Boonchai   Techaumnat,   D.Eng. (Kyoto)
Bundhit   Eua-arporn,   Ph.D. (London)
David   Banjerdpongchai,   Ph.D. (Stanford)
Somsak   Panyakeow,   D.Eng. (Osaka)
Watit   Benjapolakul,   D.Eng. (Tokyo)

ASSOCIATE PROFESSORS :

Chaodit   Aswakul,   Ph.D. (London)
Chedsada   Chinrungrueng,   Ph.D. (U.C.Berkeley)

ASSISTANT PROFESSORS :

Arporn   Teeramongkonrasmee, Ph.D. (Chula)
Chaiyachet Saivichit,   Ph.D. (London)
Chanchana   Tangwongsan,   Ph.D. (Wisconsin)
Chanin   Wissawinthanon, Ph.D. (Minnesota)
Charnchai   Pluempitiwiriyawej, Ph.D. (Carnegie Mellon)
Jitkomut   Songsiri   Ph.D. (UCLA)
Komson   Petcharaks,   Dr.Sc. Techn.(Swiss Federal Inst.
                             of Tech Zurich)
Manop   Wongsaisuwan,   D.Eng. (Tokyo Tech)
Pasu   Kaewplang,   Ph.D. (Chula)
Somboon   Sangwongwanich, D.Eng. (Nagoya)
Suchin   Arunsawatwong,   Ph.D. (Manchester)
Supatana   Auethavekiat   Ph.D. (Tokyo)
Surachai   Chaitusaney   Ph.D. (Tokyo)
Surapong   Suwankawin,   Ph.D. (Chula)
Suree   Pumrin,   Ph.D. (Washington)
Suvit   Nakpeerayuth,   M.Eng. (Chula)
Taptim   Angkaew,   D.Eng. (Osaka)
Wanchalerm Pora,   Ph.D. (London)
Weerapun   Rungseevijitprapa, Dr.-Ing. (Hannover)
Widhyakorn Asdornwised,   D.Eng. (Chula)

Cherdkul   Sopavanit,   M.Eng. (Chula)
Duang-rudee Wonglumsom,   Ph.D. (Stanford)
Kulyos   Audomvongseree,   D.Eng. (Tokyo)
Lunchakorn Wuttisittikulkij, Ph.D. (Essex)
Mana   Sriyudthsak,   D.Eng. (Tokyo Tech)
Naebboon   Hoonchareon,   Ph.D. (Purdue)
Nisachon   Tangsangiumvisai, Ph.D. (London)
Prasit   Teekaput,   Ph.D. (VPI & Su)
Somchai   Ratanathammaphan, D.Eng. (Chula)
Songphol   Kanjanachuchai, Ph.D. (Cambridge)
Sotdhipong Phichaisawat,   Ph.D. (Brunel, UK)
Supavadee Aramvith,   Ph.D. (Washington)
Thavatchai Tayjasanant,   Ph.D. (Alberta)
Watcharapong Khovidhungij,   Ph.D. (UCLA)

LECTURERS :

Apiwat   Lek-Uthai   Dr.Ing. (Karlsruhe)
Bunchauy   Supmonchai,   M.Eng. (Chula)
Channarong Banmongkol,   D.Eng. (Nagoya)
Hadsakoon   Boriphonmongkol, M.Eng. (Chula)
Jakapan   Lee,   M.Eng. (Tokyo Tech)
Panuwat   Janpugdee   Ph.D. (Ohio State)
Pisitpol   Chirapngsananurak Ph.D. (Texas)

ELECTRICAL ENGINEERING CURRICULUM
FIRST YEAR CURRICULUM
COMMON TO ENGINEERING STUDENTS

COURSE NO.	SUBJECT	CREDITS
THIRD SEMESTER		
2102201	ELECTRICAL ENGINEERING MATHEMATICS I	3
2102203	PROBABILITY AND STATISTICS FOR ELECTRICAL ENGINEERING	3
2102209	ELECTRICAL ENGINEERING ESSENTIALS	3
2102213	CIRCUIT THEORY I AND LABORATORY	4
2103213	ENGINEERING MECHANICS I	3
2301207	CALCULUS III	3
		19
FOURTH SEMESTER		
2102202	ELECTRICAL ENGINEERING MATHEMATICS II	3
2102214	CIRCUIT THEORY II AND LABORATORY	3
2102222	ENGINEERING ELECTROMAGNETICS	3
2102253	ELECTRICAL MACHINES I AND LABORATORY	4
5500208	COMMUNICATION AND PRESENTATION SKILLS	3
xxxxxxx	GENERAL EDUCATION I	3
		19
FIFTH SEMESTER		
2102311	ELECTRICAL MEASUREMENT AND INSTRUMENTATION	3
2102333	LINEAR CONTROL SYSTEMS I AND LABORATORY	4
2102360	ELECTRICAL POWER SYSTEM I	3
2102385	SEMICONDUCTOR DEVICES I	3
2102387	FUNDAMENTALS OF DIGITAL SYSTEMS AND LABORATORY	3
xxxxxxx	GENERAL EDUCATION II	3
		19

COURSE NO.	SUBJECT	CREDITS
SIXTH SEMESTER		
2102308	PROPERTIES OF ELECTRICAL ENGINEERING MATERIALS	3
2102371	PRINCIPLES OF COMMUNICATIONS AND LABORATORY	3
2102386	ELECTRONIC CIRCUITS AND LABORATORY	4
2102xxx	COMPULSORY ELECTIVES	6
xxxxxxx	GENERAL EDUCATION III	3
		19
SUMMER SEMESTER		
2100301	ENGINEERING PRACTICE	2
SEVENTH SEMESTER		
2102490	ELECTRICAL ENGINEERING PRE-PROJECT	1
2102xxx	COMPULSORY ELECTIVES	6
2102xxx	COMPULSORY ELECTIVES (LAB)	2
2102xxx	ELECTIVES	3
5500308	TECHNICAL WRITING FOR ENGINEERING	3
		15
EIGHTH SEMESTER		
2102499	ELECTRICAL ENGINEERING PROJECT	3
xxxxxxx	ELECTIVES	3
xxxxxxx	GENERAL EDUCATION IV	3
xxxxxxx	FREE ELECTIVES	6
		15

TOTAL CREDITS FOR GRADUATION = 144

NAME OF THE DEGREE

  : Master of Engineering
  : M. Eng.

PROFESSORS :

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Chanin	Wissawinthanon,	Ph.D. (Minnesota)
Charnchai	Pluempitiwiriyawej,	Ph.D. (Carnegie Mellon)
Jitkomut	Songsiri	Ph.D. (UCLA)
Komson	Petcharaks,	Dr.Sc. Techn.
(Swiss Federal Inst. of Tech Zurich)		
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Pasu	Kaewplang,	Ph.D. (Chula)
Somboon	Sangwongwanich,	D.Eng. (Nagoya)
Suchin	Arunsawatwong,	Ph.D. (Manchester)
Supatana	Auethavekiat	Ph.D. (Tokyo)
Surachai	Chaitusaney	Ph.D. (Tokyo)
Surapong	Suwankawin,	Ph.D. (Chula)
Suree	Pumrin,	Ph.D. (Washington)
Suvit	Nakpeerayuth,	M.Eng. (Chula)
Taptim	Angkaew,	D.Eng. (Osaka)
Wanchalerm	Pora,	Ph.D. (London)
Weerapun	Rungseevijitprapa,	Dr.-Ing. (Hannover)
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Panuwat	Janpugdee	Ph.D. (Ohio State)
Pisitpol	Chirapngsananurak	Ph.D. (Texas)

COURSE REQUIREMENTS

1. Required Courses

  (1.1)   **Compulsory Electives in Applied Mathematics 3 credits   from**

2102502	Random Signals and Systems	3(3-0-9)
2102504	Introduction to Mathematical Analysis	3(3-0-9)
2102505	Introduction to Optimization Techniques	3(3-0-9)
2102506	Finite Element Analysis for Electrical Engineers	3(3-0-9)
2102507	Computational Techniques For Engineers	3(3-0-9)
(1.2) 2102790	Electrical Engineering Seminar	2(2-0-6)

2)   Compulsory Electives in Electrical Engineering Research Area   9 credits   from

  - **Advanced Control and Optimization**

2102531	System Identification	3(3-0-9)
2102536	Nonlinear Control Systems I	3(3-0-9)
2102631	Optimal Control Systems	3(3-0-9)
2102635	Control System Theory	3(3-0-9)
2102637	Multivariable Control Systems	3(3-0-9)
2102638	Nonlinear Control Systems II	3(3-0-9)
2102731	Infinite-Dimensional Control Systems	3(3-0-9)
2102732	Convex Optimization and Engineering Applications	3(3-0-9)

  - **Biomedical Engineering**

2102523	Statistical Signal Processing in Biomedical Engineering	3(3-0-9)
2102547	Cognitive Engineering	3(3-0-9)
2102585	Biomaterial Science	3(3-0-9)
2102588	Biomedical Electronics	3(3-0-9)
2102611	Medical Instrumentation	3(3-0-9)
2102668	Biosensors	3(3-0-9)
2102675	Pattern Recognition	3(3-0-9)
2102676	Digital Image Processing	3(3-0-9)
2102785	Advanced Sensor Theory	3(3-0-9)
2102876	Adaptive Signal Processing	3(3-0-9)

  - **Embedded Systems and Robotics**

2102540	Microcomputer Systems	3(3-0-9)

2102544	Advanced Embedded Systems	3(3-0-9)
2102545	Digital Integrated Circuits	3(3-0-9)
2102546	Analog Integrated Circuits	3(3-0-9)
2102581	Digital Circuit Design	3(3-0-9)
2102642	Computer Vision and Video Electronics	3(3-0-9)
2102645	Embedded System Design	3(3-0-9)

- High Voltage Engineering

2102553	Fundamentals of Electromagnetic Compatibility	3(3-0-9)
2102558	Insulation Coordination	3(3-0-9)
2102650	Electrical Transients in Power Systems	3(3-0-9)
2102656	Power System Protection	3(3-0-9)
2102754	Electric Field Analysis in High Voltage Engineering	3(3-0-9)
2102755	Power System Electromagnetic Transient Simulation	3(3-0-9)

- Microwave and Lightwave Communications

2102520	Optical Fiber Transmissions and Networks	3(3-0-9)
2102521	Access Networks	3(3-0-9)
2102620	Electromagnetic Theory	3(3-0-9)
2102623	Antenna and Radar Systems	3(3-0-9)
2102625	Computational Electromagnetics for Microwave and Photonics	3(3-0-9)
2102674	Optical Communication	3(3-0-9)

- Multimedia and Signal Processing

2102571	Multimedia Communication	3(3-0-9)
2102574	Information Theory	3(3-0-9)
2102605	Fourier Transforms and its Applications	3(3-0-9)
2102675	Pattern Recognition	3(3-0-9)
2102676	Digital Image Processing	3(3-0-9)
2102874	Speech Processing	3(3-0-9)
2102875	Digital Video Processing	3(3-0-9)
2102876	Adaptive Signal Processing	3(3-0-9)

- Nanoelectronics and Photonics

2102549	Semiconductor Fabrication Technology	3(3-0-9)
2102582	Photonic Devices in Optical Communication Systems	3(3-0-9)
2102583	Introduction to Quantum Mechanics	3(3-0-9)
2102584	Introduction to Nanoelectronics	3(3-0-9)
2102589	Laser Engineering	3(3-0-9)
2102663	Solar Cell Technology	3(3-0-9)
2102680	Semiconductor Lasers	3(3-0-9)
2102682	Solid-State Physics for Electronics Engineers	3(3-0-9)
2102684	Guided-Wave Optics and Nanophotonics	3(3-0-9)

- Power Electronics

| 2102543 | Advanced Electric Motor Drives | 3(3-0-9) |

2102548	Switched-Mode Electrical Power Processing I	3(3-0-9)
2102601	Power and Energy Technologies in Smart Grids	3(3-0-9)
2102686	Switched-Mode Electrical Power Processing II	3(3-0-9)

- Power and Energy Systems

2102550	Power Electronics in Electrical Power Systems	3(3-0-9)
2102551	Computational Methods for Power System Analysis and Design	3(3-0-9)
2102552	Introduction to Distributed Generation	3(3-0-9)
2102554	Power System Harmonics	3(3-0-9)
2102555	Fundamentals of Power Quality	3(3-0-9)
2102556	Power System Economics	3(3-0-9)
2102601	Power and Energy Technologies in Smart Grids	3(3-0-9)
2102651	Power System Stability	3(3-0-9)
2102656	Power System Protection	3(3-0-9)
2102757	Power System Reliability	3(3-0-9)

- Telecommunications and Information Networking

2102525	Internet and Network Security	3(3-0-9)
2102577	Telecommunication Network	3(3-0-9)
2102578	Satellite Communications	3(3-0-9)
2102602	Information and Communication Technologies in Smart Grids	3(3-0-9)
2102627	Reliability and Survivability of Communication Networks and Systems	3(3-0-9)
2102628	Graph Theory and Combinatorial Optimization	3(3-0-9)
2102629	Traffic Engineering and Queuing Theory	3(3-0-9)
2102674	Optical Communication	3(3-0-9)
2102677	Broadband Network and Design	3(3-0-9)
2102770	Wireless Communications and Networking	3(3-0-9)
2102774	Telecommunications Switching, Transmission and Signaling	3(3-0-9)

- Smart Grids and Renewable Energy

Select 9 credits from the list of Compulsory Electives in Electrical Engineering Research Areas or Elective Courses as given in the curriculum which are relevant to Smart Grids.

3) Elective Courses   **6 credits**

| 2102598 | Special Problems in Electrical Engineering I | 3(3-0-9) |
| 2102697 | Special Problems in Electrical Engineering II | 3(3-0-9) |

Select 6 credits from the list of Compulsory Electives in Applied Mathematics or Compulsory Electives in Electrical Engineering Research Areas or Elective Courses as given in the curriculum.

- Smart Grids and Renewable Energy   **6 credits**

2102601	Power and Energy Technologies in Smart Grids	3(3-0-9)
2102602	Information and Communication Technologies in Smart Grids	3(3-0-9)

4) THESIS

2102813	THESIS	18	credits
2102816	THESIS	36	credits

NAME OF THE DEGREE

: Doctor of Philosophy
: Ph.D.

PROFESSORS :

Boonchai	Techaumnat,	D.Eng. (Kyoto)
Bundhit	Eua-arporn,	Ph.D. (London)
David	Banjerdpongchai,	Ph.D. (Stanford)
Somsak	Panyakeow,	D.Eng. (Osaka)
Watit	Benjapolakul,	D.Eng. (Tokyo)

ASSOCIATE PROFESSORS :

Chaodit	Aswakul,	Ph.D. (London)
Chedsada	Chinrungrueng,	Ph.D. (U.C.Berkeley)
Cherdkul	Sopavanit,	M.Eng. (Chula)
Duang-rudee	Wonglumsom,	Ph.D. (Stanford)
Kulyos	Audomvongseree,	D.Eng. (Tokyo)
Lunchakorn	Wuttisittikulkij,	Ph.D. (Essex)
Mana	Sriyudthsak,	D.Eng. (Tokyo Tech)
Nisachon	Tangsangiumvisai,	Ph.D. (London)
Naebboon	Hooncharoen,	Ph.D. (Purdue)
Prasit	Teekaput,	Ph.D. (VPI & Su)
Somchai	Ratanathammaphan,	D.Eng. (Chula)
Songphol	Kanjanachuchai,	Ph.D.(Cambridge)
Sotdhipong	Phichaisawat,	Ph.D. (Brunel, UK)
Supavadee	Aramvith,	Ph.D. (Washington)
Thavatchai	Tayjasanant,	Ph.D.(Alberta)
Watcharapong	Khovidhungij,	Ph.D. (UCLA)

ASSISTANT PROFESSORS :

Arporn	Teeramongkonrasmee,	Ph.D. (Chula)
Chaiyachet	Saivichit,	Ph.D. (London)
Chanchana	Tangwongsan,	Ph.D. (Wisconsin)
Chanin	Wissawinthanon,	Ph.D. (Minnesota)
Charnchai	Pluempitiwiriyawej,	Ph.D. (Carnegie Mellon)
Jitkomut	Songsiri	Ph.D. (UCLA)
Komson	Petcharaks,	Dr.Sc. Techn. (Swiss Federal Inst. of Tech Zurich)
Manop	Wongsaisuwan,	D.Eng. (Tokyo Tech)
Pasu	Kaewplang,	Ph.D. (Chula)
Somboon	Sangwongwanich,	D.Eng. (Nagoya)
Suchin	Arunsawatwong,	Ph.D. (Manchester)
Supatana	Auethavekiat	Ph.D. (Tokyo)
Surachai	Chaitusaney	Ph.D. (Tokyo)

Surapong	Suwankawin,	Ph.D. (Chula)
Suree	Pumrin,	Ph.D. (Washington)
Taptim	Angkaew,	D.Eng. (Osaka)
Wanchalerm	Pora,	Ph.D. (London)
Weerapun	Rungseevijitprapa,	Dr.-Ing. (Hannover)
Widhyakorn	Asdornwised,	D.Eng. (Chula)

LECTURERS :

Apiwat	Lek-Uthai	Dr.Ing. (Karlsruhe)
Channarong	Banmongkol,	D.Eng. (Nagoya)
Panuwat	Janpugdee	Ph.D. (Ohio State)
Pisitpol	Chirapngsananurak	Ph.D. (Texas)

COURSE REQUIREMENTS

1) Required Courses

2102791	Electrical Engineering Seminar I	2(2-0-6)
2102792	Electrical Engineering Seminar II	2(2-0-6)
2102793	Electrical Engineering Seminar III	2(2-0-6)
2102794	Electrical Engineering Seminar IV	2(2-0-6)

2) Compulsory Electives in Applied Mathematics 3 credits from

2102502	Random Signals and Systems	3(3-0-9)
2102504	Introduction to Mathematical Analysis	3(3-0-9)
2102505	Introduction to Optimization Techniques	3(3-0-9)
2102506	Finite Element Analysis for Electrical Engineers	3(3-0-9)
2102507	Computational Techniques for Engineers	3(3-0-9)

3) Compulsory Electives in Electrical Engineering Research Area 9 credits from

- Advanced Control and Optimization

2102531	System Identification	3(3-0-9)
2102536	Nonlinear Control Systems I	3(3-0-9)
2102631	Optimal Control Systems	3(3-0-9)
2102635	Control System Theory	3(3-0-9)
2102637	Multivariable Control Systems	3(3-0-9)
2102638	Nonlinear Control Systems II	3(3-0-9)
2102731	Infinite-Dimensional Control Systems	3(3-0-9)
2102732	Convex Optimization and Engineering Applications	3(3-0-9)

- Biomedical Engineering

2102523	Statistical Signal Processing in Biomedical Engineering	3(3-0-9)
2102547	Cognitive Engineering	3(3-0-9)
2102585	Biomaterial Science	3(3-0-9)
2102588	Biomedical Electronics	3(3-0-9)
2102611	Medical Instrumentation	3(3-0-9)
2102668	Biosensors	3(3-0-9)
2102675	Pattern Recognition	3(3-0-9)

2102676	Digital Image Processing	3(3-0-9)
2102785	Advanced Sensor Theory	3(3-0-9)
2102876	Adaptive Signal Processing	3(3-0-9)

- Embedded Systems and Robotics

2102540	Microcomputer Systems	3(3-0-9)
2102544	Advanced Embedded Systems	3(3-0-9)
2102545	Digital Integrated Circuits	3(3-0-9)
2102546	Analog Integrated Circuits	3(3-0-9)
2102581	Digital Circuit Design	3(3-0-9)
2102642	Computer Vision and Video Electronics	3(3-0-9)
2102645	Embedded System Design	3(3-0-9)

- High Voltage Engineering

2102553	Fundamentals of Electromagnetic Compatibility	3(3-0-9)
2102558	Insulation Coordination	3(3-0-9)
2102650	Electrical Transients in Power Systems	3(3-0-9)
2102656	Power System Protection	3(3-0-9)
2102754	Electric Field Analysis in High Voltage Engineering	3(3-0-9)
2102755	Power System Electromagnetic Transient Simulation	3(3-0-9)

- Microwave and Lightwave Communications

2102520	Optical Fiber Transmissions and Networks	3(3-0-9)
2102521	Access Networks	3(3-0-9)
2102620	Electromagnetic Theory	3(3-0-9)
2102623	Antenna and Radar Systems	3(3-0-9)
2102625	Computational Electromagnetics for Microwave and Photonics	3(3-0-9)
2102674	Optical Communication	3(3-0-9)

- Multimedia and Signal Processing

2102571	Multimedia Communication	3(3-0-9)
2102574	Information Theory	3(3-0-9)
2102605	Fourier Transforms and its Applications	3(3-0-9)
2102675	Pattern Recognition	3(3-0-9)
2102676	Digital Image Processing	3(3-0-9)
2102874	Speech Processing	3(3-0-9)
2102875	Digital Video Processing	3(3-0-9)
2102876	Adaptive Signal Processing	3(3-0-9)

- Nanoelectronics and Photonics

2102549	Semiconductor Fabrication Technology	3(3-0-9)
2102582	Photonic Devices in Optical Communication Systems	3(3-0-9)
2102583	Introduction to Quantum Mechanics	3(3-0-9)
2102584	Introduction to Nanoelectronics	3(3-0-9)
2102589	Laser Engineering	3(3-0-9)
2102663	Solar Cell Technology	3(3-0-9)
2102680	Semiconductor Lasers	3(3-0-9)
2102682	Solid-State Physics for Electronics Engineers	3(3-0-9)
2102684	Guided-Wave Optics and	3(3-0-9)

Nanophotonics

- Power Electronics

2102543	Advanced Electric Motor Drives	3(3-0-9)
2102548	Switched-Mode Electrical Power Processing I	3(3-0-9)
2102601	Power and Energy Technologies in Smart Grids	3(3-0-9)
2102686	Switched-Mode Electrical Power Processing II	3(3-0-9)

- Power and Energy Systems

2102550	Power Electronics in Electrical Power Systems	3(3-0-9)
2102551	Computational Methods for Power System Analysis and Design	3(3-0-9)
2102552	Introduction to Distributed Generation	3(3-0-9)
2102555	Fundamentals of Power Quality	3(3-0-9)
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2102651	Power System Stability	3(3-0-9)
2102656	Power System Protection	3(3-0-9)
2102757	Power System Reliability	3(3-0-9)

- Telecommunications and Information Networking

2102525	Internet and Network Security	3(3-0-9)
2102577	Telecommunication Network	3(3-0-9)
2102578	Satellite Communications	3(3-0-9)
2102602	Information and Communication Technologies in Smart Grids	3(3-0-9)
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2102629	Traffic Engineering and Queuing Theory	3(3-0-9)
2102674	Optical Communication	3(3-0-9)
2102677	Broadband Network and Design	3(3-0-9)
2102770	Wireless Communications and Networking	3(3-0-9)
2102774	Telecommunications Switching, Transmission and Signaling	3(3-0-9)

- Smart Grids and Renewable Energy

Select 9 credits from the list of Compulsory Electives in Electrical Engineering Research Areas or Elective Courses as given in the curriculum.

4) Elective Courses   12 credits
Select from any 21026xx, 21027xx and 2108xx in item 3), and the following course

| 2102697 | Special Problems in Electrical Engineering II | 3(3-0-9) |
| 2102796 | Advanced Topics in Electrical Engineering I | 3(3-0-9) |

| 2102797 | Advanced Topics in Electrical Engineering II | 3(3-0-9) |

- Smart Grids and Renewable Energy   6 credits

| 2102601 | Power and Energy Technologies in Smart Grids | 3(3-0-9) |
| 2102602 | Information and Communication Technologies in Smart Grids | 3(3-0-9) |

5) Dissertation

2102828	Dissertation	48	credits
2102829	Dissertation	60	credits
2102830	Dissertation	72	credits
2102894	Doctoral Dissertation Seminar		S/U
2102897	Qualifying Examination		S/U

COURSES DESCRIPTIONS IN ELECTRICAL ENGINEERING (B.ENG.)

2102201   Electrical Engineering Mathematics I   3(3-0-6)
Condition : Prerequisite 2301108

First-order and higher-order ordinary differential equations; series solutions of ordinary differential equations; Fourier series; Fourier integral and transform; Laplace transform; partial fraction expansion; partial differential equations; boundary-value problem; applications in Electrical Engineering.

2102202   Electrical Engineering Mathematics II   3(3-0-6)
Condition : Prerequisite 2301108

Systems of linear equations; elementary row operations; rank; matrix algebra; inverse of a matrix; LU factorization; determinants; vector spaces and subspaces; bases and dimensions; linear transformation and matrix representation; coordinate vectors; change of basis; eigenvalues and eigenvectors; diagonalization and similarity transformation; functions of a square matrix; Cayley-Hamilton theorem; infinite series, matrix exponentials; applications to differential equations; functions of a complex variable; analytic functions and derivatives; elementary functions; integration in the complex plane; Cauchy's integral theorem; Taylor and Laurent series; residue theorem and applications; conformal mapping.

2102203   Probability and Statistics for Electrical Engineering   3(3-0-6)
Condition : Prerequisite 2301108

Elements of probability: axioms of probability, conditional probability, independent events, Bayes' theorem. random variables: discrete and continuous random variables, probability functions, function of r.v., expectation, variance, covariance, moments, moment generating functions, Markov's and Chebyshev's inequalities, the weak law of large numbers. special random variables: Bernoulli, binomial, multinomial, geometric, Poisson, hypergeometric, negative binomial, uniform, normal (Gaussian), exponential,

gamma, chi-square, t, F. sampling: sample mean, sample variance, histogram, sampling distributions from a normal population. Parameter estimation: method of moments, maximum likelihood method, confidence interval, bias, mean square error. hypothesis testing: types and probability of error, tests concerning mean and variance of normal populations.

2102209   Electrical Engineering Essentials   3(3-0-6)

Basic knowledge and understanding of present trends of electrical engineering technology in various fields, i.e., electrical power, electronics, control, and communication, based on which the students can grasp the whole picture of electrical engineering. The course is composed of lectures, hands-on laboratories in basic applications and MATLAB, and study trip. The lectures will be given by the Department staffs and invited experts from the industries, and will cover the topics ranging from basic researches to state-of-the-art technologies of each field.

2102213   Circuit Theory I and Laboratory   4(3-3-6)

DC concepts; Ohm's law; Kirchhoff's laws; circuit components; passive sign convention; periodic functions; sinusoidal steady state; phasor representations; impedances and admittances; node and mesh analysis; superposition theorem; source transformation; Thevenin and Norton theorem; maximum power transfer; phasor diagram; AC power analysis; polyphase circuits; laboratories on electrical circuits and measuring equipments.

2102214   Circuit Theory II and Laboratory   3(3-1-5)
Condition : Prerequisite 2102213 Corequisite 2102201

Transient and steady-state responses: first-Order and second-order circuits, step response, zero-input and zero-state responses; Laplace transform analysis for circuit and transfer function applications: transient and steady-state responses, network and systems, frequency response, bode plots, resonant circuit; principles of basic filtering: low-pass filter, band-pass filter and high-pass filter, two-port networks: basic two-port parameters; interconnected two-port networks; hands-on activities for some relevant contents.

2102222   Engineering Electromagnetics   3(3-0-6)
Condition: Prerequisite 2301207

Vector analysis; electrostatic fields in free space; electrostatic fields in dielectrics and conductors; Laplace equation and simple solution method; energy in electrostatic fields; convection current and conduction currents; magnetostatic fields; magnetic forces; energy in magnetostatic fields; electromagnetic induction and Maxwell's equations; time-harmonic electromagnetic fields and their phasors; plane waves in an unbounded medium; free-space, dielectric and conductor; electromagnetic power transmission, Poynting's theorem.

2102253   Electrical Machines I and Laboratory   4(3-3-6)

Condition: Prerequisite 2102213

Basic principles of electromechanical energy conversion: electromagnetic forces, Faraday's law, Ampere's law, Gauss's law, magnetic materials, magnetic circuits; dc machine constructions; steady-state analysis, characteristics, and testing of dc generators and dc motors; construction and characteristics of transformers; fundamentals of ac machines; ac machine constructions; rotating magnetic fields; steady-state analysis, characteristics, and testing of synchronous generators and induction motors; hands-on activities and experimental topics related with the lecture.

2102307 Signals and Systems 3(3-0-6)
Condition: Prerequisite 2102202, 2102214

Classification of signals and systems; linear time-invariant (LTI) systems; time domain and frequency domain models of the continuous linear time-invariant (LTI) systems; convolution integral and impulse response; Fourier series and Fourier transforms; Bode plot of signals and LTI systems; Laplace transforms; analysis of LTI systems using Laplace transforms; applications to circuit analysis, feedback control, and communications.

2102308 Properties of Electrical 3(3-0-6)
Engineering Materials
Structure of materials; electrical properties of materials; magnetic properties of materials; electrical conductors; introduction to semiconductor devices; superconductivity; solid, liquid and gas dielectrics; applications of materials in electrical power.

2102311 Electrical Measurements and 3(3-0-6)
Instrumentation
Condition: Prerequisite 2102213

Units and standard of electrical measurement; instrument classification and characteristics; measurement analysis; measurement of DC and AC current and voltage using analog and digital instruments; power, power factor and energy measurement; measurement of resistance, inductance, capacitance; frequency and period/time-interval measurement; noises; transducers; calibration.

2102322 Telecommunication Transmission 3(3-0-6)
Condition: Prerequisite 2102222

Wire and wireless communication; wire communication network; Z, Y, S, ABCD matrices; connection and basic circuits, network transformation, transmission quantities, signal transmission circuit techniques, wave filters, attenuator, impedance matching, transmission line theory, equation, solution for low, medium, high frequencies, primary and secondary constant; incident and reflected waves, standing wave ratio, line characteristics for open, short, terminated load, lossless and lossy lines; reflections in time domain, bounce diagrams, near-end and far-end crosstalk, differential signaling, composite line, types of cable and unshielded twisted pair, coaxial cable; current cable standards.

2102333 Linear Control Systems I and 4(3-3-6)
Laboratory

Condition: Prerequisite 2102202, Corequisite 2102214 for EE students Prerequisite 2310312, 2102391 for non-EE students

Open-loop and closed-loop control systems; mathematical models of physical systems; linearization; block diagrams; signal flow graphs; basic control actions and compensations; time-domain responses; Routh-Hurwitz stability test; control system design by the root locus method; Bode and Nyquist plots; Nyquist stability criterion; control system design by frequency response method. computer simulation and experiment of control system design.

2102356 Electrical Machines II 3(3-0-6)
Condition: Prerequisite 2102253

Magnetic energy and coenergy; forces and torques in electromagnetic systems; starting and speed control methods of dc motors; structure and connection of three-phase transformers; parallel connection of transformers; characteristics of salient-pole synchronous generators; parallel operation of synchronous generators; characteristics and starting methods of synchronous motors; speed control of induction motors; characteristic of single-phase induction motors.

2102360 Electrical Power Systems I 3(3-0-6)
Condition: Prerequisite 2102213

Introduction to power systems; sources of electric energy; power system structure; load characteristics; basic power system calculation; electric power plants; transmission line parameters; transmission line model and performance analysis; power transformer model and per-unit system; electrical power distribution system; power system equipment.

2102371 Principles of Communications and 3(3-1-5)
Laboratory
Condition: Prerequisite 2102203 or
Consent of Faculty

Communication models, wire/cable and wireless/radio; an overview of signals, linear systems and Fourier transform; analog modulation; random process and noise in communication systems; digital baseband transmission and power spectrum analysis; Nyquist's sampling theorem and quantization; pulse code modulation, delta modulation and time division multiplexing; introduction to digital modulation and information theory; introduction to communication systems (transmission lines, radio wave propagation, microwave components and communication, satellite communications, optical communication).

2102385 Semiconductor Devices I 3(3-0-6)
Crystal properties and growth of semiconductors; atoms and electrons; energy band and charge carriers in semiconductors; excess carriers in semiconductors; junctions; field-effect transistors; bipolar junction transistors; optoelectronic devices; power devices.

2102386   Electronic Circuits and Laboratory   4(3-3-6)
Condition : Prerequisite2102213
Semiconductor devices; current-voltage and frequency characteristics; analysis and design of diode circuits; analysis and design of BJT, MOS, CMOS and BiCMOS transistor circuits, operational amplifier and its applications, power supply module; experimental topics relate to semiconductor devices, transistor amplifiers, frequency response, operational amplifier and its applications.

2102387   Fundamentals to Digital Circuits   3(3-1-5)
Number systems and codes; Boolean algebra; minterms and maxterms; sum-of-products and product-of-sums; Karnaugh maps; two-level and multi-level gate circuits; medium-scale combinational circuits: multiplexer, encoder, and decoder; combinational circuit design; sequential circuits: latch, flip-flop; register, and counter; analysis of clocked sequential circuits: Moore and Mealy machines; circuits for arithmetic operations: adder, subtractor, and multiplier; MOS and CMOS logic; VHDL for digital system design; logic simulation and FPGA programming.

2102391   Electrical Engineering I   3(3-0-6)
*Condition : Prerequisite 2304104 or
2304108*
DC circuit analysis; ac single-phase and three-phase circuit analysis; Kirchhoff's laws; complex power; basic principles, efficiency and connections of transformers; characteristics, operation, speed control and applications of dc motors, single-phase and three-phase induction motors; introduction to low-voltage electrical system design and protection.

2102392   Electrical Engineering Laboratory I   1(0-3-0)
Condition : Corequisite 2102391
A laboratory work on electric circuits and machines: dc and ac circuits; three-phase circuits; transformers; dc generators; dc motors; induction motors.

**2102401   Random Processes for Electrical   3(3-0-6)
                Engineering**
Condition: Prerequisite 2102203
Basic concepts of probability theory; random variables; stochastic processes; mean, covariances, and correlations; stationary random processes; analysis of random signals; power spectral density; response of linear systems to random signals; amplitude modulation by random signals; optimum linear estimators.

2102420   Principles of Antennas   3(3-0-6)
Condition : Prerequisite 2102222
Basic definition and theory; isotropic point source; power and field patterns; directivity and gain; efficiency, polarization; input impedance and bandwidth; Friis transmission equation, radiation from current elements; ground effects; radiation properties of wire and loop antennas; array antenna; Yagi-Uda antenna and log-periodic antenna; aperture antenna; microstrip antenna;

modern antenna for current applications; antenna characteristics measurement.

**2102421   Principles of Microwave   3(3-0-6)
                Engineering**
Condition : Prerequisite 2102222
Review of Maxwell's equations, plane waves; microwave transmission lines and waveguides; microwave network analysis; impedance and equivalent voltage and current; the s-matrix; signal flow graphs, impedance matching and tuning, microwave resonators; power dividers and directional couplers; microwave filters; point-to-point microwave link; radar system; microwave propagation; basic of microwave measurement; microwave biological effects and safety.

2102422   Principles of Telecommunication   3(3-0-6)
*Condition: Prerequisite 2102371 or Consent
                of faculty*
Introduction to telecommunications; layered communication architectures; transmission medium: wired and wireless; data link layer protocols: flow control and error control; medium access control; circuit switching and packet switching; throughput and delay performance analysis of communication link; introduction to network topology, flows and graph theory; routing principles in circuit-switched and packet-switched networks; introduction to queuing theory and basic simulation techniques; Overviews of cellular mobile phone networks, optical networks, Internet and satellite systems.

2102423   Digital Signal Processing   3(3-0-6)
Continuous-time and discrete-time signals, spectral analysis; decimation and interpolation; sampling rate conversion; discrete-Fourier transform (DFT) and fast Fourier transform (FFT); probabilistic methods in DSP; design of FIR, IIR digital filters, multirate systems and filter banks; discrete wavelet transform; introduction to some DSP applications such as image processing, speech and audio processing, array processing.

2102425   Data Communications   3(3-0-6)
Introduction to data communications and networks; layered protocols and network architectures; basics of data transmission (characteristics of transmission media, modulation, multiplexing); data link protocols (error detection, error correction, data link control protocols); point-to-point protocols at network layer (routing, flow control, error recovery); delay models in data networks; multi-access communications (Aloha, CSMA, multi-access reservations); network security; cloud network, architecture and system.

**2102426   Traffic Engineering in   3(3-0-6)
                Communication Networks**
Traffic engineering overview; traffic characteristics; performance evaluation by computer simulation; introduction to traffic models in non-queuing/queuing systems; application of traffic engineering in communication networks.

2102427   Multimedia Compression   3(3-0-6)
Technology

Introduction to multimedia compression technology; statistical methods: Huffman coding, facsimile compression, arithmetic coding; dictionary methods; image compression methods; wavelet methods; video compression methods; audio compression methods.

2102428   Introduction to Image Processing   3(3-0-6)

Fundamentals of image processing; image enhancement and restoration; image segmentation; line and edge detection; morphology; image representations; chain code; boundary and area descriptors; pyramid and multiresolution image representations.

2102432   Linear Control Systems II   3(3-0-6)
Condition: Prerequisite 2102333

State-space representation of dynamic systems; mathematical modeling of complex engineering systems; autonomous linear dynamical systems; stability analysis; linear dynamical systems with inputs and outputs; controllability and state transfer; observability and state estimation; state feedback and linear quadratic regulator; observer design; observer-based controller; case study emphasizing computer-aided analysis and design.

2102433   Digital Control Systems   3(3-0-6)
Condition: Prerequisite 2102333

Introduction to digital control; linear discrete-time system analysis; sampled-data systems; discrete equivalents to continuous transfer functions; design of digital control systems using transform techniques; design of digital control systems using state-space methods: pole placement design, estimator design; quantization effects.

2102435   Industrial Automation   3(3-0-6)
Condition : Prerequisite 2102333, 2102386

Thermal sensors; mechanical sensors; optical sensors; signal conditioning; final control elements; programmable logic control (PLC); distributed control system (DCS); communication modules; human machine interface (HMI); alarm management systems; selected applications to factory automation and process automation.

2102436   Control and Instrumentation   1(0-3-0)
Laboratory

Experimental topics related to control systems and instrumentation.

2102444   Introduction to Embedded Systems   3(3-0-6)
Condition : Prerequisite 2102387 or Consent of faculty

Embedded system architecture; microprocessor/ microcontroller; memory; I/O and peripherals; embedded C programming; interrupt; DMA and embedded system networks.

2102446   Fundamentals of Power   3(3-0-9)
Electronics

Condition : Prerequisite 2102213

Basic principles of power electronics for electrical power processing and control; basic power converters: AC-to-DC converter, DC-to-DC converter, AC-to-AC converter, DC-to-AC converter and their operations; basic characteristics of semiconductor power devices: diodes, transistors and thyristors.

2102447   Electronic Engineering Laboratory 1(0-3-0)
Condition: Prerequisite 2102213

Experimental topics related to analog and digital electronic circuits

2102456   Electrical System Design   3(3-0-6)

Basic design concepts; codes and standards; power distribution schemes; electrical wires and cables; raceways; electrical equipment and apparatus; load calculation; power factor improvement and capacitor bank circuit design; lighting and appliances circuit design; motor circuit design; load, feeder, and main schedule; emergency power systems; short circuit calculation; grounding systems for electrical installation.

2102457   Fundamentals of Light and Lighting 3(3-0-6)
Condition: Consent of faculty

Light, eyes, vision; definition and terminology in light and lighting; light sources, luminaries and control gears; measurement of lights; principle of lighting calculation; lighting quality and energy efficiency; basic lighting design and simulation.

2102458   High Voltage Engineering I   3(3-0-6)
Condition: Consent of faculty

Uses of high voltage and overvoltage in power systems; generation of high voltage for testing; high voltage measurement techniques; electric field stress and insulation techniques, breakdown of gas; liquid and solid dielectric; high voltage testing techniques; lightning and protection; insulation coordination.

2102459   High Voltage Engineering   1(0-3-0)
Laboratory I
Condition : Prerequisite 2102458

A laboratory work on high voltage engineering: generation of dc and ac high voltages and impulse voltages; measurement of electric field dielectric losses; breakdown characteristics, partial discharges; electrical tests of insulators; RIV test of insulators; BIL test on transformers; sparkover test on lightning arresters; behavior of air gaps under dc, ac and impulse voltages; characteristics of impulse voltage dividers; protective devices; grounding resistance measurement.

2102461   Electrical Power Systems II   3(3-0-6)
Condition : Prerequisite 2102360

Power system modeling; network equations; load flow analysis; economic operation of power systems; symmetrical faults; symmetrical components;

unsymmetrical faults; protective devices and power system protection; power system stability.

2102463 Electrical Power System Protection 3(3-0-6)
Condition : Prerequisite 2102360

Introduction and philosophies of power system protection; instrument transformer; protective relays; non-directional and directional overcurrent and earth fault protection; differential protection; protection of transmission line, power transformers, generators, motors, buses, reactors and shunt capacitors.

2102464 Fundamentals of Electric Motor Drives 3(3-0-6)
Condition: Prerequisite 2102253

Electric drive components; load characteristics; operating region of drives; braking methods of motors; calculation of motor ratings for various loads; control circuits and control methods of dc motors; control circuits and control methods of ac motors; servo drive systems; applications of electric drives.

2102465 Electrical Power Laboratory 1(0-3-0)
Experimental topics related to power systems and electrical machines.

2102472 Fundamental of Digital Communication 3(3-0-6)
Condition: Prerequisite 2102371 or Consent of Faculty

Signals and Spectra; random signals and power spectral density; review of sampling theorem; probability and random processes; baseband and bandpass transmission; baseband digital modulation and pulse shaping; bandpass digital modulation; detection theory; coherent and non-coherent receiver; performance analysis: bit and symbol error rate; channel equalization; time synchronization; multipath fading channels; spread spectrum techniques; multichannel and multicarrier systems; introduction to information theory; source coding, channel coding.

2102473 Communication Engineering Laboratory 1(0-3-0)
Hands-on laboratory in three major areas related to communication engineering, namely, telecommunications, electromagnetic waves and digital signal processing.

2102474 Communication System Design 3(3-0-6)
Trends of telecommunication; wiring (twisted pair, coaxial, optical fiber and standard interfaces such as RS-232); switching, PABX and call center; architectures, characteristics and standards of local area network (LAN); metropolitan area network (MAN) and wide area network (WAN); intelligent buildings; Internet and intranet; cable and security management; design of intelligent buildings;

design of MAN and WAN; economic consideration; traffic and future planning for expansion; applications and case studies.

2102479 Optical Fiber Communication 3(3-0-6)
Overview of optical fiber communications; wave guiding in optical fibers, mode theory for dielectric circular waveguides; signal distortion in optical fibers due to loss and dispersion; optical sources, laser diodes; modulation techniques; photodetector, optical receiver operation; digital transmission systems, power budget analysis; dispersion management; optical fiber amplifiers; principle and components in WDM systems; introduction to FTTX.

2102488 Semiconductor Devices II 3(3-0-6)
Condition : Prerequisite 2102385

Review of physics and properties of semiconductors; compound semiconductors; metal-semiconductor junctions; heterojunctions; MESFET; heterojunction transistors (HEMT and HBT); microwave devices; introduction to quantum and nano-electronic devices.

2102489 Principles of Analog Circuit Design 3(3-0-6)
Transistor fabrication in integrated circuits; transistor modeling in integrated circuits; passive devices in integrated circuits; one- and two-transistor amplifiers; differential amplifiers; current sources and active loads; voltage and current references; output stages; operational amplifier analysis; frequency response; feedback, stability, and compensation; basic operational amplifier design; basic communication circuits; commercial analog circuits; applications of analog circuits.

2102490 Electrical Engineering Pre-Project 1(0-2-1)
Condition : Consent of Faculty

Problem framework; guidelines for problem solving and solution of an electrical engineering project.

2102499 Electrical Engineering Project 3(0-6-3)
Condition : Consent of Faculty

Practical and interesting projects or problems in various fields of electrical engineering: power, electronics, control systems and communications.

COURSE DESCRIPTIONS IN ELECTRICAL ENGINEERING (M.Eng., Ph.D.)

2102502 Random Signals and Systems 3(3-0-9)
Statistical independence and conditional probability; Hilbert space of 2nd –order random variables; conditional mean and covariance of multidimensional Gaussian distribution; Bayesian estimator; stationary discrete-time random signals; discrete-time linear systems with random signals input-output relation; rational spectral densities factorization; continuous-time stationary Gaussian processes and spectral factorization; ergodic processes; Hilbert space of square integrable functions on a time interval; karhunen-Loeve vs. Fourier series expansion of

random signals; discrete-time Kalman filtering problem formulation; innovation sequence and update formula; propagate formula; Kalman filter equations.

2102504 Introduction to Mathematical Analysis 3(3-0-9)

Mathematical proofs; basic set theory; the real number system; topology on the real line; sequence and convergence; limit and continuity of functions; vector spaces and linear operators; normed linear spaces; bounded operators; inner-product spaces; orthogonality and orthonormal bases; adjoint operators; applications to electrical engineering topics.

2102505 Introduction to Optimization Techniques 3(3-0-9)
Condition : Prerequisite 2102202 or
2102205 or Consent of Faculty

Review of linear algebra; solution of nonlinear equations; optimality conditions for unconstrained optimization; numerical methods for unconstrained optimization: steepest descent, Newton's, variable metric and conjugate gradient methods; optimality conditions for constrained optimization; numerical methods for constrained optimization: penalty and barrier function methods, sequential quadratic programming; solution of linear programs by the simplex method.

2102506 Finite Element Analysis for Electrical Engineers 3(3-0-9)
Condition : Prerequisite 2102201 , 2102202
or Consent of Faculty

Introduction of domain-dividing methods; fundamentals of discretization; elements and interpolating functions; mapped elements; weighted residual method; variational principle; electrostatic and electro-quasistatic problems; heat transfer; fluid flow problems; magnetic field problems; electromagnetic wave analysis; programming considerations; numerical quadratures; solutions of linear equation system; finite element analysis in practice; advanced topics.

2102507 Computational Techniques for Engineers 3(3-0-9)
Condition : Prerequisite 2102205 or Consent of Faculty

Mathematical preliminaries; computer arithmetics; solutions of nonlinear equations; solving system of linear equations; approximating functions; numerical differentiation and integration; numerical solutions of ordinary differential equations.

2102520 Optical Fiber Transmissions And Networks 3(3-0-9)
Condition : Consent of Faculty

Overview of optical fiber telecommunication; enabling technologies for optical fiber transmissions; standard for optical fiber transmission; signal propagation in optical fiber; design of optical fiber point- optical fiber telecommunication; enabling technologies for optical fiber transmissions; standard for optical fiber transmission; signal propagation in optical fiber; design of optical fiber point-to-point link; dispersion compensation methods and their optimum design rules; wavelength division multiplexed(WDM) transmission systems; Dense WDM (DWDM); long-haul EWDM transmission design; enabling technologies for optical fiber networks; standard for optical fiber networks; first generation optical networks; access networks; FTTx; SONET and SDH optical ring network; FTTx; SONET and SDH optical ring network; DWDM networks: ring, mesh, and broadcast-and-selective topologies; design of DWDM optical local-area-network (LAN), DWDM optical metropolitan-area network (MAN), and DWDM optical wide-area network (WAN); engineering DWDM network; fiber system installations; fiber system tests and measurements; recent trends in fiber-optic transmissions and networks.

2102521 Access Networks 3(3-0-9)
Condition : Consent of Faculty

Overview of access networks, access networks and core networks, xDSL: Variety of DSL versions; Standards of xDSL systems and components; Transmission of DSL signal in twisted pair and limitations; xDSL system design; business models in xDSL, HFC: standards of HFC and Docsis; HFC systems and components; transmission of video and data in HFC and limitations; HFC system design; business model in HFC, FTTx: variety of FTTx versions; standards of FTTx; FTTx systems and components; transmission of optical signals in FTTx system and limitations; FTTx system design; business models in FTTx, PLC: standards of PLC system; PLC systems and components; transmission of PLC signals in power system; PLC system design WiMAX : standards of WiMAX; WiMAX systems and components; of PLC signals in power system; PLC system, PLC system design, WiMAX: standards of WiMAX; WiMAX systems and components; transmission of WiMAX signals WiMAX system design; business models in WiMAX, WiFi: standards of WiFi; WiFi systems and components; transmission of WIFi signals; WiFi system design, other minor access networks: Bluetooth UWB; FSO; comparison of access networks nature of access networks; future trends.

2102523 Statistical Signal Processing in Biomedical Engineering 3(3-0-9)
Condition : Prerequisite 2102207 or
Consent of Faculty

Characterization of signals and linear time-invariant systems; conversion of continuous-time signals to discrete-time signals; modeling of stochastic signals from white noise; energy and power signals; the principles of autocorrelation for discrete-time signals; linear prediction and optimum linear filtering; Least-Squares methods for system modeling and filtering design; all topics focused on biomedical engineering perspective.

2102525 Internet and Network Security 3(3-0-9)
Condition : Consent of Faculty

Overview of internet TCP/IP protocol and multimedia traffics; medium access controls protocols; wireless LAN

networks; gigabit Ethernet; dynamic routing protocols (RIP and OSPF), LAN switching transport layer protocols: UDP and TCP, IP multicast, NAT, DHCP, DNS, SNMP; routing mechanism and congestion control algorithms; future broadband networks: WDM technology, advanced network architecture, network simulation, performance analysis, and measurement; network security; basic concept of cryptography: secret-key, public-key, digital signatures; authentication and identification schemes; intrusion detection: viruses; security of electronic mail and the World Wide Web; electronic commerce: payment protocols, electronic cash and firewalls.

2102531   System Identification   3(3-0-9)
Condition : Prerequisite (2102332 or 2102333)
and 2102203 or Consent of Faculty

Models for linear time-invariant systems; properties of estimators; consistency, unbiasedness, and efficiency of estimators; linear least-squares method and its variants; instrument variable estimation; maximum-likelihood estimation; maximum a posteriori estimation; minimum mean square error estimation; model structure selection and model validation; recursive identification; experiment design and choice of input signals; real-world applications of system identification.

2102536   Nonlinear Control Systems I   3(3-0-9)
Condition: Prerequisite 2102432 or
Consent of Faculty

Introduction to nonlinear control systems; state-space and phase-plane analyses; describing functions; Lyapunov stability; circle and Popov criteria; nonlinear control systems design.

2102540   Microcomputer Systems   3(3-0-9)
Condition : Prerequisite 2102444 or
Consent of Faculty

Microcomputer hardware: CPU, bus, memory, I/O units; interfacing techniques and programming; interfacing peripherals; software design techniques; real time systems and programming; microcomputer operating systems; high-level languages; microcomputer applications in control and instrumentation.

2102543   Advanced Electric Motor Drives   3(3-0-9)
Condition: Prerequisite 2102356 or
Consent of Faculty

Modeling and dynamic equations of dc motors; control principles of motor drives; semiconductor devices used in motor drive systems; various converter topologies for dc motor drives; modeling and dynamic equations of induction and synchronous motors; control principles of induction and synchronous motors; various inverter topologies for ac motor drives.

2102544   Advanced Embedded Systems   3(3-0-9)
Condition: Prerequisite 2102444 or Consent of
Faculty

Hardware and software platforms for embedded systems; devices and buses; embedded programming; real time operating system; hardware-software co-design in an embedded system; testing.

2102545   Digital Integrated Circuits   3(3-0-9)
Condition : Consent of Faculty

Internal circuits of different families of gates; NMOS, CMOS, ECL, and PECL; internal configuration of large-scale integrated circuits including ROM, RAM, PAL, PLA and FPGA; dynamic digital circuits such as domino and clocked circuits; input/output interface circuits; testing and verification of digital integrated circuits.

2102546   Analog Integrated Circuits   3(3-0-9)
Condition : Consent of Faculty

MOS transistor models; operational amplifier design; stability and frequency compensation of feedback amplifiers; bandgap references; switched-capacitor circuits; effect of nonlinearity and mismatch; oscillators and phase lock loops.

2102547   Cognitive Engineering   3(3-0-9)

Introduction to cognitive science from Descartes concepts to Informatics; Psychophysics: visual system, auditive system and somatosensory system; human cognitive function: sensory-motor system, perception, memory, learning, reasoning, decision making and problem solving, instrumentation and cognitive process: signal detection, image perception, speech recognition; applications of sensors and actuators in cognitive process; examples of computational modeling and brain process: artificial intelligence, neural network.

2102548   Switched-Mode Electrical Power   3(3-0-9)
Processing I
Condition : Consent of Faculty

Analysis of PWM converters and their derivatives; phase-controlled rectifier and PWM inverter operations and characteristics; PWM converters modeling using circuit averaging and averaged-switch modeling technique; dc and ac models of PWM converters; converters transfer functions; modeling of Pulse-Width Modulators; control of PWM converters; applications of phase-controlled rectifiers, PWM converter and inverters; analysis of resonant inverters using fundamental frequency approximation and their applications.

2102549   Semiconductor Fabrication   3(3-0-9)
Technology
Condition : Prerequisite 2102385 or
Consent of Faculty

Integrated circuit fabrication technologies: crystal growth, vapor phase epitaxy, liquid phase epitaxy, molecular beam epitaxy, thermal oxidation, thermal diffusion, ion implantation, chemical vapor deposition, metallization, lithography, annealing, assembly and packaging, future trends.

2102550   Power Electronics in Electrical   3(3-0-9)
Power Systems
Condition : Consent of Faculty

Basic structure of electrical power system networks; fundamentals of power flow in power systems; basic characteristics of transmission systems; compensation in transmission systems; interconnection of power systems through FACTS and HVDC; active and reactive power flow control; voltage and current compensation for power quality; power electronic circuits for conversion of renewable energy generation.

2102551   Computational Methods for Power   3(3-0-9)
System Analysis and Design
Condition: Prerequisite 2102461 or
Consent of Faculty

Power network representation and reconfiguration algorithms; problem formulation and solution methods for the studies fundamental to planning, design and operation of electric power systems including power flow, security assessments, optimal power flow and fault calculations; dynamic simulation for power system studies.

2102552   Introduction to Distributed   3(3-0-9)
Generation
Condition : Co-requisite 2102461 or
Consent of Faculty

Introduction to Distributed Generation (DG); technologies of DG; power generation systems: synchronous, induction, converter; DG impact on load flow and voltage profiles; DG impact on fault and protection; and DG impact on power quality.

2102553   Fundamental of Electromagnetic   3(3-0-9)
Compatibility
Condition: Consent of Faculty

EMI/EMC understanding and measurements; sources of EMI; definition and effect of EMI; EMMI measurements and methods; EMC/ EMI limitation and protection with suitable equipment and system grounding; ground system tests and maintenance; shielding theory, materials and performance; different types of filter selection and usage.

2102555   Fundamentals of Power Quality   3(3-0-9)
Condition : Consent of Faculty

Definitions and technical terms of power quality ; sources and effects of power quality disturbances; harmonics and interharmonics analysis voltage sag analysis; voltage fluctuations and flicker analysis; Power quality standards and mitigation techniques.

2102556   Power System Economics   3(3-0-9)
Condition : Prerequisite 2102461

Economic dispatch problems; economic dispatch considering transmission system losses; introduction to unit commitment planning; microeconomic theory; power pool structure; bilateral contract structure; power system analysis considering market structures.

2102558   Insulation Coordination   3(3-0-9)
Condition : Prerequisite 2102458

Switching overvoltage between phase and ground, between phase and phase and at substation; lightning overvoltage on transmission line and at substation; lightning protection for transmission line and substation; selection of lightning arrester; insulation coordination according to IEC60071.

2102571   Multimedia Communication   3(3-0-9)
Condition : Consent of Faculty

Introduction to multimedia communication; image coding standards; video coding standards; audio coding standards; speech coding standards; IP networks; wireless networks; multimedia communication protocols; multimedia communication applications.

2102574   Information Theory   3(3-0-9)
Condition : Consent of Faculty

Information theory; probability and entropy; the source coding theorem; symbol codes; stream codes; communication over a noisy channel; the noisy-channel coding theorem; error-correcting codes; constrained noiseless channels; marginalization; low-density parity-check codes; convolutional codes and turbo codes; other modern codes.

2102577   Telecommunication Network   3(3-0-9)
Condition : Consent of Faculty

Telecommunication network fundamentals; multiplexing and switching; OSI principle; various network equipment technologies; network interconnection; signaling in network and applications; various network interconnection types; network management activities; telecommunication network management; network evaluation; network performance.

2102578   Satellite Communications   3(3-0-9)
Condition : Consent of Faculty

Fundamentals of satellite communication; satellite orbits; satellites; satellite link design; modulation and multiplexing; multiple access; earth station; error control coding; polarization; interference; VSAT; various types of satellites and their operations such as geostationary, non-geostationary, low earth orbit, direct broadcast and global positioning systems.

2102581   Digital Circuit Design   3(3-0-9)
Condition : Prerequisite 2102383 or 2102387
or Consent of Faculty

Introduction to digital circuit design; synthesis of logic circuits; CAD tools and VHDL; standard chips, programmable logic devices and gate arrays; optimized implementation of logic functions; combinational circuit design; synchronous sequential circuit design; system controller; digital system design; microcontroller based design.

2102582   Photonic Devices in Optical   3(3-0-9)
Communication Systems

Condition : Consent of Faculty

Fundamentals of semiconductor physics; electronic and optical properties of semiconductors; optical processes in semiconductors; junction theory; propagation of light; waveguide theory; waveguide couplers, coupled-mode theory; operating principles, structures and properties of LEDs, laser diodes, photodetectors, optical modulators/switches, optical amplifiers and semiconductor optical amplifiers (SOAs); the fabrication technology of photonic devices.

2102583   Introduction to Quantum   3(3-0-9)
             Mechanics
Condition: Consent of Faculty

Schroedinger's equation; bound states; wave packets and uncertainty relations; scattering by simple barriers; expectation values and operators; angular momentum; hydrogen atom; expansion principle and matrix formulation; perturbation theory.

2102584   Introduction to Nanoelectronics   3(3-0-9)
Condition : Prerequisite 2102385 or
Consent of Faculty

Introduction to nanotechnology, nanoscale fabrication (e.g. photolithography, electron-beam lithography, self-assemble growth); nanoscale characterisations (e.g. SEM, TEM, AFM); 1D quantum structure (quantum wires); 0D quantum structure (quantum dots); single electron devices, carbon nanotubes; molecular electronics, DNA chips, quantum dot cellula automata; MEMS/NEMS; spintronics.

2102585   Biomaterial Science   3(3-0-9)
Condition : Consent of Faculty

Biological interactions with materials or any invasion: protein adsorption, blood coagulation, inflammation, immunology, hypersensitivity and infection; various types of biomaterials that have been used in biomedical applications: metals, synthetic polymers, hydrogel, ceramics, composites, and natural materials.

2102588   Biomedical Electronics   3(3-0-9)
Condition : Consent of Faculty

Electrical signals in human body; action potential in cells; electrodes; amplifiers; transducers; electronic monitoring systems: ECG, EEG, EMG; blood pressure and blood flow measurement; catheterisation; electrical hazards and prevention; medical instrumentation; computer in medicine.

2102589   Laser Engineering   3(3-0-9)
Condition : Prerequisite 2102385 or
Consent of Faculty

Fundamental theory: energy states in atoms, electron-population inversion, spontaneous emissions, stimulated emissions; principles of lasers; coherent light; gas lasers; solid-state lasers, semiconductor lasers; applications of lasers in medical science, precision measurement,

telecommunications, material processing, spectroscopy, display hologram and nonlinear optics.

2102598   Special Problems in Electrical   3(3-0-9)
             Engineering
Condition : Consent of Faculty

Special problems assigned by the instructor with consent of the head of the Department.

2102601   Power and Energy Technologies   3(3-0-9)
             In Smart Grids
Condition : Consent of Faculty

Introduction to smart grids; fundamentals principles of electrical power system operation and control; distributed generation; microgrid and active networks; introduction to wide area monitoring and wide area protection systems; renewable energy generation; energy storage; electric vehicle; grid connection codes; renewable energy policy and regulations.

2102602   Information and Communication   3(3-0-9)
             Technologies in Smart Grids
Condition : Consent of Faculty

Substation operation and related communication within substation; equipment in distribution system; communication between control centers; architecture and components of Automatic Meter Infrastructure/Automatic Meter Reading including phasor measurement unit, digital fault recorder and interoperability; energy efficiency within home, building and factory; communication channels in smart: wired, wireless, optical fiber; network layer, sensing/control and control protocol; database management and cyber security.

2102605   Fourier Transforms and its   3(3-0-9)
             Applications
Condition : Consent of Faculty

Fourier's theorem; Fourier transforms of functions; discrete Fourier transform; other related transforms; applications to electric networks, sampling, antennas, noise waveforms, Fourier optics and statistics.

2102611   Medical Instrumentation   3(3-0-9)
Condition : Consent of Faculty

Basic concepts of amplifiers, signal processing, electrodes, biopotential, sensors, medical devices, therapeutic devices, medical imaging, electrical safety; measurement of blood pressure, blood flow, and biopotential signals; designing and constructing simple medical instruments.

2102620   Electromagnetic Theory   3(3-0-9)
Condition : Prerequisite 2102322 or
Consent of Faculty

Maxwell's equations; theorem of electromagnetic energy and power; properties of materials in electromagnetic fields; boundary conditions; theorems of electromagnetic fields, duality principle, uniqueness, image theory, equivalence principle, induction theorem, reciprocity; potential functions; electromagnetic wave equations, plane wave functions, cylindrical wave functions,

spherical wave functions; mathematical tools for electromagnetic fields, separation of variables technique, transverse resonance method, perturbation and variational techniques, Green's functions, geometric algebra; solution methods for electrostatic, magnetostatic, and quasi-static fields problems; plane wave propagation problems, propagation in unbounded medium, multilayered medium, and anisotropic medium; wave guidance problems, field analysis in typical waveguides, modal expansion method; resonators and filters; radiation problems, radiation from current sources and apertures; scattering problems, scattering by cylinder, wedge, and sphere; optical waves, optical waveguides, optical wave propagation in photonic crystal.

2102623 Antennas and Radar Systems 3(3-0-9)
Condition : Consent of Faculty
Introduction and fundamental parameter of antennas; Transmitting and receiving antennas; Friis Transmission equation; Basic antenna types; Phased array antennas; Smart antennas and multiple-input/multiple-output (MIMO) systems; Introduction and basic principle of radar systems; Radar cross section; Radar equation; Continuous wave radar, Pulsed radar, Target tracking radar.

2102625 Computational Electromagnetics 3(3-0-9)
for Microwave and Photonics
Condition : Consent of Faculty
Basic concept of numerical modeling for electromagnetic problems; computational methods and programming techniques for solving linear electromagnetic wave problems in frequency domain for microwave and photonic applications such as finite-element method (FEM), boundary-element method (BEM), finite-volume method (FVM), and meshless method; computational methods and programming techniques for solving linear electromagnetic problems in time domain such as finite-difference time-domain (FDTD), finite- element time-domain (FETD), and finite-volume time-domain (FVTD).

2102627 Reliability and Survivability of 3(3-0-9)
Communication Networks and Systems
Condition : Consent of Faculty
Fundamental probability; network reliability; approaches to calculating network reliability; generic reliability and maintainability concepts; network survivability; fiber transport system components and signals; APS; dual homing; self healing rings; SONET analysis; DCS networks; survivable network design; IP and ATM network survivability.

2102628 Graph Theory and Combinatorial 3(3-0-9)
Optimization
Condition : Consent of Faculty
Introduction to graph theory; concept of paths, cycles and trees; various types of graphs; transshipment problem; shortest path problem; maximum flows problem; minimum cost flows problem; network optimization; matching; Matriods and greedy algorithms; applications.

2102629 Traffic Engineering and 3(3-0-9)
Queuing Theory
Condition : Consent of Faculty
Fundamentals of traffic engineering and queuing theory: quality of service and system performance analysis; revision on probability theory; computer simulation: discrete-time simulation, discrete-event simulation, confidence interval estimation; fundamental mathematical models: stochastic process, discrete-time Markov chain (DTMC), continuous-time Markov chain (CTMC), birth and death processes; theory of non-queuing/loss system; queuing theory; advances in traffic engineering and queuing theory.

2102631 Optimal Control Systems 3(3-0-9)
Condition : Prerequisite 2102505 or
Consent of Faculty
Discrete-time linear quadratic regulator; calculus of variations; continuous-time linear quadratic regulator; time-optimal control; constrained control input problem; the Pontryagin's maximum principle; singular control; dynamic programming; optimal controller design; computational methods in optimal controller synthesis.

2102635 Control System Theory 3(3-0-9)
Condition: Consent of Faculty
Review of linear algebra; least-squares methods and minimum norm methods; mathematical descriptions of dynamic systems; solutions of linear dynamic equations; stability, controllability, observability; internal stability of interconnected systems; state feedback; linear quadratic regulation; observers and observer-based compensation; introduction to nonlinear systems.

2102637 Multivariable Control Systems 3(3-0-9)
Condition : Consent of Faculty
Performance issues in multivariable systems; uncertainties and robustness; multivariable control system designs: frequency domain methods, LOG and LTR methods, parameter optimization methods; H_2 and H_∞ control; model reduction.

2102638 Nonlinear Control Systems II 3(3-0-9)
NONLIN CONT SYS II
Condition : Consent of Faculty
Input-output stability; small gain theorems; basic of differential geometry; feedback linearization; geometric nonlinear control theory; nonlinear control system design.

2102642 Computer Vision and Video 3(3-0-9)
Electronics
Condition : Consent of Faculty
Human vision; geometric camera models; image segmentation; object recognition; video signals and standards; video input and output circuits; computer vision and digital video applications.

2102645 Embedded System Design 3(3-0-9)
Condition : Consent of Faculty
Practical examples; performance evaluation; complex system designs: automotive, multimedia, biomedical instrumentation, measurement instrumentation, and robot.

2102650 Electrical Transient in Power 3(3-0-9) Systems
Condition : Prerequisite 2102458 or Consent of Faculty
Introduction to electrical transient; switching transient: simple and abnormal switch transients, transients in three phase circuits; transient in conversion equipment; electromagnetic phenomena under transient conditions; lighting effects on power systems; traveling wave on transmission line; effects of transient voltage on transformer windings; protection of systems and equipment against transient overvoltage and insulation co-ordination; computer aids to the calculation of electrical transients.

2102651 Power System Stability 3(3-0-9)
Condition : Prerequisite 2102461 or Consent of Faculty
Basics and descriptions of power system stability problems; mathematical reviews of state-space analysis and numerical integration; reference frame theory; synchronous machine representation in stability studies; power network representations and characteristics; excitation system components and functions; active power and frequency control; transient stability; small-signal stability; methods of improving transient and small-signal stability.

2102656 Power System Protection 3(3-0-9)
Condition : Consent of Faculty
Principles of power system protection; relays and their operating principles and characteristics; and protection of generators, motors, transformers, buses and lines.

2102663 Solar Cell Technology 3(3-0-9)
Condition : Consent of Faculty
Band theory of semiconductors; optical properties of semiconductor; structure of solar cells; characteristics of solar cells; equivalent circuit of solar cells; p-n junction silicon solar cells; polycrystalline silicon solar cells; amorphous silicon solar cells; gallium arsenide solar cells; $CuInSe_2$/CdS solar cells; photovoltaic system design; concentrated sunlight system; photovoltaic system applications.

2102668 Biosensors 3(3-0-9)
Condition : Consent of Faculty
Necessary concepts relevant to the principle of measuring chemical and biological phenomena with emphasis on integrating these concepts of develop to apply and to construct novel instruments for observing, examining, and controlling various phenomena in the field of biotechnology, medical science, chemical engineering for both fundamental research and process development in industrial production.

2102674 Optical Communication 3(3-0-9)
Condition : Prerequisite 2102605 or Consent of Faculty
An outline of optical communication systems; properties of laser light; characteristics of optical communication; fundamentals of optical fiber; light sources; modulation and demodulation; optical devices; optical communication and applications.

2102675 Pattern Recognition 3(3-0-9)
Condition : Prerequisite 2102383 or 2102387 or Consent of Faculty
Statistical pattern recognition: linear discriminant functions, Bayesian decision theory, maximum-likelihood and Bayesian parameter estimation.

2102676 Digital Image Processing 3(3-0-9)
Image perception; image digitization; image enhancement; image restoration; image segmentation; image compression; morphological image processing; image representation and description.

2102677 Broadband Network And Design 3(3-0-9)
Condition : Consent of Faculty
Demand for ATM broadband network; ATM fundamentals; ATM broadband network operation, administration and maintenance (OAM) fundamentals; ATM network management; quality of service (QoS) and ATM performance; policing in ATM networks; 3G/4G wireless network architectures; next-generation wireless networks; wireless access technologies; demand for broadband network services; network design approaches; introductory graph theory and topological design; campus/LAN/WAN design; leased-line network consideration; requirements definition and service provider selection; network planning and management; network design project management.

2102680 Semiconductor Lasers 3(3-0-9)
Condition : Prerequisite 2102222 and 2102385 or Consent of Faculty
A review of semiconductor physics; optical process in semiconductor; junction theory; waveguide theory; coupler-mode theory; fundamental of semiconductor lasers ; semiconductor laser structure and its characteristics; quantum well lasers; dynamic single-mode lasers; vertical cavity surface emitting lasers; array lasers; quantum wire and quantum dot lasers; quantum cascade lasers; semiconductor laser modeling; the fabrication technology of semiconductor lasers.

2102682 Solid-State Physics for 3(3-0-9) Electronics Engineers
Condition : Consent of Faculty
Crystal structures and lattices; dynamics of crystal lattices; lattice vibration and thermal properties of crystals; crystalline defects; elementary quantum mechanics; modern theory of solids; quantum theory of metals; quantum theory of electrons in periodic lattices; semiconductors and their electrical and optical properties; dielectric materials and insulation;

magnetism and magnetic resonances; superconductivity; optical properties of materials.

2102684 Guided-Wave Optics and Nanophotonics 3(3-0-9)
Condition : Consent of Faculty

Optical waveguides : planar, two-dimensional and three-dimensional waveguides; interaction between optical waveguides; optical waveguide devices; photonic crystals and photonic band gaps; photonic-crystal fibers and supercontinuum light generation; structures and optical properties of quantum nanostructures: quantum wells, quantum wires, quantum dots, and interaction between these structures; their applications in nanoelectronic and nanophotonic devices; coupled quantum nanostructures.

2102686 Switched-Mode Electrical Power Processing II 3(3-0-9)
Condition : Consent of Faculty

Modeling of PWM converters using state-space averaging technique; state-space averaging of non-ideal converters; Analysis of PWM converters operating in discontinuous conduction mode; modeling of DCM PWM converters; current-mode control of PWM converters; current-programmed control; current-programmed converter model and transfer functions; current-programmed controller model; switched-mode rectifiers; switching loss reduction technique; snubbers for PWM switches; ZVS ZCS single resonant switches; analysis of basic converters using single resonant switches; analysis of resonant inverters and resonant converters;

2102697 Special Problems in Electrical Engineering II 3(3-0-9)
Condition : Consent of Faculty

Special problems in various fields of electrical engineering.

2102731 Infinite-Dimensional Control System 3(3-0-9)

Semigroup theory and evolution equations; stability theory; controllability, observability and realizability; linear quadratic optimal control; frequency-domain approach; controller design for infinite-dimensional systems.

2102732 Convex Optimization and Engineering Applications 3(3-0-9)
Condition : Prerequisite 2102505 or Consent of Faculty

Convex sets, functions, and optimization problems; basics of convex analysis; least-squares, linear and quadratic programs, semidefinite programming, minimax, extremal volume, and other problems; localization methods: cutting-plane, ellipsoid algorithms; optimality conditions, duality theory, theorems of alternative, and applications; interior-point methods; applications to control systems and other engineering topics.

2102754 Electric Field Analysis in High Voltage Engineering 3(3-0-9)

Basics of electric field analysis : practical problems in the field analysis of high-voltage systems : Introduction to numerical methods in field analysis; charge simulation method: surface charge method; boundary element method; examples of field analysis; comparison of methods: advanced topics.

2102755 Power System Electromagnetic Transient Simulation 3(3-0-9)

Analysis of power system transient phenomena: lightning surges, switching surges, temporary overvoltage; modeling technique of lines and cables, transformers, rotating machines, arresters, protective systems.

2102757 Power System Reliability 3(3-0-9)
Condition : Prerequisite 2102651, 2102652 or Consent of Faculty

Reliability evaluation and reliability indices; comparison between deterministic and probabilistic criterias; operating state modeling of power system equipment; generation system modeling; generation system reliability evaluation; generation system expansion planning; interconnection system reliability evaluation; operating reserve; composite system reliability evaluation; distribution system reliability evaluation.

2102770 Wireless Communications and Networking 3(3-0-9)

Overview of future broadband wireless systems for voice video data and multimedia services; wireless channel characterization and statistical models, narrowband and wideband; capacity of wireless channels; advanced digital modulation: spread spectrum, mutlicarrier modulation, CDMA, OFDM, multiuser systems, multiple input/output systems (MIMO), adaptive modulation; future wireless networks: sensor networks, automated motorways, Ad-Hoc networks design and applications.

2102774 Telecommunications Switching, Transmission and Signaling 3(3-0-9)

Telecommunications traffic; congestion; mathematical model of telecommunications traffic; lost-call systems; queuing systems; switching networks; single-stage networks; gradings; link systems; grades of service of link systems; non-blocking networks; space and time switching; time-division switching networks; grades of service of time-division switching networks; non-blocking time-division switching networks; synchronization; telecommunications transmission systems; transmission of the 64-kbps signal; PCM primary rate transmission; higher order PCM transmission; optical fiber transmission system; SDH transmission system; subscriber networks; signaling; signalling networks; signalling system No. 7 levels.

2102785 Advanced Sensor Theory 3(3-0-9)
Condition : Consent of Faculty

Principle and theory of physical and chemical sensors; thermodynamics and sensor operation; sensor fabrication technology; micro-machining; sensor fusion; intelligent sensors; data processing and analytical methods.

2102790 Electrical Engineering Seminar 2(2-0-6)
Condition : Consent of Faculty
Seminar in current research topics in electrical engineering including technical writing and presentation techniques of research works and thesis. Literature reviews of international journal papers relevant to the research topic. Submit a summary report in the forms of technical paper and thesis proposal which describes the motivation, problem formulation, main results and, examples.

2102791 Electrical Engineering Seminar I 2(2-0-6)
Preliminary lectures by instructors; seminar on current and new topics in electrical engineering, in which each student is required to present an oral and written report.

2102792 Electrical Engineering Seminar II 2(2-0-6)
Preliminary lectures by instructors; seminar on current and new topics in electrical engineering, in which each student is required to present an oral and written report.

2102793 Electrical Engineering Seminar III 2(2-0-6)
Preliminary lectures by instructors; seminar on current and new topics in electrical engineering, in which each student is required to present an oral and written report.

2102794 Electrical Engineering Seminar IV 2(2-0-6)
Preliminary lectures by instructors; seminar on current and new topics in electrical engineering, in which each student is required to present an oral and written report.

**2102796 Advanced Topics in Electrical 3(3-0-9)
Engineering I**
Interesting topics or new developments in the field of electrical engineering.

**2102797 Advanced Topics in Electrical 3(3-0-9)
Engineering II**
Interesting topics or new developments in the field of electrical engineering.

2102874 Speech Processing 3(3-0-9)
Condition : Consent of Faculty
Sampling; scalar quantization; vector quantization; speech modeling; speech perception; psychoacoustic; waveform coding; vocoders; hybrid coding; feature extraction; phonemes; statistical model training (HMM); speaker verification; text-to-speech (TTS); noise reduction techniques.

2102875 Digital Video Processing 3(3-0-9)
Condition : Consent of Faculty

Analog and digital video; video sampling and rate conversion; video modeling; two-dimensional motion estimation; foundation of video coding: binary coding, quantization, transform coding; image and video compression standards; error control in video communications.

2102876 Adaptive Signal Processing 3(3-0-9)
Condition : Consent of Faculty
Adaptive filtering and linear time-invariant filters together with their applications; linear optimum filtering including the principle of orthogonality and minimum mean-squared error performance criterion; least-mean-square (LMS) algorithm, and the method of least-squares and recursive least-squares.

2102813 Thesis 18 credits

2102816 Thesis 36 credits

2102828 Dissertation 48 credits

2102829 Dissertation 60 credits

2102830 Dissertation 72 credits

2102894 Doctoral Dissertation Seminar 0(0-0-0)

2102897 Qualifying Examination 0(0-0-0)

DEPARTMENT OF MECHANICAL ENGINEERING

Mechanical Engineering is a very broad field of science, engineering, and technology. It encompasses virtually all aspects of everyday life. To get some perspective, it can be broadly identified according to the foundation, role, and purpose of mechanical engineering as:

The science, engineering, and technology that are foundation to research and development, design and manufacturing, and installation and maintenance, of devices, machines or systems that transform, transmit, or utilize energy for the benefit of humankind. These devices, machines, or systems generally involve the transform of energy into motion and motion into energy;

People who study and practice mechanical engineering can therefore

- function in many different roles such as researchers, inventors, designers, practicing engineers, etc.;
- work in many different areas such as power generation, distribution and utilization; engine, vehicle and transportation; material, design and manufacturing; dynamics, control and robotics; machinery and maintenance; refrigeration, air conditioning and building technology; energy resource, management, utilization and conservation; environment technology; MEMS and nanotechnology, etc.;
- work in many different places, both public and private sectors, such as in industry, factory, hospital, large building and structure, consulting company, governmental office, university, etc.

MISSION

The mission of the Department of Mechanical Engineering is to provide firm-foundationed and creative-minded mechanical engineers for the advancement of mechanical engineering and for the development of the country.

Its integrated educational programs emphasize

- fundamental knowledge of advanced mathematics, sciences, engineering, and mechanical engineering;
- general knowledge in social sciences and humanity;
- mathematical, scientific, and engineering methodologies;
- design and conduct of experiments, analysis of data, and meaningful physical interpretation of data;
- identification, formulation, and solving engineering problems;
  o conceptualization of objectives and constraints,
  o identification of governing physical principles,
  o application of fundamental analytical tools as well as modern engineering tools, with sound appreciation of its capabilities and limitations and with sound understanding of the underlying physics and physical insights.
- open-ended problems, design projects, and research;
- effective written and verbal communication skills;

- independent study experiences as well as teamwork efforts;
- appreciation of engagement in life-long learning; and
- appreciation of the roles and responsibilities of mechanical engineers in society.

DEGREES OFFERED

The Department of Mechanical Engineering offers two degreed programs (Bachelor of Engineering, B.Eng.) in Mechanical Engineering and Automotive Engineering, at the undergraduate level. At the graduate level, the department offers a Master of Engineering (M.Eng.) and a Doctor of Philosophy (Ph.D.), in Mechanical Engineering. Details for each program are given in the following sections.

HEAD:

| Pairod | Singhatanadgid | Ph.D. (Washington) |

PROFESSORS :

Pramote	Dechaumphai	Ph.D. (Old Dominion)
Somsak	Chaiyapinunt	Ph.D. (Oregon State)
Viboon	Sangveraphunsiri	Ph.D. (Georgia Tech.)

ASSOCIATE PROFESSORS :

Asi	Bunyajitradulya	Ph.D. (UC, Irvine)
Angkee	Sripakagorn	Ph.D. (Washington)
Boonchai	Lertnuwat	D.Eng. (Tokyo)
Chittin	Tangthiang	Ph.D. (Penn State)
Kanit	Wattanavichien	Ph.D. (University of Melbourne)
Kuntinee	Maneeratana	Ph.D. (London)
Pairod	Singhatanadgid	Ph.D. (Washington)
Phongsaen	Pitakwatchara	Ph.D. (Tokyo)
Ratchatin	Chanchareon	D.Eng. (Chula)
Thitima	Jintanawan	Ph.D. (Washington)
Thanyarat	Singhanart	Ph.D. (Tokyo)
Nopdanai	Ajavakom	D. Eng (California)

ASSISTANT PROFESSORS :

Alongkorn	Pimpin	D.Eng. (Tokyo)
Chanat	Ratanasumawong	D.Eng. (Tokyo Tech.)
Chanyaphan	Virulsri	D.Eng. (Tokyo)
Jirapong	Kasivitamnuay	D.Eng. (Tokyo)
Niphon	Wansophark	D.Eng. (Chula)
Nuksit	Noomwong	Ph.D. (TUAT)
Pairat	Tangpornprasert	D.Eng. (Tokyo)
Sompong	Putivisutisak	Ph.D. (London)
Sunhapos	Chatranuwathana	Ph.D. (Michigan)
Witaya	Wannasuphoprasit	Ph.D. (Northwestern)

| Werayut | Srituravanich | Ph.D. (UCLA) |
| Gridsada | Phahomcheng | Ph.D. (Minnesota) |

LECTURERS :

Chirdpun	Vitooraporn	Ph.D. (M.I.T.)
Tawan	Paphapote	M.S. (Illinois)
Saran	Salakit	Ph.D. (Oregon)
Surat	Kwanmuang	Ph.D. (Michigon)

MECHANICAL ENGINEERING UNDERGRADUATE PROGRAMS

The general aim of the Department of Mechanical Engineering is to give the student an understanding of theoretical principles and also, through experiment and design work, to provide him/her with confidence in solving practical problems. In accordance with the credit system of study, the Department provides an undergraduate curriculum for two programs: Mechanical Engineering, and Automotive Engineering. Students who plan to further their study for higher degrees, as well as those who wish to specialize in any of the fields offered, are strongly urged to consult their advisors in order to select and prepare the required elective programs.

NAME OF THE DEGREE

: Bachelor of Engineering
: B.Eng.

COURSE REQUIREMENTS

Mechanical Engineering Program

Total credits for graduation	147	credits

1.	General Education	30	credits
2.	Basic Science	27	credits
Basic Engineering			
	Science	26	credits
4.	Program Core Courses	46	credits
5.	Elective Courses	12	credits
6.	Free Electives	6	credits

Automotive Engineering Program

Total credits for graduation	147	credits

1.	General Education	30	credits
2.	Basic Science	27	credits

Basic Engineering

	Science	26	credits
4.	Program Core Courses	52	credits
5.	Elective Courses	6	credits
6.	Free Electives	6	credits

STUDY PROGRAM: MECHANICAL ENGINEERING
FIRST YEAR CURRICULUM
COMMON TO ALL ENGINEERING STUDENTS

COURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS
	THIRD SEMESTER			**SIXTH SEMESTER**	
2103211	STATICS	3	2102391	ELEC ENG I	3
2103241	THERMODYNAMICS I	3	2102392	ELEC ENG LAB I	1
2301215	MULTIVARIABLE CALCULUS	3	2103320	DES MECH ELEM	3
2301216	LINEAR ALGEBRA AND		2103361	EN THERM DESIGN I	3
	DIFFERENTIAL EQUATIONS	3	2103433	INTRO MECH VIBRAT	3
2603284	STAT PHYS SCIENCE	3	2103460	ME EXP LAB III	2
xxxxxxx	GENERAL EDUCATION	3	5500208	COM PRES SKIL	3
		18			**18**
	FOURTH SEMESTER			**SUMMER SEMESTER**	
2103212	DYNAMICS	3	2100301	ENG PRACTICE	2
2103231	MECH OF MAT I	3			
2103260	ME EXP LAB I	2		**SEVENTH SEMESTER**	
2103305	MFR PROC ME	3	2103325	ME DES PROJ	2
2103351	FLUID MECHANICS I	3	2103409	INTRO MECHATRONICS	3
xxxxxxx	GENERAL EDUCATION	6	2103489	MECH ENG PRE-PROJECT	1
		20	XXXXXXX	ELECTIVE COURSES	6
			XXXXXXX	GENERAL EDUCATION	3
	FIFTH SEMESTER		XXXXXXX	FREE ELECTIVES	3
2100311	ENG ESSENTIALS	3			**18**
2103301	DES MTHD ME	3			
2103304	AUTO CONTROL I	3		**EIGHTH SEMESTER**	
2103306	COM-AIDED ME DES	3	2103499	MECH ENG PROJECT	3
2103322	MECH MACHINERY	3	OR 2100499	ENG PROJECT	
2103360	ME EXP LAB II	2	5500308	TECH WRIT ENG	3
2103463	HEAT TRANSFER	3	XXXXXXX	ELECTIVES COURSES	6
		20	XXXXXXX	FREE ELECTIVES	3
					15

TOTAL CREDITS FOR GRADUATION = 147

STUDY PROGRAM : AUTOMOTIVE ENGINEERING
FIRST YEAR CURRICULUM
COMMON TO ALL ENGINEERING STUDENTS

COURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS
	THIRD SEMESTER			**SIXTH SEMESTER**	
2103211	STATICS	3	2102391	ELEC ENG I	3
2103241	THERMODYNAMICS I	3	2102392	ELEC ENG LAB I	1
2301215	MULTIVARIABLE CALCULUS	3	2103320	DES MECH ELEM	3
2301216	LINEAR ALGEBRA AND		2103482	MECH VEHICLES II	3
	DIFFERENTIAL EQUATIONS	3	2103393	ME LAB NON ME	1
2603284	STAT PHYS SCIENCE	3	2103433	INTRO MECH VIBRAT	3
XXXXXXX	GENERAL EDUCATION	3	2103471	INTER COMB ENGIN	3
		18	5500208	COM PRES SKIL	3
					20
	FOURTH SEMESTER				
2103212	DYNAMICS	3		**SUMMER SEMESTER**	
2103231	MECH OF MAT I	3	2100301	ENG PRACTICE	2
2104257	MFR PROC	3			
2104258	MFR PROC LAB	1			
2103351	FLUID MECHANICS I	3		**SEVENTH SEMESTER**	
2103481	AUTOMOTIVE ENG	4	2103483	AUTOMOTIVE SYS DES	3
		17	2103461	AE ENG LAB	2
			2103555	ENGINE EMIS & CONT	3
	FIFTH SEMESTER		2103489	MECH ENG PRE-	1
2100311	ENG ESSENTIALS	3		PROJECT	
2103382	MECH VEHICLES I	3	XXXXXXX	ELECTIVES COURSES	3
2103408	AUTOMOTIVE CONTROL	3	XXXXXXX	GENERAL EDUCATION	3
2103335	VEH STRUC ANAL I	3	XXXXXXX	FREE ELECTIVES	3
2103322	MECH MACHINERY	3			**18**
2103463	HEAT TRANSFER	3			
XXXXXXX	GENERAL EDUCATION	3		**EIGHTH SEMESTER**	
		21	2103499	MECH ENG PROJECT	3
			5500308	TECH WRIT ENG	3
			XXXXXXX	ELECTIVES COURSES	3
			XXXXXXX	GENERAL EDUCATION	3
			XXXXXXX	FREE ELECTIVES	3
					15

TOTAL CREDITS FOR GRADUATION = 147

APPROVED ELECTIVES FOR UNDERGRADUATE PROGRAMS FOR 2017

Mechanical Engineering				Automotive Engineering
2102505	2103302	2103404	2103510	2103302
2102532	2103382	2103405	2103530	2103303
2102537		2103406	2103532	2103314
2103204		2103407	2103533	2103362
2104303		2103421	2103535	2103382
		2103432	2103540	2103421
		2103433	2103541	2103433
		2103443	2103552	2103465
		2103454	2103555	2103467
		2103462	2103560	2103472
		2103465	2103567	2103479
		2103467	2103570	2103483
		2103471	2103571	2103495
		2103472		2103496
		2103475		2103510
		2103477		2103532
		2103478		2103540
		2103479		2103541
		2103481		2103555
		2103485		2103556
		2103491		2103558
		2103495		2109418
		2103496		

Remark : Approved electives are subjected to change and will be announced by the department.

MECHANICAL ENGINEERING GRADUATE PROGRAMS

The mechanical engineering department offers a graduate program leading to the degrees of Master of Engineering and Doctor of Philosophy in Mechanical Engineering. The program is housed in the Mechanical Engineering Department which offers three different majors: Solid Mechanics, Heat transfer/ Thermodynamics/ Fluids, and Control/ Dynamics/ Manufacturing. Approximately one hundred and thirty graduate students are full-time students in the department. Students who have demonstrated record of high academic achievement normally receive a kind of financial support which may be in a form of educational grant from different supporting organizations, or as teaching or research assistants, as well as the eligibility for waiving the tuition fee.

Presently, there are approximately 30 faculty members who are associated with the graduate program in the mechanical engineering department. The department is involved in research activities in a number of different fields. Several faculty members are associate technical editors for journals. A large number of technical papers resulted from faculty research and student theses have been published annually.

MASTER DEGREE PROGRAM

NAME OF THE DEGREE

: Master of Engineering
: M.Eng.

ADMISSION

The applicant must hold a Bachelor's Degree in Mechanical Engineering or related fields and meet the Graduate School requirements.

DEGREE REQUIREMENTS

There are two programs in the degree of Master of Engineering in Mechanical Engineering.

Program A1

This program is for students who have demonstrated high academic achievement and are approved from the graduate program committee. Students do not need to study course work. 36 credits for thesis are required in the program A1.

Program A2

Each of the following area of study consists of 18 credits for course work, one credit for engineering seminar, and 18 credits for thesis. One of the three programs below must be chosen:
Solid Mechanics area of study
Heat Transfer/ Thermodynamics/ Fluids area of study
Control/ Dynamics/ Manufacturing area of study
A small successful candidate must obtain an overall grade point average of at least 3.00.

For both programs, a period of study is not more than 8 regular semesters. The student must also demonstrate his or her power of the original thought and ability to organize his or her finding by presenting an acceptable thesis accompanied by an oral examination. Students are also required to pass the thesis proposal within 4 regular semesters otherwise they will be dismissed from the Department according to the Graduate School Regulation.

COURSE REQUIREMENTS
(For Program A2)

COURSE REQUIREMENTS
1) Required Courses for all area of study

2103790	Seminar in Mechanical Engineering	1(0-3-1)

2) Additional Required Courses for each area of study

2.1) Solid Mechanics:

2103601	Advanced Engineering Mathematics	3(3-0-9)

3 credits are to be chosen from the

2103612	Elasticity	3(3-0-9)
2103614	Continuum Mechanics	3(3-0-9)

2.2) Heat Transfer/Thermodynamics/Fluid:

2103601	Advanced Engineering Mathematics	3(3-0-9)

6 credits are to be chosen from the

2103602	Measurement and Instrumentation	3(2-3-7)
2103650	Advanced Engineering Thermodynamics	3(3-0-9)
2103651	Advanced Fluid Mechanics	3(3-0-9)
2103652	Combustion Theory	3(3-0-9)
2103655	Convection Heat Transfer	3(3-0-9)

2.3) Control/Dynamics/Manufacturing:

2103603	Mathematic for Control Engineers	3(3-0-9)
2103631	Control of Dynamic Systems	3(3-0-9)

3) Approved Elective Courses for each area of study

3.1) Solid Mechanics:
9 credits are to be chosen from the

2103510	Mechanics of Composite Materials	3(3-0-9)
2103511	Introduction to Continuum Mechanics	3(3-0-9)
2103540	Failure Analysis and Non-destructive Testing	3(2-3-4)
2103541	Vibration Monitoring and Analysis	3(2-3-4)
2103570	Micro Fabrication Technology	3(3-0-9)
2103571	Micro and Nano Electromechanical Systems (MEMS-NEMS)	3(3-0-9)
2103602	Measurement and Instrumentation	3(2-3-7)
2103612	Elasticity	3(2-3-4)

2103613	Plasticity	3(3-0-9)
2103614	Continuum Mechanics	3(3-0-9)
2103615	Mechanical Vibrations	3(3-0-9)
2103616	Optimum Design of Complex Mechanical Elements	3(3-0-9)
2103620	Theory of Elastic Stability I	3(3-0-9)
2103621	Energy Principles in Solid Mechanics	3(3-0-9)
2103622	Analysis of Composite Structure	3(3-0-9)
2103623	Fatigue of Metals	3(3-0-9)
2103625	Advanced Finite Element Method	3(3-0-9)
2103626	Thermal Stress Analysis	3(3-0-9)
2103701	Selected Topics in Mechanical Engineering	3(3-0-9)
2103721	Fracture Mechanics	3(3-0-9)

3.2) Heat Transfer/Thermodynamics/Fluid:
9 credits are to be chosen from the

2103552	An Introduction to Computational Fluid Mechanics	3(3-0-9)
2103555	Engine Emissions and Control	3(3-0-9)
2103556	Fundamental of Engine Fuel Control Systems	3(3-0-9)
2103558	Intake Manifold and Induction System Design	3(3-0-9)
2103560	Gas Turbine Performance	3(3-0-9)
2103566	Compressible Fluid Dynamics	3(3-0-9)
2103567	Turbulent Shear Flows	3(3-0-9)
2103602	Measurement and Instrumentation	3(2-3-7)
2103604	Advanced Numerical Methods	3(3-0-9)
2103605	Advanced Finite Element Method	3(3-0-9)
2103650	Advanced Engineering Thermodynamics	3(3-0-9)
2103651	Advanced Fluid Mechanics	3(3-0-9)
2103652	Combustion Theory	3(3-0-9)
2103653	Fluid Dynamics Aspects of Wind Turbines	3(3-0-9)
2103654	Conduction Heat Transfer	3(3-0-9)
2103655	Convection Heat Transfer	3(3-0-9)
2103656	Radiation Heat Transfer	3(3-0-9)
2103658	Advanced Internal Combustion Engine	3(3-0-9)
2103659	Utilization of Alternative Fuels	3(3-0-9)
2103663	Advanced Refrigeration and Air Conditioning	3(3-0-9)
2103664	Design of Thermal Systems	3(3-0-9)
2103665	Advanced Computational Fluid Dynamics	3(3-0-9)
2103666	Finite Element Method for Computational Fluid Dynamics	3(3-0-9)

3.3) Control/Dynamics/Manufacturing:
9 credits are to be chosen from the

2103510	Mechanics of Composite Materials	3(3-0-9)
2103530	Industrial Robots I	3(3-0-9)
2103532	Computer-Aided Design and Computer-Aided Manufacturing	3(2-3-7)
2103535	Mechatronics	3(3-0-9)
2103602	Measurement and Instrumentation	3(2-3-7)
2103604	Advanced Numerical Methods	3(3-0-9)
2103615	Mechanical Vibrations	3(3-0-9)

2103616	Optimum Design of Complex Mechanical Elements	3(3-0-9)
2103617	Advanced Dynamics	3(3-0-9)
2103625	Advanced Finite Element Method	3(3-0-9)
2103630	Industrial Robots II	3(3-0-9)
2103632	Applied Nonlinear Control	3(3-0-9)
2103633	Applied Optimal Control	3(3-0-9)
2103634	Dynamics System Modeling and Simulation	3(3-0-9)

4) Elective Courses

4.1) Solid Mechanics: **3 credits**
4.2) Heat Transfer/Thermodynamics/Fluid: **none**
4.3) Control/Dynamics/Manufacturing : **3 credits**
Elective courses are to be chosen from the following list:

2103510	Mechanics of Composite Materials	3(3-0-9)
2103511	Introduction to Continuum Mechanics	3(3-0-9)
2103530	Industrial Robots I	3(3-0-9)
2103532	Computer-Aided Design and Computer-Aided Manufacturing	3(2-3-7)
2103535	Mechatronics	3(3-0-9)
2103540	Failure Analysis and Non-destructive Testing	3(2-3-4)
2103541	Vibration Monitoring and Analysis	3(2-3-4)
2103552	An Introduction to Computational Fluid Mechanics	3(3-0-9)
2103555	Engine Emissions and Control	3(3-0-9)
2103556	Fundamental of Engine Fuel Control Systems	3(3-0-9)
2103558	Intake Manifold and Induction System Design	3(3-0-9)
2103560	Gas Turbine Performance	3(3-0-9)
2103566	Compressible Fluid Dynamics	3(3-0-9)
2103567	Turbulent Shear Flows	3(3-0-9)
2103570	Micro Fabrication Technology	3(3-0-9)
2103571	Micro and Nano Electromechanical Systems (MEMS-NEMS)	3(3-0-9)
2103602	Measurement and Instrumentation	3(2-3-7)
2103604	Advanced Numerical Methods	3(3-0-9)
2103612	Elasticity	3(2-3-4)
2103613	Plasticity	3(3-0-9)
2103614	Continuum Mechanics	3(3-0-9)
2103615	Mechanical Vibrations	3(3-0-9)
2103616	Optimum Design of Complex Mechanical Elements	3(3-0-9)
2103617	Advanced Dynamics	3(3-0-9)
2103620	Theory of Elastic Stability I	3(3-0-9)
2103621	Energy Principles in Solid Mechanics	3(3-0-9)
2103622	Analysis of Composite Structure	3(3-0-9)
2103623	Fatigue of Metals	3(3-0-9)
2103625	Advanced Finite Element Method	3(3-0-9)
2103626	Thermal Stress Analysis	3(3-0-9)
2103630	Industrial Robots II	3(3-0-9)
2103631	Control of Dynamic Systems	3(3-0-9)
2103632	Applied Nonlinear Control	3(3-0-9)
2103633	Applied Optimal Control	3(3-0-9)

2103634	Dynamics System Modeling and Simulation	3(3-0-9)
2103650	Advanced Engineering Thermodynamics	3(3-0-9)
2103651	Advanced Fluid Mechanics	3(3-0-9)
2103652	Combustion Theory	3(3-0-9)
2103653	Fluid Dynamics Aspects of Wind Turbines	3(3-0-9)
2103654	Conduction Heat Transfer	3(3-0-9)
2103655	Convection Heat Transfer	3(3-0-9)
2103656	Radiation Heat Transfer	3(3-0-9)
2103658	Advanced Internal Combustion Engine	3(3-0-9)
2103659	Utilization of Alternative Fuels	3(3-0-9)
2103663	Advanced Refrigeration and Air Conditioning	3(3-0-9)
2103664	Design of Thermal Systems	3(3-0-9)
2103665	Advanced Computational Fluid Dynamics	3(3-0-9)
2103666	Finite Element Method for Computational Fluid Dynamics	3(3-0-9)
2103701	Selected Topics in Mechanical Engineering	3(3-0-9)
2103721	Fracture Mechanics	3(3-0-9)

5) Thesis

2103813	Thesis	18	credits
2103816	Thesis	36	credits

Ph.D. DEGREE PROGRAM

NAME OF THE DEGREE

: Doctor of Philosophy
: Ph.D.

ADMISSION

1. The applicant must have bachelor degree in mechanical engineering or master degree in mechanical engineering/related fields. The applicant with bachelor degree must have average grade point of not less than 3.25 based on a 4 point grading system or receiving second class honor degree. The applicant with master degree must earn the thesis qualification at the good or excellent level. Both the bachelor and master degree applicants must posses other qualifications which the Doctor of Philosophy Program Committee considers sufficient to enter the program.

2. The applicant must present three letters of recommendation written by persons who are engaging in teaching the graduate study and/or his or her academic advisors.

3. The applicant must possess other qualifications which fulfill the regulations governing the study in Chulalongkorn University's Graduate School and the standard of study for the Doctor of Engineering Degree, 1981.

DEGREE REQUIREMENTS

The applicant with bachelor degree must take 24 credits of the listed elective courses. The applicant with master degree may take 0-12 credits of the listed elective courses depending on the consideration of the Program Committee. Both the bachelor and master degree applicants are required to submit a dissertation of 48 credits and satisfactory pass an oral examination. In addition, the applicant must fulfill the requirements of the graduate school by passing the English examination and publishing technical paper in an international journal.

COURSE REQUIREMENTS

1) Elective Courses

2103601	Advanced Engineering Mathematics	3(3-0-9)
2103602	Measurement and Instrumentation	3(2-3-7)
2103603	Mathematics for Control Engineers	3(3-0-9)
2103604	Advanced Numerical Methods	3(3-0-9)
2103612	Elasticity	3(3-0-9)
2103613	Plasticity	3(3-0-9)
2103614	Continuum Mechanics	3(3-0-9)
2103615	Mechanical Vibrations	3(3-0-9)
2103616	Optimum Design of Complex Mechanical Elements	3(3-0-9)
2103617	Advanced Dynamics	3(3-0-9)
2103620	Theory of Elastic Stability I	3(3-0-9)
2103621	Energy Principles in Solid Mechanics	3(3-0-9)
2103622	Analysis of Composite Structures	3(3-0-9)
2103623	Fatigue of Metals	3(3-0-9)
2103625	Advanced Finite Element Method	3(3-0-9)
2103626	Thermal Stress Analysis	3(3-0-9)
2103630	Industrial Robots II	3(3-0-9)
2103631	Control of Dynamic Systems	3(3-0-9)
2103632	Applied Nonlinear Control	3(3-0-9)
2103633	Applied Optimal Control	3(3-0-9)
2103634	Dynamic System Modeling and Simulation	3(3-0-9)
2103650	Advanced Engineering Thermodynamics	3(3-0-9)
2103651	Advanced Fluid Mechanics	3(3-0-9)
2103652	Combustion Theory	3(3-0-9)
2103653	Fluid Dynamic Aspects of Wind Turbines	3(3-0-9)
2103654	Conduction Heat Transfer	3(3-0-9)
2103655	Convection Heat Transfer	3(3-0-9)
2103656	Radiation Heat Transfer	3(3-0-9)
2103658	Advanced Internal Combustion Engine	3(3-0-9)
2103659	Utilization of Alternative Fuels	3(3-0-9)
2103663	Advanced Refrigeration and Air Conditioning	3(3-0-9)
2103664	Design of Thermal Systems	3(3-0-9)
2103665	Advanced Computational Fluid Dynamics	3(3-0-9)
2103666	Finite Element Method for Computational Fluid Dynamics	3(3-0-9)
2103701	Selected Topics in Mechanical Engineering	3(3-0-9)

2103721	Fracture Mechanics	3(3-0-9)

2) Dissertation

2103828	Dissertation	48 credits
2103829	Dissertation	60 credits
2103894	Doctoral Dissertation Seminar	0(0-0-0)
2103897	Qualifying Examination	0(0-0-0)

COURSES DESCRIPTIONS
IN MECHANICAL ENGINEERING
(UNDERGRADUATE LEVEL)

2103106   Engineering Drawing   3(1-4-4)

Introduction, Lettering, Apply geometry, Orthographic projection principle, Orthographic writing, Pictorial sketching, Orthographic reading, Dimensioning, Threaded fastener, Assembly drawing, Introduction to computer-aid drafting.

2103211   Statics   3(3-0-6)

Force system; resultants; equilibrium; structures and machines; distributed forces; friction, friction in machines; principle of virtual work; stability.

2103212   Dynamics   3(3-0-6)
Condition: Corequisite 2103211 or   2103213

Kinematics and kinetics of particles and planar rigid body; Newton's second law; equations of motion; work and energy; impulse and momentum of particles and planar rigid body; fundamental theory of vibration; free vibration and natural frequency.

2103231   Mechanics of Materials I   3(3-0-6)
*Condition : Corequisite 2103211 or
2103213*

Concept of stress and strain; stress and strain components; plane stress and plane strain; Mohr's circle of plane stress; Hooke's law and modulus of elasticity; engineering stress-strain diagrams; working stress; factor of safety; problems in axial loading including statically indeterminate problems and temperature changes; thin-walled pressure vessel; torsion of circular shaft; statically indeterminate shaft; beam; stress in beam; deflection of beam; statically indeterminate beam; Euler's formula; combined stress.

2103241   Thermodynamics I   3(3-0-6)

Some introductory comments, some concepts   and definitions, properties of pure substances, work and heat, the first law of thermodynamics, the first law analysis for a control volume, the second law of thermodynamics, entropy, second law analysis for a control volume, power and refrigeration system.

**2103260   Mechanical Engineering   2(1-3-2)
            Experimentation and Laboratory I**

Understanding the configuration and underlying principles/theories of mechanical engineering devices or systems; basic knowledge in measurement and instrumentation; basic concept in experimentation; conducting simple experiments using simple devices or systems.

**2103301   Design Methodology for Mechanical 3 (2-2-5)
            Engineering**

Design process; defining design problems, conceptual design, evaluating conceptual design; configuration design; introduction to simple mechanisms and mechanical devices; standard parts in mechanical works; conceptual design project.

**2103303   Numerical Methods for Mechanical   3(3-0-6)
            Engineering**

Digital computer principles and computer languages; root of algebraic and transcendental equations; solution of simultaneous algebraic equations; curve fitting; numerical integration and differentiation; numerical integration of ordinary differential equations: initial-value problems, ordinary differential equations: boundary-value problems.

2103302   Engineering Measurements   3(2-2-5)
Condition : Consent of Faculty

Engineering measurement systems, basic measurement standards; fundamentals of selection and operation of instrumentation components of measuring systems; error analysis, and propagation of error.

2103304   Automatic Control I   3(3-0-6)

Introduction to control system; mathematical models of systems; state-space description; dynamics simulation; feedback control system characteristics; the performance of feedback control systems; the stability of linear feedback systems; essential principles of feedback, the root-locus method; frequency response methods; stability of the frequency domain, time-domain analysis of control systems; the design and compensation of feedback control systems.

**2103305   Manufacturing Process for   3(2-2-5)
Mechanical Engineering**

Manufacturing process: casting, turning, milling, welding, heat treatment; manufacturing process selection for materials and shapes; manufacturing process selection for linear tolerance and geometric tolerance; surface roughness; metrology and examination techniques.

**2103306   Computer-Aided Mechanical   3(3-0-6)
            Engineering Design**

Use of computer-aided engineering for design and analysis of mechanical engineering problems. Physical modeling and simulations of mechanical engineering problems and related applications. Numerical methods for analysis, modeling and design of mechanical engineering problems

2103320   Design of Mechanical Elements   3(3-0-6)
Condition : Prerequisite 2103231

Properties of materials, theory of failure; fatigue analysis for mechanical design, design of various interesting mechanical elements.

2103322 Mechanics of Machinery 3(3-0-6)
Condition : Prerequisite 2103212

Basic Mechanisms; Position, velocity and acceleration of Linkages, Graphical linkage synthesis; Linkage synthesis; Static and dynamic force analysis; Static and dynamic balancing of a simple rotating and reciprocating machine.

2103325 Mechanical Engineering Design 2(0-4-2)
Project
Condition : Corequisite 2103320,2103322 and 2103361

Conducting a practical interesting design; project presentation and complete report writing.

2103332 Shipbuilding Engineering 3(3-0-6)

Ship types; shipbuilding materials and material testing; classification societies and related regulation; welding and cutting processes in shipbuilding; classification society weld testing; fabrication of main ship structural items; keel and bottom construction; shell plating, framing systems and decks; bulkheads and pillars; superstructures, etc.; fabrication of minor ship structural items; pumping and piping system; ventilation, refrigeration and insulation; shipbuilding process; shipyard layout and facilities; shipbuilding quality control; shipyard management and organization; industrial relations and psychology.

2103335 Vehicle Structural Analysis 1 3(3-0-6)
Condition: Prerequisite 2103231

Types and functions of vehicle body and chassis, layout of driving system, and chassis's load; factors affecting the structural design : safety; analysis of stress and deformation in beam and frame under axial load, bending moment, torque, transverse load and thermal load, respectively. The analysis involves both analytical method and finite element method, use of software in solving structural problems.

2103342 Thermodynamics II 3(3-0-6)
Condition: Prerequisite 2103241

Gaseous mixture; thermodynamic relations; fuel and chemical reactions; irreversibility, availability or exergy and second law efficiency; compressible flow.

2103351 Fluid Mechanics I 3(3-0-6)
Condition: Prerequisite 2103241 or 2103295

Introduction and fundamental concepts: fluid as a continuum, velocity field, nature of forces in fluid; fluid statics: fluid in rigid-body motion; Reynolds' transport theorem; governing equations for fluid motion in integral form: conservation of mass, linear momentum, angular momentum, and energy; introduction to kinematics of fluid motion: Eulerian and Lagrangian description of fluid motion, substantial derivative, translation, rotation, vorticity and circulation, deformation; introduction to governing equations for fluid motion in differential form: conservation of mass, stress in fluid motion, resultant force due to stress, the Navier-Stokes equation; introduction to inviscid flow: Euler's equation, Bernoulli's equation; dimensional analysis and similarity; introduction to internal viscous flow: fully-developed laminar flow, flow in pipes and ducts, flow measurements; introduction to external

viscous flow: boundary layer flow, flow about immersed bodies.

2103352 Ship's Buoyancy and Stability 3(2-3-4)
Condition: Corequisite 2103351

Ship geometry; ship's lines, nomenclature of form floatation; buoyancy; computations of areas, volumes and moments, the properties of floating bodies, hydrostatic curves; equilibrium and initial stability: equilibrium of floating objects, initial stability, metacentric radius, the inclining experiment, trim, stability curves; cross curves, stability characteristics; weight effects of stability; weight effects of stability; weight addition weight removal, grounding and docking; impaired stability and control of damage, free surface, flooding, permeability, estimate of the damaged ship's condition.

2103360 Mechanical Engineering 2(1-3-2)
Experimentation and Laboratory II
Condition : Prerequisite 2103260

Basic concepts and framework of experimentation; uncertainty analysis; analysis of data; interpretation of experimental results; analysis of characteristics and physical behavior of the system from experimental results via the use of physical observation and knowledge of basic physical principles; practices in applying principles and theories and evaluating the results of the application of such principles and theories in thermodynamics, fluid or solid mechanics systems.

2103361 Energy and Thermal-Fluid System
Design I 3(3-0-6)
Condition : Prerequisite 2103241 and 2103351

Characteristics and performance of energy thermal-fluid systems; analysis; modeling; energy transformation; design constraints; economic concept in engineering design; parametric study; introduction to optimization.

2103382 Mechanics of Vehicles I 3(3-0-6)
Condition: Prerequisite 2103211

Dynamics of wheels; vehicle's resistance forces and power requirement; performance & fuel consumption; dynamics of breaking.

2103393 Mechanical Engineering 1(0-3-0)
Laboratory For NoN-ME
Condition: Prerequisite 2103241 or 2103295 or 2103261

Experiments are designed to familiarize non mechanical students with experimental technique and instrumentations in the field of mechanical engineering. This course involves students working together in small groups on various experimental problems including gasoline and diesel engines, air compressor, hydraulic pump and turbine, friction loss in pipe and refrigeration cycle.

2103404 Dynamic Systems Simulation 3(3-0-6)
Condition: Prerequisite 2103304

Introduction; multiport systems and bond graphs; basic component models; system models; state-space equations; analysis of linear systems; multiport fields and junction structures; transducers, amplifiers, and instruments.

2103405 Automatic Control II 3(3-0-6)
Condition: Prerequisite 2103304
Describing-function analysis of non-linear control systems, phase-plane analysis, state-space analysis of control system; linear dynamical equations and impulse-response matrices; controllability and observability of linear dynamical equations, irreducible realizations: strict system, equivalence and identification.

2103406 Digital Control 3(3-0-6)
Condition: Prerequisite 2103304
Introduction to discrete systems by time-domain representations of linear discrete systems; the analysis of discrete-time systems, z-transformation of linear discrete systems; state variable representation; analysis of linear discrete-time system: z-domain approach; the analytical design of discrete systems; engineering characteristics of computer control systems.

2103407 Industrial Control 3(3-0-6)
Pasic control system; industrial control components: pneumatic electric, electronic and fluid devices; analysis and design of the complete control systems; special control applications; boiler control air condition control flight control; introduction to direct digital control and supervisory control.

2103408 Automotive Control 3(3-0-6)
Basic electronics; principle of feedback control system; digital control system; control device in automotive; sensors, controller, actuator; various control systems in automobile; system failure analysis.

2103409 Introduction to Mechatronics 3(3-0-6)
Introduction to Mechatronic Systems; Digital circuits; OP-AMP and analog circuits; Sensors and Measurement Systems; Actuators; Microprocessor; Programming, Project in Mechatronics.

2103421 Introduction to Finite Element 3(3-0-6)
Method for Mechanical Engineering
Condition: Prerequisite 2103303
Mathematical preliminaries and matrices, general procedure of the finite element method, derivation of finite equations using; direct approach, variational approach and method of weighted residuals, finite element types in one, two and three dimensions, and their interpolation functions, applications to structural, heart transfer, and fluid flow problems.

2103432 Mechanics of Materials II 3(3-0-6)
Condition: Prerequisite 2103231
Analysis of stresses at a point; analysis of stresses at adjacent points; analysis of strain at a point; analysis of strain at adjacent points; introduction to theory of elasticity;

applications to thick cylinders; compound cylinders: rotating disks: criteria of yielding: energy method.

2103433 Introduction to Mechanical 3(3-0-6)
Vibration
Condition: Prerequisite 2301312 or
Concurrent 2103212
Definitions; system with one degree of freedom; simple harmonic motion; torsional vibration; method of equivalent system; energy method; Rayleigh method; vibration with damping; viscous damping; coulomb damping; force vibration; system having several degree of freedom: dynamic absorber.

2103437 Ship Design I 3(3-0-6)
Condition: Prerequisite 2103352
Ship types and rules of construction, international convention, ship owner's requirement, choice of vehicles; tendering and specifications; general design characteristics; estimation of principal parameters and dimensions; mass equations and estimation of masses, capacities, stability and trim; body plan design, choice of form and modification; producing of line plan general arrangement, inboard, inboard profile, out board profile, transverse sections through engine room and others; engine foundations, sturntube, struts, propellers rudders; engine room layout, piping systems; electric and electronic system, refrigerating systems and others.

2103443 Refrigeration 3(3-0-6)
Condition: Prerequisite 2103241,2103351
Various types of refrigerating system; refrigeration cycle: single stage, booster, multi-stage and cascade system; basic principles of cryogenic technique; properties of refrigerants; blast freezer and anteroom construction: refrigeration load estimation; cold storage construction; freezing preservation of foods; low temperature refrigeration system; introduction to cryogenic technique; control system and instrumentations.

2103454 Ventilation and Air Conditioning 3(3-0-6)
Condition: Prerequisite 2103342, 2103351
Psychrometric properties and process of air, criteria for thermal comfort; general ventilation; industrial ventilation; fume and dust removal; air conditioning load calculation; various types of air conditioning system and equipment; air distribution and duct system design; air conditioning piping design; noise and vibration control: air.

2103460 Mechanical Engineering 2(1-3-2)
Experimentation and Laboratory III
(ME EXP LAB III)
Condition: Prerequisite 2103360
Concepts in experimentation and design of an experiment, setting up specifications and objectives of an experiment; systematic design of an experiment according to the specifications and objectives using tools such as data reduction diagram (DRD) and uncertainty analysis, and knowledge and application of basic physical principles, and knowledge of instruments and measurement; outlining the process of extracting experimental results and conclusions

from the designed experiment; outlining of data collection and data analysis schemes; outlining of experimental project phases, tasks, and schedule; design documentation and review by oral and written presentation; practices in the design of an experiment in the project-based setting; introduction to modern instrumentation and data acquisition through demonstration.

2103461   Automotive Engineering   2(1-3-2)
            Experimentation and Laboratory
Basic concepts and framework of experimentation; uncertainty analysis; analysis of data; interpretation of experimental results; analysis of characteristics and physical behavior of the system from experimental results via the use of physical observation and knowledge of basic physical principles; practices in applying principles and /theories in automotive systems.

2103462   Fluid Mechanics II   3(3-0-6)
Condition: Prerequisite 2103241
and 2103351
Fundamental concepts in fluid mechanics: methods of description of fluid motion, kinematics of fluid motion, stress at a point, the Navier-Stokes equation; inviscid irrotational flows: vorticity and circulation, velocity potential, stream function, Euler's equation of motion, Bernoulli's equation, elementary plane flows, superposition of elementary plane flows, lift and circulation; laminar viscous flows: Poiseuille flow, Couette flow, flow between rotating concentric cylinders; laminar boundary layers: displacement and momentum thicknesses, thin shear layer assumption and laminar boundary layer equation, flat plate boundary layer, momentum integral equation; introduction to turbulent flows: mean flow and turbulence, the Reynolds-Average Navier-Stokes equation, turbulent flows in channel and pipe, turbulent boundary layers; lift and drag of immersed bodies; introduction to compressible flows: local isentropic reference states, steady one-dimensional compressible flows with area change, with friction, and with heat transfer, normal shock.

2103463   Heat Transfer   3(3-0-6)
Condition: Prerequisite 2103241 and
2103351
Modes of heat transfer; heat conduction equation; steady, one-dimensional heat conduction; steady, two-dimensional heat conduction; unsteady, one-dimensional heat conduction; Introduction to convection heat transfer; velocity and thermal boundary layer; forced convection along external surfaces; forced convection inside tubes; free convection; introduction to thermal radiation; blackbody radiation; real surface emission; surface absorption, reflection and transmission; view factor; radiation exchanger between blackbody; radiation exchanger between real surface; heat exchanger design; boiling and condensation.

2103465   Fluid Power System   3(3-0-6)

Condition: Prerequisite 2103351, 2301312
Fundamentals of fluid power system, basic components and circuits, standard symbols, definitions using steady-state characteristics, transmission system, logic components and circuits, electrical components and wiring diagrams definition using transient characteristic, dynamic of fluid power system.

2103467   Combustion Technology   3(3-0-6)
Condition: Prerequisite 2103342, 2103351
Combustion phenomena; chemical kinetics, total collision frequency, equation of Arrhenius, activation energy, rates of reaction, ignition, quenching distance, flammability limits, fuel technology, stoichiometric combustion calculation, thermochemical analysis, theoretical flame temperature, performance of steam boilers, boiler's efficiency, boiler's heat balance sheet, boiler draught and fan power calculation, classification of industrial furnaces, heat source and heating method, operating method and material transfer equipment, furnace's radiative heat transfer, combustion apparatus, fuel-to-steam efficiency.

2103471   Internal Combustion Engines 3(3-0-6)
Condition: Prerequisite 2103241
Fundamental of how the design and operation of internal combustion engine effect their performance and fuel requirements. Study of fluid flow, thermodynamics, combustion, heat transfer and friction phenomena, and fuel properties, relevant to engine power, efficiency, and emissions. Examination of design features and operating characteristics of different types of engine: spark-ignition, compression-ignition.

2103472   Power Plant Engineering   3(3-0-6)
Condition: Prerequisite 2103241
Power plant and energy conversion systems: load calculation; power plant economics; fuel and combustion; steam turbines; steam and nuclear generators; condensers and auxiliary equipments; steam, internal combustion engine, gas turbine and hydroelectric plans.

2103473   Ship Resistance and Powering   3(3-0-6)
Condition: Prerequisite 2103351
Frictional resistance, residuary resistance, wave making resistance, Froude's law of comparison; model tests; powering of ships; estimation of effective horse power; propulsion and propellers horsepower, wake thrust deduction, hull efficiency, propellers, geometry of the screw propeller, propellers and law of similarity, design procedure.

2103475   Energy Management in Building   3(3-0-6)
Condition : Senior project
Energy audit program for building and facilities, initiating energy management program, guidelines for methods of reducing energy usage in each area in buildings, conservation of the energy in the planning, design, installation, utilization, maintenance and modernization of

the mechanical systems in existing and new buildings, utilization of microcomputer in energy management and in automatic control of air conditioning and ventilation systems in buildings.

2103477   Design of Industrial Piping   3(3-0-6)
Condition: Prerequisite 2103351
Boiler, principle of steam piping system, steam trapping, condensate recovery, flash steam, steam system design; principle of industrial compressed air piping system, air compressor and equipments, compressed air system design; air compressor and equipments, compressed air system design; principle of low pressure gas piping, pressure reducing station, calculation and sizing of gas pipes.

2103478   Energy Management in Industry   3(3-0-6)
Condition: Prerequisite 2103351
Energy balance studies for various equipment in industrial plants and options for improved efficiency, waste heat recovery techniques, cogeneration concepts in industry and management for efficient use of emergy.

2103479   Engine Cooling Systems   3(3-0-6)
Function of engine cooling system; fundamental of engine heat transfer; engine cooling system components; engine temperature; engine cooling circuits; vehicle coolant circuits; heat rejection; failure mode of cooling system; system characteristics; design process and test methods.

2103481   Automotive Engineering   4(3-3-6)
Basic principles; suspension system ; body and chassis, brake system; steering system; front wheel geometry; transmission system, automotive equipment; performance factors.

2103482   Mechanics of Vehicles   3 (3-0-6)
PART I: Introduction, degree of freedom, mechanical replacement system, uneven road surface, one-mass system, impulse due to the unevenness of the road, sprectral density, spectral density of uneven road surfaces, evaluation criteria of vibration and its calculation, evaluating the effect of the vibration on person, tyre, seat, vibration of motor vehicles and single point excitation, magnification factor (amplitude ratio), assessment criteria.
PART II: Single-track model, equation of motion, center of curvature and instantaneous center, tyre characteristics, aerodynamic characteristic values, linear differential equation of the single-track model, steady-state circular test at a constant speed, characteristic variable and its subjective assessment, effect of vehicle data, dynamic behavior, drive with large slip angles (in non-linearized range), effect of the height of center of mass.

2103483   Automotive System Design   3(1-4-4)
Condition: Prerequisite 2103320
A practical interesting automotive system design project assigned by the instructor; the project must be completed within one semester; a complete written design report is required.

2103484   Marine Engineering   3(3-0-6)
Condition : Consent of Faculty
Marine machinery; types and their layouts: pumps, fans, steering gear mechanism, anchoring device, winches, and cranes; propulsion; propeller geometry and definitions; lift and drag; momentum and blade element theories; steering and design of rudders; ship auxiliary services; ventilation, refrigeration, air conditioning, pumping, flooding and draining, and waste heat utilization.

**2103485   Agricultural Tractor Systems and   3(3-0-6)
                Design**
Condition : Senior Standing
Principles of design, constructional features, and operation of farm tractors, with emphasis on mechanics of tractor chassis, tractor transmission systems, hydraulic control systems, tractor-implement relationship, tractor-soil relationship, and tractor steering.

2103489   Mechanical Engineering Pre- Project 1(0-2-1)
Condition : Senior Standing or Consent of Faculty
Conduct and complete design processes for a mechanical engineering project in a team as well as documenting and presenting the processes in a professional manner.

2103491   Rolling Stock Engineering   3(3-0-6)
Fundamentals of railway rollings stock engineering railway stock components; introduction to railway vehicle dynamics; stability analysis; bogie, suspension, propulsion and brake system; fundamentals of bogie forms and design concept ; principle of railway rolling stock maintenance.

**2103495   Advanced Topics in Mechanical   3(3-0-6)
                Engineering I**
Condition : Consent of Faculty
Topics of current interest and new developments in various fields of mechanical engineering.

**2103496   Advanced Topics in Mechanical   3(3-0-6)
                Engineering II**
Condition : Consent of Faculty
Topics of current interest and new developments in various fields of mechanical engineering.

**2103499   Mechanical Engineering   3(0-6-3)
Project**
*Condition : Senior Standing or Consent of
                Faculty*
Conduct and complete a mechanical engineering project in a team such that the processes comply with prescribed design processes as well as documenting and presenting the project in a professional manner.

**COURSES DESCRIPTIONS IN MECHANICAL ENGINEERING
(GRADUATE LEVEL)**

**2103510   Mechanics of Composite   3(3-0-9)
                Materials**

Basic concepts of fiber reinforced composite materials and their application, stress and strain analysis of continuous fiber composite materials; Hooke' law and hygrothermal behavior of orthotropic lamina; classical lamination theory, failure criterion, and design concepts, as applied to composite structures; analysis of composite beams and plates; introduction to material fabrication and testing.

2103511 Introduction to Continuum   3(3-0-9)
Mechanics
Condition : Consent of Faculty
Introduction to continuum mechanics; essential mathematics: notations, tensor and operations, transformation, equation and symbol presentation; Kinematics of motion and small deformation; engineering stress; governing equations; constitutive equations; applications: setting and interpretation of heat conduction, solid mechanics and fluid mechanics.

2103530 Industrial Robots I   3(3-0-9)
Introduction Industrial Robots; robot reference frames; manipulator kinematics; inverse manipulator kinematics; Jacobian; manipulator dynamics; introduction to robot controls; trajectory generation; mechanism design; introduction to hybrid force/position control; summary.

2103532 Computer Aided Design and   3(2-3-7)
Computer Aided Manufacturing
Introduction to CAD/CAM; basic concept of CAD/CAM/CAE; product design and strategy; 3D modeling concept; techniques for geometry modeling; surface design; computer aided manufacturing concept; the design and manufacturing interface; NC programming & verification; link to manufacture; CAD/CAM standard and data exchange; rapid-prototyping concept; total approach to product development.

2103535 Mechatronics   3(3-0-9)
Introduction to mechanical system interfacing; combinational digital logic; industrial electronic components; industrial sensors; simple computer structure; low level programming techniques; embedded control computers; microcontroller; stepping motors; DC motors; analog/digital conversion; position and velocity measurement; amplifiers; projects related to mechatronics.

2103540 Failure Analysis and Non-destructive 3(2-3-7)
Testing
Condition : Consent of Faculty
Stress at crack tip and concerning parameters; failure phenomena: crack propagation, creep, corrosion, failure surface; life assessment; case studies; nondestructive testing; practice on NDT techniques.

2103541 Vibration Monitoring and   3(2-3-7)
Analysis
Condition : Consent of Faculty
Predictive maintenance; mechanical vibration; Fourier series and Fast Fourier Transform; measurement and instrumentation; symptoms of vibration signals; diagnosis; setup of alarm band; case studies; and projects.

2103552 An Introduction to Computational 3(3-0-9)
Fluid Mechanics
Dynamics of body moving through a fluid medium; numerical solution of ordinary differential equations. Inviscid fluid flows. Numerical method for solving elliptic partial differential equations. Viscous fluid flows: explicit and implicit methods for solving parabolic partial differential equations. Artificial viscosity. Mathematical behavior of partial differential equations. Boundary condition and Grid transformation.

2103555 Engine Emissions and Control   3(3-0-9)
Air pollution system, effects of pollutants; engine fundamentals, engine emissions; emission control techniques; instrumentation and techniques for measuring emissions.

2103556 Fundamental of Engine Fuel   3(3-0-9)
Control System
Fuel properties; fuel tank; carburetor; fuel injection system; injector; injection timing and control strategies; injector quality evaluation and testing; throttle body analysis and design; idle air control; fuel rail; fuel pumps and pressure regulator; fuel control systems for alternative fuels.

2103558 Intake Manifold and Induction   3(3-0-9)
System Design
Engine intake manifold design; primary design parameters and tuning, analysis methods; multicylinder wave dynamics; flow losses in induction systems; testing method for performance evaluation; noise in induction system, silencers.

2103560 Gas Turbine Performance   3(3-0-9)
Condition : Prerequisite 2103342
and 2103351 or Consent of Faculty
Introduction, thermodynamics of gas turbine cycle: efficiency and output of hypothetical cycle of intercooling, reheat and regenerative separately and in combination: the aeroturbo-propeller engine; the turbojet engine, the bypass jet engine, the supersonic turbojet engine; component matching problem.

2103566 Compressible Fluid Dynamics   3(3-0-9)
Condition : Consent of Faculty
Thermodynamics of motion; physical acoustics; wave equation; speed of sound; quasi-one-dimensional flow with friction and heat addition; shock waves and related discontinuities; one-dimensional unsteady flow; two-dimensional steady flow; method of characteristics; nozzle design; linearized flow; flow visualization using optical techniques.

2103567 Turbulent Shear Flows   3(3-0-9)
Characteristics of turbulent flows; Reynolds equations; dynamics of turbulence; free turbulent shear flows; jets, wakes, mixing layers, channel and pipe flows; turbulent transport of scalar quantities.

2103570 Micro Fabrication Technology   3(3-0-9)

Photo-lithography, etching, deposition, thermal oxidation, diffusion, ion implantation, bulk and surface micromachining, metrology, packaging, advanced lithography and the applications of micro and nanofabrication.

2103571   Micro and Nano Electromechanical   3(3-0-9)
**   Systems (MEMS-NEMS)**

Overview of MEMS, review of engineering mechanics and thermo-fluid engineering, electromechanics and light phenomena, micro system design of micromechanical devices, MEMS materials, review of micro fabrication, applications of MEMS, micro sensor, micro actuator, micro fluidic systems, display technologies, future trends.

2103601   Advanced Engineering
**   Mathematics   3(3-0-9)**

Numerical and graphical methods of approximate solution; finite difference method; calculus of variations, solution of classical partial differential equations of mathematical physics including application of conferral mapping and the Laplace transformation.

2103602   Measurement and Instrumentation 3(2-3-7)

Generalized performance characteristic of instruments; static and dynamic characteristics, study of measurement method for temperature, pressure, mass flow, stress-strain and vibration; experimental design and data analysis.

2103603   Mathematics for Control Engineers 3(3-0-9)

System representation; linear system analysis; state-space solutions and realizations; stability; controllability and observability; minimal realization; nonlinear systems analysis; phase plane analysis; Lyapunov theory for autonomous system; introduction to Lyapunov theory for non-autonomous systems; differential geometry; Lie derivative and Lie bracket; the Frobenius theorem; describing function analysis; Fourier series; Fourier integral; discrete-time mathematic; digital signal processing and fast Fourier transform (FFT).

2103604   Advanced Numerical Methods   3(3-0-9)
Condition : Consent of Faculty

Solution of equation; numerical Instabilities and their cure; simultaneous linear algebraic equations; numerical differentiation and integration; least squares approximations; ordinary differential equations; boundary value problems; partial differential equations.

2103612   Elasticity   3(3-0-9)

Two and three dimensional stress and strain analysis, theory of elasticity, Hooke's law for two and three dimensional problems, equilibrium conditions, compatibility conditions; stress function: two and three dimensional problems in Cartesian, polar and curvilinear coordinate systems; introduction to three dimensional elasticity.

2103613   Plasticity   3(3-0-9)
Condition: Prerequisite 2103612 or
Consent of Faculty

Stress tensors and tensor notations, yield criteria, stress-strain relations, plastic-elastic problems, introduction to incremental plasticity theory, plane strain compression, slip-line fields, friction effects, extrusion, deep drawing, rolling, limit analysis, upper bound and lower bound solutions.

2103614   Continuum Mechanics   3(3-0-9)
Condition : Consent of Faculty

Introduction to continuum mechanics; Essential mathematics: notations, tensor and operations, transformation, integral theorems of Gauss and Stokes; Kinematics of deformation and motion; Stress principles; Governing equations; Constitutive equations; Applications (heat conduction, solid mechanics, fluid mechanics); Introduction to computational modelling.

2103615   Mechanical Vibrations   3(3-0-9)

One degree of freedom systems; applications of vibration principles to various types of practical problems; multi-degrees of freedom systems, formulation of equation, numerical solving methods, continuous system, non-linear vibration.

2103616   Optimum Design of Complex   3(3-0-9)
**   Mechanical Elements**

Techniques for optimum design with application to simple mechanical elements in problem with practical constraints.

2103617   Advanced Dynamics   3(3-0-9)

Kinematics and kinetics of particles; variable mass problems; rigid body dynamics; Lagrange's equation; Hamilton's principle; Hamilton's canonical equations; Hamilton-Jacobi theory.

2103620   Theory of Elastic Stability I   3(3-0-9)
Condition: Prerequisite 2103432 or
Consent of Faculty

Stability of mechanical models and elastic beams by classical, kinetic, and energy approaches; snapthrough and bifurcation buckling; buckling of beams on elastic foundation; approximate methods for critical loads, buckling of rings and arches.

2103621   Energy Principles in Solid   3(3-0-9)
**   Mechanics**

Variational calculus; energy principles of structural mechanics; Hamilton's principle and Lagrange's equations; formulation and solution of engineering problems by direct variational methods.

2103622   Analysis of Composite Structures 3(3-0-9)

Concept and analysis structural response of laminated composite components; bending, vibration and stability of laminated composite structures; interlaminar stresses;

effect of shear deformation on structural response; numerical modeling of laminated plates.

2103623 Fatigue of Metals 3(3-0-9)
Fatigue damage process; analysis and design against fatigue failure through stress-based, strain-based and fracture mechanics-based approaches; problems of high temperature fatigue.

2103625 Advanced Finite Element Method 3(3-0-9)
Procedures of the finite element method for structural, thermal and fluid differential equations; nonlinear structural static and dynamic problems with discrete and continuum structures; transient nonlinear heat transfer problems with conduction, convection and radiation; steady and unsteady nonlinear incompressible and compressible fluid flow problems.

2103626 Thermal Stress Analysis 3(3-0-9)
Derivation of different classes for thermal stress differential equations and analytical solutions to thermal stress problems. Numerical methods for solving thermal stress problems with arbitrary continuum bodies and built-up structures.

2103630 Industrial Robots II 3(3-0-9)
Condition: Prerequisite 2103530 or
Consent of Faculty
Arm kinematics, homogenous transformation, Denavit-Hartenberg representation, kinematic equations for manipulators, inverse kinematics solutions, differential relationships of arm kinematics, arm dynamics, Lagrange-Euler equations of motion of robot manipulator arms, Newton-Euler formulation, computer simulation of arm dynamics, control of multiple-joint manipulator arms.

2103631 Control of Dynamic Systems 3(3-0-9)
Classical control; linear system theory; response of linear, lumped-parameter stationary systems; stability of linear lumped-parameter stationary systems; scalar input-output systems and feedback control; frequency response; introduction to multi-variable control systems; linear digital control.

2103632 Applied Nonlinear Control 3(3-0-9)
Introduction; phase plane analysis; describing function analysis; feedback linearization; sliding control; adaptive control.

2103633 Applied Optimal Control 3(3-0-9)
Introduction; parameter optimization problems, optimization problems for dynamic systems, optimization problems for dynamic systems with path constraints, optimal feedback control, linear system with quadratic criteria.

2103634 Dynamic System Modeling and 3(3-0-9)
Simulation
Mechanical background; mathematical modeling and numerical solution of engineering problems; modeling of

mechanical systems; model representation and response; modeling of electrical, hydraulic and thermal system; modeling of mixed systems; time response analysis of linear dynamic systems; introduction to optimization and numerical solution; solution techniques for non-linear systems; signal processing.

2103650 Advanced Engineering 3(3-0-9)
Thermodynamics
Review of principles and essential concepts; thermodynamic properties relations of mixtures and solutions, chemical reactions, introduction to phase and chemical equilibrium; thermodynamics of high speed flow.

2103651 Advanced Fluid Mechanics 3(3-0-9)
Review of principles and concepts; Cartesian tensor; transport eq., special model for steady laminar flow; shear flows, boundary layer equations, the concept of similarity; turbulent flow.

2103652 Combustion Theory 3(3-0-9)
Review of combustion processes, review of chemical thermodynamics, stoichiometric combustion analysis, equation of Arrhenius, activation energy, reaction orders, chain reactions, premixed laminar flames, thermal theories, comprehensive theory, Spalding's theory, ignition, minimum ignition energy, quenching distance, application in combustion engineering.

2103653 Fluid Dynamic Aspects of Wind 3(3-0-9)
Turbines
Basic fluid dynamics, aerodynamic theory, boundary layers, aerofoils; basic wind turbines; characteristics and mathematical modelling. principles of testing.

2103654 Conduction Heat Transfer 3(3-0-9)
Introduction; definition of concept and statement of general laws; formulation of heat conduction equations; lumped integral and differential formulation of general laws; initial and boundary conditions. solutions for steady and unsteady problems, one; two and three dimensional problems; method of solution, separation of variables, Laplace transform, partial solution, etc.

2103655 Convection Heat Transfer 3(3-0-9)
Governing equations for heat and mass transfer, basic solutions for heat transfer in ducts and over external surfaces; heat and momentum transfer analogy, free convection; boiling and condensation.

2103656 Radiation Heat Transfer 3(3-0-9)
Physics of radiation, radiation properties, radiation shapes factor; radiative exchange between surfaces; radiation through absorbing and transmitting media, radiation properties of gases; solar radiation.

2103658 Advanced Internal Combustion 3(3-0-9)
Engine
Standard air engine cycle, theory of combustion, fuel and combustion, reaction kinetics, reaction rates of air and

fuel, engine combustion, gas exchange processes, heat transfer, principle of flow and combustion process modelling, engine's performance prediction.

2103659   Utilization of Alternative Fuels   3(3-0-9)
Special requirements for the use of alternative fuels in furnances, the use of alternative fuels in transport, engine-fuels matching and optimisation, alternative engines, durability, vehicle fuel storage options, engine-vehicle matching.

**2103663   Advanced Refrigeration and Air   3(3-0-9)
             Conditioning**
Condition: Prerequisite 2103443,
2103454 or Consent of Faculty
Low temperature refrigeration, refrigeration system study, industrial applications of refrigeration, air conditioning system and building thermal environmental influences on air conditioning design, ventilation, direct contact, transfer processes between moist air and water, flow in ducts and a unconfined spaces, automatic control, testing, adjusting and balancing, economic factors in air conditioning, noise, and vibration control.

2103664   Design of Thermal System   3(3-0-9)
Engineering design, design of a workable system, economics, equation fitting and mathematical modelling, system simulation, optimization, Lagrange multipliers, search methods, dynamic programming, linear programming.

**2103665   Advanced Computational Fluid   3(3-0-9)
             Dynamics**
Mathematical and Numerical aspects of heat transfer and Fluid mechanics, finite difference and finite volume methods for solving basic governing equations of fluid flow and heat transfer: continuity, momentum and energy, discretisation methods for two and there dimensional problems, boundary conditions, numerical schemes and solvers, consistency, stability and convergence, advanced numerical techniques for CFD, applications of the method for some engineering problems.

**2103666   Finite Element Method for   3(3-0-9)
             Computational Fluid Dynamics**
Finite element method for solving fluid dynamics problems with complex geometries under different boundary conditions; solutions the problem of potential flows, inviscid and viscous flows, incompresible and compressible flows; finite element equations and corresponding computer programs in each case.

**2103701   Selected Topics in Mechanical   3(3-0-9)
             Engineering**
Topics are drawn from various fields of current interest in mechanical engineering.

2103721   Fracture Mechanics   3(3-0-9)
Condition: Prerequisite 2103612 or
Consent of Faculty
Rheology, model and law of material evolution in time, model of elastic material; model of non-elastic material; linear model of Newton, Maxwell and Voight Kehin; application of Zener's solid; elementary crystal model linear solid generalization; dynamic equation. Fracture mechanics, Griffith criteria; stress intensity, influence of plastic zone at notch root; crack opening displacement.

**2103790   Seminar in Mechanical   1(0-3-1)
             Engineering**
Discussion of special topics in the advent of mechanical engineering; written report is required.

2103811   Thesis   12 credits

2103813   Thesis   18 credits

2103816   Thesis   36 credits

2103828   Dissertation   48 credits

2103829   Dissertation   60 credits

2103894   Doctoral Dissertation Seminar   0(0-0-0)
2103897   Qualifying Examination   0(0-0-0)

DEPARTMENT OF INDUSTRIAL ENGINEERING

The courses in industrial engineering are designed to produce engineers specializing in problem solving and decision making functions. To this end production, planning and control, work study, quality assurance and control, systems and procedures analysis of emphasized in general, practical applications of production oriented operations research techniques, data processing, and computer programming fundamentals are also stressed. As well as the aforementioned techniques, the department is also making an effort in developing studies on human aspects industry as exemplified by the topics of human relationship in industry, ergonomics (Small group activities) and industrial law.

The Department of Industrial Engineering provides the Bachelor of Engineering degree, the Master of Engineering degree, and the Doctor of Philosophy (Ph.D.).

HEAD :

Paveena   Chaovalitwongse,   Ph.D. (Florida)

PROFESSORS :

Parames   Chutima,   Ph.D. (Nottingham)

ASSOCIATE PROFESSORS :

Jittra	Rukijkanpanich,	D.Eng. (AIT)
Jirapat	Ngaoprasertwong,	M.Sc. (Iowa)
Natcha	Thawesaengskulthai,	Ph.D. (Nottingham)
Paveena	Chaovalitwongse,	Ph.D. (Florida)
Somkiat	Tangjitsitcharoen,	D.Eng. (Kobe)
Wipawee	Tharmmaphornphilas,	Ph.D. (Pittsburgh)

ASSISTANT PROFESSORS :

Angsumalin Senjuntichai,	D.Eng. (AIT)
Daricha	Sutivong,	Ph.D. (Stanford)
Haruetai	Mekaroonreung,	MS. (Virginia Tech)
Naragain	Phumchusri,	Ph.D. (Georgia Tech)
Napassavong	Osotssilp,	Ph.D. (Wisconsin)
Oran	Kittithreerapronchai,	Ph.D. (Georgia Tech)
Phairoat	Ladavichitkul,	Ph.D. (Texas Tech)
Pisit	Jarumaneeroj,	Ph.D. (Georgia Tech)
Poom	Luangjarmekorn,	M.Eng. (Nagoya)
Pramual	Suteecharuwat,	Ph.D. (TITECH)
Prasert	Akkharaprathomphong,	M.Eng. (Keio)
Seeronk	Prichanont,	Ph.D. (Wisconsin)
Somchai	Puajindanetr,	Ph.D. (LONDON)
Surapong	Sirikulvadhana,	MS. IOE (Michigan)

LECTURERS :

Amonsiri	Vilasdaechanont,	Ph.D. (Wisconsin)
Arisara	Jiamsanguanwong,	D.Eng. (Tokyo Tech)
Natt	Leelawat	D.Eng. (Tokyo Tech)
Worachok	Chaiwong,	M.Eng. (Chula)

INDUSTRIAL ENGINEERING UNDERGRAD PROGRAMS

The department provides two undergraduate tracks of study: a general track and a co-operative education track. Similar to other Chulalongkorn University's engineering curriculums, the general track requires 2 credits of engineering practice during the third year's summer semester. The co-operative education track offers one more semester (seventh semester) for students to practice their skills in real workplaces.

INDUSTRIAL ENGINEERING CURRICULUM OF BACHELOR'S DEGREE
FIRST YEAR CURRICULUM
COMMON TO ALL ENGINEERING STUDENTS

GENERAL STUDY PROGRAM

COURSE NO.	SUBJECT	CREDITS
	THIRD SEMESTER	
2103213	ENGINEERING MECHANICS I	3
2104251	INTRODUCTION TO MANUFACTURING SYSTEMS	2
2104253	ENGINEERING STATISTICS I	3
2301312	DIFFERENTIAL EQUATIONS	3
5500208	COMMUNICATION AND PRESENTATION SKILLS	3
2104255	APPLICATION DEVELOPING FOR INDUSTRIAL ENGINEERING	3
xxxxxxx	FREE ELECTIVE	3
		_20_

COURSE NO.	SUBJECT	CREDITS
	FOURTH SEMESTER	
2103261	FUNDAMENTALS OF THERMO-FLUID ENGINEERING	3
2103393	ME LAB FOR NON ME	1
2104252	OPERATIONS MANAGEMENT	2
2104254	ENGINEERING STATISTICS II	3
2104256	QUALITY MANAGEMENT	2
2104257	MANUFACTURING PROCESSES	3
2104258	MANUFACTURING PROCESSES LABORATORY	1
2104259	OPERATIONS RESEARCH	3
		_18_

COURSE NO.	SUBJECT	CREDITS
	FIFTH SEMESTER	
2102391	ELECTRICAL ENGINEERING I	3
2102392	ELECTRICAL ENGINEERING LABORATORY I	1
2104351	WORK DESIGN	3
2104353	ENGINEERING ECONOMY	3
2104355	COMPUTER AND INFORMATION TECHNOLOGY FOR IE	2
2104356	QUALITY CONTROL	2
2104357	ENGINEERING EXPERIMENTAL DESIGN	3
2104361	INDUSTRIAL ENGINEERING LAB I	1
		_18_

COURSE NO.	SUBJECT	CREDITS
	SIXTH SEMESTER	
2104352	FACILITY DESIGN	3
2104358	INTRODUCTION TO SAFETY ENGINEERING	3
2104354	INDUSTRIAL COST ANALYSIS AND BUDGETING	3
2104359	SIMULATION PROGRAMMING	3
2104362	INDUSTRIAL ENGINEERING LAB II	1
5500308	TECHNICAL WRITING FOR ENGINEERING	3
xxxxxxx	GENERAL EDUCATION	3
		_19_

COURSE NO.	SUBJECT	CREDITS
	SUMMER SEMESTER	
2100301	ENGINEERING PRACTICE (S/U)	2
		_2_

COURSE NO.	SUBJECT	CREDITS
	SEVENTH SEMESTER	
2104491	INDUSTRIAL ENGINEERING PRE-PROJECT	1
xxxxxxx	ELECTIVES	6
xxxxxxx	GENERAL EDUCATION	6
xxxxxxx	FREE ELECTIVE	3
		_16_

COURSE NO.	SUBJECT	CREDITS
	EIGHTH SEMESTER	
2104409	INDUSTRIAL BUSINESS MANAGEMENT	3
2104425	MAINTENANCE ENGINEERING	3
2104499	INDUSTRIAL ENGINEERING PROJECT	3
OR2100499	SENIOR PROJECT	
xxxxxxx	ELECTIVES	3
xxxxxxx	GENERAL EDUCATION	3
		_15_

TOTAL CREDITS FOR GRADUATION = 144

INDUSTRIAL ENGINEERING CURRICULUM OF BACHELOR'S DEGREE
FIRST YEAR CURRICULUM
COMMON TO ALL ENGINEERING STUDENTS

GENERAL STUDY PROGRAM

COURSE NO.	SUBJECT	CREDITS
THIRD SEMESTER		
2103213	ENGINEERING MECHANICS I	3
2104251	INTRODUCTION TO MANUFACTURING SYSTEMS	2
2104253	ENGINEERING STATISTICS I	3
2301312	DIFFERENTIAL EQUATIONS	3
5500208	COMMUNICATION AND PRESENTATION SKILLS	3
2104255	APPLICATION DEVELOPING FOR INDUSTRIAL ENGINEERING	3
xxxxxxx	FREE ELECTIVE	3
		_20_

COURSE NO.	SUBJECT	CREDITS
FOURTH SEMESTER		
2103261	FUNDAMENTALS OF THERMO-FLUID ENGINEERING	3
2103393	ME LAB FOR NON ME	1
2104252	OPERATIONS MANAGEMENT	2
2104254	ENGINEERING STATISTICS II	3
2104256	QUALITY MANAGEMENT	2
2104257	MANUFACTURING PROCESSES	3
2104258	MANUFACTURING PROCESSES LABORATORY	1
2104259	OPERATIONS RESEARCH	3
		_18_

COURSE NO.	SUBJECT	CREDITS
FIFTH SEMESTER		
2102391	ELECTRICAL ENGINEERING I	3
2102392	ELECTRICAL ENGINEERING LABORATORY I	1
2104351	WORK DESIGN	3
2104353	ENGINEERING ECONOMY	3
2104355	COMPUTER AND INFORMATION TECHNOLOGY FOR IE	2
2104356	QUALITY CONTROL	2
2104357	ENGINEERING EXPERIMENTAL DESIGN	3
2104361	INDUSTRIAL ENGINEERING LAB I	1
		_18_

COURSE NO.	SUBJECT	CREDITS
SIXTH SEMESTER		
2104352	FACILITY DESIGN	3
2104358	INTRODUCTION TO SAFETY ENGINEERING	3
2104354	INDUSTRIAL COST ANALYSIS AND BUDGETING	3
2104359	SIMULATION PROGRAMMING	3
2104362	INDUSTRIAL ENGINEERING LAB II	1
5500308	TECHNICAL WRITING FOR ENGINEERING	3
xxxxxxx	GENERAL EDUCATION	3
		_19_

COURSE NO.	SUBJECT	CREDITS
SUMMER SEMESTER		
2100301	ENGINEERING PRACTICE (S/U)	2
		_2_

COURSE NO.	SUBJECT	CREDITS
SEVENTH SEMESTER		
2104491	INDUSTRIAL ENGINEERING PRE-PROJECT	1
xxxxxxx	ELECTIVES	6
xxxxxxx	GENERAL EDUCATION	6
xxxxxxx	FREE ELECTIVE	3
		_16_

COURSE NO.	SUBJECT	CREDITS
EIGHTH SEMESTER		
2104409	INDUSTRIAL BUSINESS MANAGEMENT	3
2104425	MAINTENANCE ENGINEERING	3
2104499	INDUSTRIAL ENGINEERING PROJECT	3
OR2100499	SENIOR PROJECT	
xxxxxxx	ELECTIVES	3
xxxxxxx	GENERAL EDUCATION	3
		_15_

TOTAL CREDITS FOR GRADUATION = 144

NAME OF THE DEGREE

: Master of Engineering
: M. Eng.

The department offers two plans of study: plan A1 and plan A2. Plan A1 is non-coursework plan (36 credits for thesis only). Plan A2 requires 24 coursework credits (6 required course credits and 18 approved elective credits) and 12 thesis credits.

Plan A1
COURSE REQUIREMENTS

1)   *Required Courses*   *36 credits*

2104816   Thesis   36(0-144-0)

Plan A2
COURSE REQUIREMENTS

1)   *Required Courses*   *18 credits*

2104696   System Improvement   3(3-0-9)
2104697   System Modeling and Analysis   3(3-0-9)
2104811   Thesis   12(0-144-0)

2)   *Approved Elective*   *18 credits*

2104505	Machinery and Instrument Appraisal	3(3-0-9)
2104506	Engineering Project Management	3(3-0-9)
2104507	Logistics and Supply Chain Management	3(3-0-9)
2104509	Warehouse and Warehousing Management	3(3-0-9)
2104511	Introduction to Virtual Environments	3(3-0-9)
2104512	Production And Operations Management Information Systems	3(3-0-9)
2104513	Industrial Engineering Integration	3(3-0-9)
2104515	Responsible Care	3(3-0-9)
2104516	Quality Improvement	3(3-0-9)
2104518	Quality System	3(3-0-9)
2104520	Visual Factory	3(3-0-9)
2104521	Computer Programming for Industrial Engineering	3(3-0-9)
2104523	Introduction to Stochastic Models	3(3-0-9)
2104524	Operations & Service Management	3(3-0-9)
2104525	Work Process Design and Improvement	3(3-0-9)
2104529	Computational Methods for Industrial Engineering	3(3-0-9)
2104548	Strategic Planning for Engineers	3(3-0-9)
2104555	System Safety	3(3-0-9)
2104559	Risk Management for Industry	3(3-0-9)

2104590	Introduction to Quantitative Data Analysis	3(3-0-9)
2104601	Engineering Economic Analysis	3(3-0-9)
2104602	Analysis of Business System	3(3-0-9)
2104604	Advanced Quality Management	3(3-0-9)
2104606	Advanced Industrial Organization and Management	3(3-0-9)
2104609	Reliability Theory in Engineering	3(3-0-9)
2104611	Inventory Analysis	3(3-0-9)
2104612	Computer Simulation Techniques	3(3-0-9)
2104613	Principle of Optimization	3(3-0-9)
2104615	Engineering Experimental Design	3(3-0-9)
2104616	Activity Scheduling	3(3-0-9)
2104617	Industrial Scheduling	3(3-0-9)
2104624	Factory and Production Management	3(3-0-9)
2104625	Computerized Statistical Data Analysis	3(3-0-9)
2104626	Materials and Processing	3(3-0-9)
2104627	Product and Production Design	3(3-0-9)
2104640	Decision Analysis in Engineering	3(3-0-9)
2104642	Decision Support Systems	3(3-0-9)
2104644	Advanced Maintenance Management	3(3-0-9)
2104645	Applied Biomechanics	3(2-3-7)
2104646	Work Physiology	3(2-3-7)
2104647	Hazardous Material and Fire Protection Engineering	3(3-0-9)
2104648	Strategic Planning for Engineers	3(3-0-9)
2104649	Cognitive Ergonomics	3(3-0-9)
2104650	Project Management Concepts	3(3-0-9)
2104671	Advanced Work Design	3(2-3-7)
2104677	Seminar in Safety Engineering	3(2-3-7)
2104684	Technology and Innovation Management	3(3-0-9)
2104688	Research Methodology in Industrial Engineering	3(3-0-9)
2104690	Quantitative Data Analysis for Industrial Engineering	3(3-0-9)
2104691	Research Problems in Industrial Engineering I (OR techniques)	3(3-0-9)
2104711	Advanced Manufacturing Engineering	3(3-0-9)
2104723	Artificial Intelligence for Industrial Engineering	3(3-0-9)
2104741	Comparative Engineering Management	3(3-0-9)

<u>Remark</u> : The student can select other courses offered by the Industrial Engineering, which will be announced by Industrial Engineering Department.

INDUSTRIAL ENGINEERING CURRICULUM OF MASTER'S DEGREE

Plan A1

COURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS
	FIRST SEMESTER			**THIRD SEMESTER**	
2104816	THESIS	<u>9</u>	2104816	THESIS	<u>9</u>
		9			9
	SECOND SEMESTER			**FOURTH SEMESTER**	
2104816	THESIS	<u>9</u>	2104816	THESIS	<u>9</u>
		9			9

TOTAL CREDITS FOR GRADUATION = 36

Plan A2

COURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS
	FIRST SEMESTER			**THIRD SEMESTER**	
2104696	SYSTEM IMPROVEMENT	3	xxxxxxx	APPROVE ELECTIVE	6
2104697	SYSTEM MODELING AND ANALYSIS	3	2104811	THESIS	<u>3</u>
xxxxxxx	APPROVE ELECTIVE	<u>3</u>			9
		9			
	SECOND SEMESTER			**FOURTH SEMESTER**	
xxxxxxx	APPROVE ELECTIVES	6	xxxxxxx	APPROVE ELECTIVE	3
2104811	THESIS	<u>3</u>	2104811	THESIS	<u>6</u>
		9			9

TOTAL CREDITS FOR GRADUATION = 36

NAME OF THE DEGREE

: Doctor of Philosophy
: Ph.D..

The doctoral degree is non-coursework (48 dissertation credits). Doctoral seminar and qualifying exam are also required, but the credits will not be assessed toward the degree.

INDUSTRIAL ENGINEERING CURRICULUM OF DOCTORAL DEGREE

COURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS
	FIRST SEMESTER			**FOURTH SEMESTER**	
2104781	DOCTORAL SEMINAR IN INDUSTRIAL ENGINEERING I	(1)*	2104784	DOCTORAL SEMINAR IN INDUSTRIAL ENGINEERING IV	(1)*
2104828	DISSERTATION	6	2104828	DISSERTATION	9
		7			10
	SECOND SEMESTER			**FIFTH SEMESTER**	
2104782	DOCTORAL SEMINAR IN INDUSTRIAL ENGINEERING II	(1)*	2104785	DOCTORAL SEMINAR IN INDUSTRIAL ENGINEERING V	(1)*
2104828	DISSERTATION	6	2104828	DISSERTATION	9
		7			10
	THIRD SEMESTER			**SIXTH SEMESTER**	
2104783	DOCTORAL SEMINAR IN INDUSTRIAL ENGINEERING III	(1)*	2104786	DOCTORAL SEMINAR IN INDUSTRIAL ENGINEERING VI	(1)*
2104828	DISSERTATION	9	2104828	DISSERTATION	9
2104897	QUALIFYING EXAM	(0)*			
		10			10

TOTAL CREDITS FOR GRADUATION = 48

Remarks :   * Credits for this course are not assessed towards the degree program

2104204   General Manufacturing Process Lab 1(0-3-0)

Basic measuring equipment and general manufacturing process; drawing and reading designs for work operation: use of tools in designing and work operation and use of machine for manufacturing: turning machine, milling machine, drilling machine; designing and manufacturing parts and conclusion of work operation in the manufacturing process.

**2104251   Introduction to Manufacturing   2(2-0-4)
Systems**

Manufacturing systems overview; systematic problem solving ; modeling in IE and performance measurement; basic IE tools and techniques; management concepts in manufacturing systems; push and pull manufacturing concepts; logistics and supply chain management.

2104252   Operations Management   2(2-0-4)
*Condition: Prerequisite 2104251 or Consent
of Faculty*

Operations strategies, inventory and distribution management, capacity management, aggregate planning, master production scheduling, material requirements planning, operation scheduling, project management.

2104253   Engineering Statistics I   3(3-0-6)

Basis Engineering in Descriptive statistics; probability; discrete probability distributions; continuous probability distributions; joint probability distributions; point estimation; interval estimation; hypothesis and statistical inference for one population; engineering applications.

2104254   Engineering Statistics II   3(3-0-6)
*Condition: Prerequisite 2104253 or Consent
of Faculty*

Basis Engineering in Hypothesis and statistical inference for two populations; analysis of variance; randomized blocks; latin square design; goodness of fit test; non-parametric statistics; linear regression analysis; time- series analysis; engineering applications.

2104255   Application Developing for IE   3(2-3-4)
*Condition: Prerequisite 2110101 or Consent
of Faculty*

Application Developing for Industrial Engineering; object-oriented programming; event-driven programming; application developing from data structure and algorithm; application design.

2104256   Quality Management   2(2-0-4)

Quality philosophy; quality management strategies: total quality management (TQM), Six Sigma; quality system management: ISO, Thailand Quality Award (TQA); problem solving tools; team building techniques; organizing for quality.

2104257   Manufacturing Processes   3(3-0-6)

Introduction to manufacturing industry; economic principles of manufacturing processes; mechanical characterization of materials; casting; metal forming: rolling, metal drawing, extrusion, forging, cold forming; machining: turning, shaping and planing, milling, grinding; non-traditional machining; metal cutting: tool shape, forces and power requirement in metal cutting; tool's life equations; power metallurgy and cutting tool material; welding technology and welding inspection; CNC technology.

2104258   Manufacturing Processes Lab   1(0-3-0)

Practice in manufacturing processes: machining and hand tools, heat treatment, welding and casting.

2104259   Operations Research   3(3-0-6)

Deterministic operations research in industrial engineering problem solving with emphasis on the use of mathematical models; linear programming; transportation model; and game theory.

2104351   Work Design   3(2-3-4)

Fundamentals of method, work and process analysis; line balancing; collection of operation data, process improvement through the use of flow process chart; operation process chart (assembly process chart), Gantt chart, multi-activity chart, motion Study (micromotion study), introduction to anthropometry, work physiology and biomechanics, macro and temporal ergonomics, guidelines for design and organization of work stations, guidelines for manual material handling and hand tools, guidelines for controls and displays, principles of motion economy, proposed method implementation, learning curves, stopwatch time study, performance rating and allowances, standard data and formulas, predetermined time systems, work sampling, indirect and expense labor standards.

2104352   Facility Design   3(3-0-6)
*Condition: Prerequisite 2104351 or Consent
of Faculty*

Introduction to facility design; importance and process of facility design; preliminary analysis of facility design: layout and related factors: products, processes, material handling, machine, man, selection of facility location.

2104353   Engineering Economy   3(3-0-6)

Interest formulation; time value of money; equivalent value and rate of return; project analysis and evaluation; breakeven point; sensitivity analysis; risk and uncertainty analysis; asset replacement decision; depreciation and tax.

**2104354   Industrial Cost Analysis and   3(3-0-6)
Budgeting**

Fundamentals of financial reports; cost analysis for planning process; capital expenditure; cost control and opportunity loss management; capital rationing; profitability analysis and decision making for investment in challenging projects under uncertainty and risk.

2104355   Computer and Information   2(1-3-2)
**   Technology for IE**
Condition: Prerequisite 2110101 or Consent of Faculty

Database system; network systems; information communication technology; network application development.

2104356   Quality Control   2(2-0-4)
Condition: Prerequisite 2104253 and 2104254 or Consent of Faculty

Quality control philosophy; methods of statistical quality control: control charts, process capability analysis, measurement system analysis, acceptance sampling; product reliability.

2104357   Engineering Experimental Design 3(3-0-6)
Condition: Prerequisite 2104254 or Consent Of Faculty

Factorial design; 2^k factorial design; blocking and confound: fractional factorial design; factorial experiments with random factors; nested and split-plot design; non-linear regression analysis; response surface analysis.

2104358   Introduction to Safety Engineering 3(3-0-6)

Safety principles and safety standards; basic human anatomy; study of the following hazards: noise, chemicals, electricity, fire, radiation, machine tools and pressure vessels, work in hot environment; hazard prevention method; accident investigation techniques; safety law; principle of safety management; introduction to industrial psychology; laboratory and field trips.

2104359   Simulation Programming   3(3-0-6)
Condition: Prerequisite 2104253, 2104254 or Consent of Faculty

Probabilistic operations research in industrial engineering problem solving with emphasis on the use of simulation; queuing theory; and inventory model.

2104361   Industrial Engineering Laboratory 1(0-3-0)

Laboratory work related to design, assign, control, and evaluation of work considering productivity and quality aspects.

2104362   Industrial Engineering   1(0-3-0)
**   Laboratory II**

Laboratory work related to design, assign, control, and evaluation of work considering productivity, safety and cost aspects.

2104391   Materials Technology I   3(2-3-4)

Various production techniques of material powders, manufacturing techniques of metal and ceramic components from powders, powder characterization techniques, mechanical properties of components in relation to micro-structure production and physical properties of inorganic glasses.

2104401   Co-operative Education   6(0-36-0)

Full-time job training in a real-life industrial environment; working as an organization's employee in the discipline associated with each student's curriculum and career goals.

2104408   Energy management in Industry 3(3-0-6)

Types of energy in industrial processes; laws related to energy consumption; energy saving measures; instruments and energy auditing; economic analysis and work standard for efficient energy usage.

2104409   Industrial Business Management 3(3-0-6)

Basic knowledge about Organization - Business - Industry - Supply Chain; changed directions of the world and industry and adaptation; strategic Management; innovation management; operations management; ,management and utilization of data / information / knowledge / information technology; project development and project management; leadership; change management; human resource management; good governance and risk management; virtue; ethics; code of conduct; social responsibility; business management according to the philosophy of Sufficiency Economy

2104414   CNC Turning Technology   3(3-0-6)

Introduction to CNC Turning, CNC Lathe Cutting Fundamentals, CNC Lathe Control and Operation, CNC Lathe Technical Data, CNC Lathe Rapid and Feed Moves, CNC Lathe Circular interpolation, Tool Nose Radius Compensation and Command of CNC lathe by CNC Lathe Fixed Cycles G70-G94 and others.

2104415   CNC Machining Technology   3(3-0-6)

Introduction to CNC turning   centres, CNC turning fundamentals, CNC turning centre cutting fundamentals, CNC turning centre control and operation, CNC turning centre technical data, CNC turning centre rapid and feed moves, CNC turning centre circular interpolation, CNC cutter diameter compensation, CNC canned cycles and CNC canned cycles G84, G86, and G76.

2104424   Applied Ergonomics   3(2-3-4)

Science of motion; biomechanics; 2-D analysis; problems of neck, shoulder, wrist, elbow, lower back, using a goniometer and EMG; psychophysics principles; fatigue and motivation; factory survey; work design; doing term projects, and presentation.

2104425   Maintenance Engineering   3(3-0-6)

Maintenance concepts; terotechnology; preventive maintenance; corrective maintenance; maintenance organization planning and control of maintenance activities; materials and spare part management;

reliability and failure statistics; application of waiting line theory to maintenance problem, critical part scheduling, measurement and evaluation maintenance performance; depreciation causes; machine and equipment inspection.

2104426   Cooperative Education   3(0-18-0)
Full-time job training in a real-life industrial environment; working as an organization's employee in the discipline associated with each student's curriculum and career goals.

2104429   Applications of OR   3(3-0-6)
Condition: Prerequisite 2104259 and 2104359 or Consent of Faculty
Applications of Operations Research techniques: Linear Programming, Integer Programming, Stochastic Programming, and Simulation to solve real-world problems of industrial organizations.

2104431   Automation   3(2-3-4)
Basic concepts of automation systems in manufacturing industry; equipment in automation systems: pneumatics, hydraulics, sensor; logical control; industrial robot technology; control theory.

**2104432   Introduction to Cognitive   3(3-0-6)
              Ergonomics**
Specialty the inter-discipline of design and system development that are involved with humans to make the systems more effective and more robust, focusing on amplifying human capability in performing cognitive work by integrating technical functions with human cognitive processes to create efficient and reliable systems.

2104456   Ergonomics   3(2-3-4)
Introduction to Ergonomics; human body as a working system (i.e. bones, joints, muscles, metabolism); anthropometry; work demand evaluation and factory inspection using biomechanics and physiology method; displays and controls; introduction to human information processing.

2104459   Value Engineering   3(3-0-6)
Introduction to value engineering methodology; application for value engineering technique to product design; procurement and manufacturing in order to reduce cost without loss of quality.

2104463   Project Feasibility Study   3(3-0-6)
Condition: Prerequisite 2104353 or Consent of Faculty
Study key factors crucial to decision making in industrial investment.

2104491   Industrial Engineering Pre-Project 1(0-2-1)
Problem framework; guidelines for problem solving and solutions to the problems in an industrial engineering project.

2104493   Special Problems in IE   III   3(2-3-4)

Study or investigation of special problems assigned by the instructor with the consent of the head of the departmental.

2104494   Advanced Topics in IE   III   3(3-0-6)
Study of current interesting topics and new development in industrial engineering.

2104495   Advanced Topics in IE   I   3(3-0-6)
Study of current interesting, topics and new development in industrial engineering.

2104496   Advanced Topics in IE   II   3(3-0-6)
Study of current interesting topics and new development in industrial engineering.

2104497   Special Problems in IE   I   3(2-3-4)

Study or investigation of special problems assigned by the instructor with the consent of the head of the department.

2104498   Special Problems in IE   II   3(2-3-4)
Study or investigation of special problems assigned by of the instructor with the consent of the head of the department.

2104499   Industrial Engineering Project   3(0-9-0)
Practical interesting project or problems in various fields of industrial engineering assigned by the instructor.

COURSE DESCRIPTIONS IN INDUSTRIAL ENGINEERING (M.ENG., PH.D.)

**2104505   Machinery and Instrument   3(3-0-9)
              Appraisal**
Importance of appraisal for machines; equipment and instruments; life cycle of machinery; conditions and efficiency of machinery; factor effects to appraisal; step of appraisal; engineering economy; reporting case studies.

2104506   Engineering Project Management 3(3-0-9)
Project management models; project initiation; project planning, organization, scheduling and control; resource and cost management; risk management; project termination; project management information system; case study.

**2104507   Logistics and Supply Chain   3(3-0-9)
              Management**
Definition of logistics and supply chain management; distribution network design; distribution strategies production-inventory models; transportation design; coordination and information technology; international issues.

2104509   **Warehouse and Warehousing**   **3(3-0-9)**
           Management
Condition : Prerequisite 2104252 and 2104524
or Consent of Faculty

The role of the warehouse; warehousing decisions; warehousing operations; materials handling and packaging.

2104511   **Introduction to Virtual**   **3(3-0-9)**
           Environments

Theory, development, and applications of virtual reality (VR) technology for the generation of the virtual environments (VE); human-computer interaction based on the 5 basic senses of human perception; use of 3D software and some scripting language to generate models in the CAVE system; application of VR technology in product and production design and others.

2104512   **Production and Operations**   **3(3-0-9)**
           Management Information Systems
Condition : Prerequisite 2104252 or 2104524
or Consent of Faculty

Information strategy, business information systems, ERP, system analysis and design, database for production and operations management, information systems for production and operations management and control; systems implementation; systems operation and support, case studies.

2104513   **IE Integration**   **3(3-0-9)**
Condition : Prerequisite 2104252 or Consent of Faculty

Work in the manufacturing systems, servicing system and business system; Components of the management and control systems, core processes and supporting systems; design of organization structure, products, facilities, transformation process, supporting system and detail operation ; operation and monitoring, evaluation, reviews and improvement.

2104515   **Responsible Care**   **3(3-0-9)**

Importance of Responsible Care (RC), A history of RC principles, laws, rules and standards, cooperation among organizations : producers, distributors, users, transporters, disposers, RC organizational structure, necessary internal activities for RC, emergency response, data managing and reporting concerning environment, health and safety.

2104516   **Quality Improvement**   **3(3-0-9)**
Condition: Prerequisite 2104254 or 2104690
or Consent of Faculty

Quality improvement based on Six Sigma approach; improvement project selection; steps for quality improvement; tools for quality improvement; appraisal of return on quality investment in quality improvement project.

2104518   **Quality System**   **3(3-0-9)**

Concept of quality system; several types of quality system, design and application of quality system in manufacturing or service industry; evaluation; analysis and improvement of quality system.

2104520   **Visual Factory**   **3(3-0-9)**

Meaning and principles of visual factory; need for communication in a factory; traditional methods for communication in a factory; key elements of a visual factory: workplace organization and standardization; visual displays; visual controls; good visual communication; visual production control; visual quality control; process indications; and implementing visual communication.

2104521   **Computer Programming for IE**   **3(3-0-9)**

Practical Computer programming including database implementation, graphic user interface (GUI), network programming.

2104523   **Introduction to Stochastic Models**   **3(3-0-9)**
Condition: Prerequisite 2104253 or 2104690
Consent of Faculty

Unconditional and conditional probability; discrete models; evaluation of complexity of problems; partitioning problems; use of statistics in decision making; systematic approach for problem solving.

2104524   **Production and Service**   **3(3-0-9)**
           Management

Work study; production time improvement; flow process chart; Therblig symbol; work measurement; time study; skill and effort rating; standard time; man machine Chart; motion and time study; Gang process chart; human factor integration and cognitive science; reengineering.

2104525   **Work Process Design and**   **3(3-0-9)**
           Improvement
Condition: Consent of Faculty

Design Layout and Routing, Material Handling Method Study; Analysis & Improvement Standard Method Work & Motion, Motion Economy Work Measurement; Standard Time in Work Element Level and Motion Level Safety and Environment of Work Human Factor; Manual Work, Cognitive Work, Hand Tools Design, Workstation Design, Psychophysics, Job Analysis and Job Evaluation, Incentive and Work Payment, Shift Management and Cost; Unit Cost & ABC Analysis.

2104529   **Computational Methods for IE**   **3(3-0-9)**

Industrial engineering problem solving using computational methods; data mining and visualizing; algorithms for inventory models, production planning, production scheduling, production analysis, and optimization

2104548   **Strategic Planning for Engineers**   **3(3-0-9)**

Strategic planning process; analytical techniques used in formulating plans; concepts of manufacturing strategy.

2104555   System Safety   3(3-0-9)
Human Error; System Safety Design Requirements; Hazard Identification; Analysis and Resolution; Hazard Resolution Matrix; Preliminary Hazard Analysis (PHA); Failure Modes and Effects Analysis (FMEA); Event Trees; Fault Trees; Fault Classification; Fault-Tree Construction; Direct Evaluation of Fault Tree; Fault Trees Evaluation by Cut Sets.

2104559   Risk Management for Industry   3(3-0-9)
Introduction to Risk Management; types and classification of Risk from both internal factor and external factor with cover production industry and service industry; tools and techniques for Systems/Process Analysis and Internal Control System Setting in order to reduce and prevent failure of the designed System supported by ICT as a monitoring tool.

2104590   Introduction to Quantitative   3(3-0-9)
Data Analysis
Probability theory and statistical inference used in engineering applications; random variables and distributions, probability models, parameter estimation and sampling distribution, confidence intervals, hypothesis testing, simple and multiple linear regression models, analysis of variance for design of experiments.

2104601   Engineering Economic Analysis   3(3-0-9)
Condition: Prerequisite 2104353 or Consent of Faculty
Theoretical foundations and advanced topics in engineering economic analysis; investment project evaluation in industrial and engineering works under conditions of uncertainty; analysis of capital budgeting decisions.

2104602   Analysis of Business System   3(3-0-9)
Business enterprises; business area; business components; product/services; business plan; concepts of business system strategies: marketing, production, and financial strategies; strategic management; performance measurement by Key Performance Indicator (KPI) and the Balanced Scorecard approach; improvement tools; improvement methods and process; quality systems and quality award.

2104604   Advanced Quality Management   3(3-0-9)
Theory, principles, concepts of quality system development including Quality Control, Quality Inspection, Quality Assurance, Quality Improvement, Quality Management, Quality Enhancement and Innovation; analysis and design of quality problem solving approach.

2104606   Advanced Industrial Organization   3(3-0-9)
and Management
Management science; information systems for executive; strategic management; job and organization design; managerial decision making process; leadership in organization and organization communication; financial analysis; case analysis; production control.

2104609   Reliability Theory in Engineering   3(3-0-9)
Condition: Prerequisite 2104690 or Consent of Faculty
Reliability analysis with emphasis on the exponential, weibull, gamma, lognormal and extreme value distributions; reliability of systems; redundancy; maintainability and availability.

2104611   Inventory Analysis   3(3-0-9)
Condition: Prerequisite 2104690 or Consent of Faculty
Development of models of deterministic and stochastic inventory systems; derivation of optimal decision rules for the timing and size of replenishment orders; application of dynamic programming and markov chains in the modeling of dynamic systems.

2104612   Computer Simulation Techniques   3(3-0-9)
Condition: Prerequisites 2104690 or Consent of Faculty
Application of simulation techniques to optimization of large scale operations; construction of simulation models; validation of simulation models; limitations of simulation techniques; programming with simulation languages.

2104613   Principle of Optimization   3(3-0-9)
Linear programming; the simplex method: big M and two-phase method; sensitivity and duality; integer linear programming and branch and bound method; goal programming; nonlinear programming: convex and concave functions, one variable, unconstrained with several variables, steepest ascent, Lagrange multipliers, Khun -Tucker conditions; intro to heuristic search.

2104615   Engineering Experimental Design   3(3-0-9)
Applications of experimental design to engineering Problems. Emphasis on the methods of experimental set up, data collection, and data analysis.

2104616   Activity Scheduling   3(3-0-9)
Principle of activity scheduling selection and application of appropriate models to deal with scheduling problems.

2104617   Industrial Scheduling   3(3-0-9)
Condition: Prerequisite 2104616 or Consent of Faculty
Concepts of industrial scheduling; single machine scheduling with both types of performance measures: tardiness based and utilization based measures; flow shop scheduling; parallel machine scheduling and batch sequencing; network based scheduling; job shop scheduling and open shop scheduling

**2104624 Factory and Production 3(3-0-9)
Management**

Emphasis on small industrial management; project management; plant site, layout and tool selection; types of production processes and their control; use of budgets for decision making and integrating the roles of various units.

**2104625 Computerized Statistical Data 3(3-0-9)
Analysis**

Condition: Prerequisite 2104690 or Consent of Faculty

Use of computer for research design, data collection planning, data preparation, data analysis.

2104626 Materials and Processing 3(3-0-9)

Types and characteristics of materials; manufacturing processes; mechanical, physical, and chemical analyses of materials.

2104627 Product and Production Design 3(3-0-9)

Condition: Prerequisite 2104626 or Consent of Faculty

The design of product for optimal production cost under specified tolerance; analysis of factors of production and processes.

2104640 Decision Analysis in Engineering 3(3-0-9)

Analysis of decisions in engineering and industry under uncertainty; decision tree analysis, expected monetary value and expected utility ; expected value of perfect information and sampling information; basis for expected utility theory; rating and ranking of alternatives using multiple criteria ; case studies.

2104642 Decision Support Systems 3(3-0-9)

Taxonomy of decision support systems (DSSs); a framework of the development of DSSs; multi-criteria decision methodology; components of an architecture for DSS; an approach for an integrated DSS for strategic planning; executive information and support systems; group decision support system; intelligent DSS; using DSSs in various situations.

**2104644 Advanced Maintenance 3(3-0-9)
Management**

Framework of maintenance management (MM); maintenance philosophies; interaction between production management and maintenance philosophies; maintenance management decision making; balancing between preventive and corrective maintenance; performance evaluation; computerized maintenance management system; ISO9000 and ISO14000 compliance.

2104645 Applied Biomechanics 3(2-3-7)

Applying biomechanics in order to design and develop work tasks, work places and tools based on ergonomics, which considers human strength as the first priority.

2104646 Work Physiology 3(2-3-7)

Applying physiology in order to design and develop

work tasks, workplaces, tools and working environments or exhaustion based on ergonomics which considers human endurance as the first priority.

**2104647 Hazardous Material and Fire 3(3-0-9)
Protection Engineering**

Evaluation ,design, development of a workplace under a risk of fire and hazardous material based on engineering rules, which covers a protection and stop the hazardous events with consideration of safety management and safety engineering usage.

2104648 Strategic Planning for Engineers 3(3-0-9)

Strategic planning process; analytical techniques used in formulating plans; concepts of manufacturing strategy.

2104649 Cognitive Ergonomics 3(2-3-7)

Specialty inter-discipline of design and system development that are involved with containing humans to make the systems more effective and more robust, focusing on amplifying human capability in performing cognitive work by integrating technical functions with human cognitive processes to create efficient and reliable systems.

2104650 Project Management Concepts 3(3-0-9)

Introduction to engineering project management including overview and concepts of project management, planning successful projects, implementing, executing and closeout.

**2104660 Stochastic Models for Financial 2(2-0-6)
Engineering**

Probability; random variables; probability distributions; discrete-time Markov chain; Poisson process; normal distribution; continuous-time Markov chain; Martingale; random walk; Brownian motion.

**2104661 Statistical Methods for Financial 2(2-0-6)
Engineering**

Random sample; estimation and forecasting; confidence intervals; hypothesis testing; goodness of fit test; maximum likelihood estimators; general method of moments; volatility estimation; linear regression analysis.

**2104662 Optimization for Financial 2(2-0-6)
Engineering**

Local and global optimality; linear programming; simplex algorithm; linear duality; sensitivity; nonlinear programming; Newton's method; Kuhn-Tucker conditions; saddle point conditions; convergence of algorithms; portfolio optimization.

**2104663 Time-Series Analysis for Financial 2(2-0-6)
Engineering**

ARMA, ARIMA, ARCH, GARCH processes for univariate and multivariate variables; unit root and cointegration; vector autoregression.

2104664 Statistics for Financial Engineering 3(3-0-3)

Asymptotic properties of estimators; sampling statistics; hypothesis testing; linear regression; weighted linear regression; endogeneity problems and instrumental variable estimation; maximum likelihood estimators; nonlinear regression; Wald test; likelihood ratio test; general method of moments; information criteria.

2104671   Advanced Work Design   3(2-3-7)
An advanced study of work design and methods of improving human work; factors affecting work such as fatigue, learning and physical capacity.

2104677   Seminar in Safety Engineering   3(2-3-7)
Intensive study of safety programs in industrial organization; critical discussion and review of existing working conditions in industry; case studies and factory tours used as means to recognize safety problems; analysis and discussion of solutions to the problems required as well as reports.

2104684   Technology and Innovation   3(3-0-3)
Management
Key issues and core concept of technology and innovation management, develop a framework for innovation strategy, in search of innovation, technology and innovation selection, techniques and tools for effective implementation of innovation, the management of operations, execution of innovation, manufacturing and commercializing science and technology based ideas.

2104688   Research Methodology in IE   3(3-0-9)
and Operations Management
Research philosophy; epistemology; ontology; qualitative and quantitative research methodology in industrial engineering and operations management; research proposal; literature review; research topic; research design; bibliography; research presentation.

2104690   Quantitative Data Analysis for IE   3(3-0-9)
Probability theory and statistical inference used in engineering applications; random variables and distributions, probability models, jointly distributed random variables, parameter estimation and sampling distribution, confidence intervals, hypothesis testing, simple and multiple linear regression models, analysis of variance for design of experiments, non-parametric statistics.

2104691   Research problems in IE I (OR)   3(3-0-9)
Interesting problems in industry (OR techniques); current knowledge that helps solve the problems, searching for and sharing of knowledge that helps solve the problems.

2104692   Research problems in IE II   3(3-0-9)
(Production)
Condition : Consent of Faculty
Interesting problems in industry (Production techniques); current knowledge that helps solve the problems, searching for and sharing of knowledge that helps solve the problems.

2104693   Research problems in IE III   3(3-0-9)
(Management)
Interesting problems in industry (Management techniques); current knowledge that helps solve the problems, searching for and sharing of knowledge that helps solve the problems.

2104694   Research problems in IE IV   3(3-0-9)
(Safety)
Condition : Consent of Faculty
Interesting problems in industry (Safety techniques); current knowledge that helps solve the problems, searching for and sharing of knowledge that helps solve the problems.

2104696   System Improvement   3(3-0-9)
Principles, guidelines, and processes for system development or improvement in manufacturing and service industries to respond to stakeholders' requirements in terms of productivity, quality, safety, and worthiness by integrating resources such as personnel, machines, materials, methods, and budget

2104697   System Modeling and Analysis   3(3-0-9)
Principles of system modeling and controls, System dynamics, System analysis; decisions and issues in Operating system

2104711   Advanced Manufacturing   3(2-3-7)
Engineering
Recent advances in engineering materials and processing; cost and value engineering as related to material and processing system selection and specification; computer controls of machines and processes in manufacturing systems; industrial robotics and flexible assembly; laboratory assignments.

2104723   Artificial Intelligence for IE   3(3-0-9)
Application of artificial intelligence techniques to industrial engineering problems, with emphasis on expert systems, neural networks, fuzzy logic, genetic algorithm, simulated annealing, and their hybrid forms.

2104741   Comparative Engineering   3(3-0-9)
Management
Analysis and comparison of western and eastern practices in engineering management in the areas of manufacturing, marketing and technology strategy; effects of differences in national and organizational cultures; case studies.

2104781   Doctoral Seminar in IE I   1(1-0-3)
Literature survey and discussion of academic development and recent applications in industrial engineering.

2104782   Doctoral Seminar in IE II   1(1-0-3)
Literature survey and discussion of academic development and recent applications in industrial engineering.

2104783   Doctoral Seminar in IE III   1(1-0-3)
Literature survey and discussion of academic development and recent applications in industrial engineering.

2104784   Doctoral Seminar in IE IV   1(1-0-3)
Literature survey and discussion of academic development and recent applications in industrial engineering.

2104785   Doctoral Seminar in IE V   1(1-0-3)
Literature survey and discussion of academic development and recent applications in industrial engineering.

2104786   Doctoral Seminar in IE VI   1(1-0-3)
Literature survey and discussion of academic development and recent applications in industrial engineering.

2104811 Thesis   12 credits
Research and report of research results in industrial engineering.

2104816 Thesis   36 credits
Research and report of research results in industrial engineering.

2104828   Dissertation   48 credits

2104894   Doctoral Dissertation Seminar   0(0-0-0)

2104897   Qualifying Examination   0(0-0-0)

5801601   Operations Management for IE   2(2-0-6)
Principles of operations management in manufacturing and service sectors; concepts and techniques for design, planning, and control of operations; quality and productivity improvement.

5801602   Microeconomics Analysis for IE   2(2-0-6)
The determination of prices in competitive markets; effects of government intervention on prices in competitive markets; profit-maximizing pricing decisions; game theory and its applications in oligopoly markets.

5801603   Macroeconomics Analysis for IE   2(2-0-6)
Principles of economics and macroeconomics; economic fluctuations; fiscal policy, monetary policy; international macroeconomics; economics growth and national competitiveness.

**5801604   Accounting for Engineering   2 (2-0-6)
           Decision Making**
Principles of accounting, accounting relationship among asset, liability, and shareholders' equity; financial reports; concepts of securities, bonds, and investments; receivable and revenue recognition

**5801605   Finance for Engineering Decision 2(2-0-6)
           Making**
Principles of finance, time value of money, interest rates, debt evaluation, capital budgeting, and applications in personal finance; investment evaluation; analysis of risk and return

DEPARTMENT OF CHEMICAL ENGINEERING

The Department of Chemical Engineering offers a Bachelor of Engineering degree, a Master of Engineering degree, and a Doctor of Engineering degree in Chemical Engineering. The department currently accepts a sophomore class of about 70 students for Bachelor's program, 100 students for Master program (50-60 for M.Eng.program, 30-40 for weekend M.Eng.program) and 5-10 students for Doctoral program.

The Bachelor of Engineering's degree program offers a complete set of basic courses in Chemical Engineering. The curriculum also allows the students to choose several elective courses. This special feature broadens the student's knowledge to meet his or her interest and the demands of the industries. The senior project introduces the students to the integration of knowledge and gives them hand-on experiences in solving the engineering and technological problems. The curriculum additionally stresses the training of the student to think and present oneself logically and independently.

The department of Chemical Engineering offers two graduate programs leading to the degree of Master of Engineering and the degree of Doctor of Engineering

Students entering graduate study in the Department normally have a bachelor's degree in Chemical Engineering. The Department also admits exceptional students who majored in another branch of engineering, or science at the undergraduate level. Depending on their background, these students have to take undergraduate chemical engineering courses as necessary, while simultaneously taking graduate level subjects for which they have adequate preparation.

The applicant for a doctoral degree must hold either a Bachelor's degree in Chemical Engineering with Second Class Honors or equivalent or a master's degree in Chemical Engineering.

The research activities at the department are grouped into 10 areas of interest, namely, biochemical engineering, catalysts and catalytic reaction engineering, control and system engineering, environmental chemical engineering and safety, life cycle engineering, oleochemical, particle technology and material processing, polymer science and polymer engineering, process systems engineering, and separation technology. Each student can choose to do his or her research in any one of these research areas.

The collaboration between the department and top universities in several countries such as Japan, Canada, England, Australia and China will strengthen graduate program of the department.

The above curriculum and research activities together with strong interaction between faculties and students in all levels have produced the graduates who can meet the demands and needs of the chemical, petrochemical, and related industries as well as various governmental organizations. Additionally, these have paved the way for the Department of Chemical Engineering to establish herself as an active partner in the advancement of Chemical Engineering discipline in Thailand.

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Paisan Kittisupakorn, Ph.D. (London)

PROFESSOR:
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Muenduen Phisalaphong,	B.Sc. (Kasetsart), M.Eng. (Chula), M.Sc. (Lehigh), Ph.D. (Colorado State)
Varong Pavarajarn,	Ph.D. (Oregon State)
Ura Pancharoen,	B.S. (Newark), M.Sc., D.Eng.Sc. (NJIT)

ASSISTANT PROFESSORS :
Amornchai Arpornwichanop,	D.Eng. (Chula)
Apinan Soottitantawat,	B.Eng.(Chula), M.Sc.,D.eng. (Tottori)
Nattaporn Tonanon,	D.Eng. (Kyoto)
Sorada Kanokpanont,	Ph.D. (Drexel)
Suphot Phatanasri,	B.Sc. (Chiangmai), M.Eng. (Chula), D.Eng. (Kyoto)

LECTURERS :
Akawat Sirisuk,	Ph.D. (Wisconsin)
Chutimon Satirapipathkul,	D.Eng (Tokyo Tech)
Jirdsak Tscheikuna,	Ph.D.(OklahomaState)
Sirijutaratana Covavisaruch,	Ph.D. (Michigan, Ann Arbor)
Sirikanya Singcuna,	M.S. (Waterloo)
Varun Taepaisitphongse,	Ph.D. (UCLA)
Pimporn Ponpesh	Ph.D. (California)

CHEMICAL ENGINEERING CURRICULUM
FIRST YEAR CURRICULUM
COMMON TO ALL ENGINEERING STUDENTS

COURSE NO.	SUBJECT	CREDITS
	THIRD SEMESTER	
2103213	ENG MECHANICS I	3
2105220	CHE CHEM	3
2105221	CHE CHEM LAB	1
2105222	CHE THERMO I	3
2105261	CHEM PROD IND	3
2105262	CHE PRIN	3
5500208	COM PRES SKIL	3
		19

FOURTH SEMESTER

2103231	MECH OF MAT I	3
2105223	CHE THERMO II	3
2105230	CHE MATH I	3
2105251	UNIT OP I	3
XXXXXXX	GENERAL EDUCATION	6
		18

FIFTH SEMESTER

2105331	CHE MATH II	3
2105332	CHE STAT	3
2105352	UNIT OP II	3
2105356	UNIT OP LAB I	1
2105373	CHEM ENG KIN REACT	3
5500308	TECH WRIT ENG	3
XXXXXXX	GENERAL EDUCATION	3
		19

SIXTH SEMESTER

2105301	CHE SEM I	1
2102391	ELEC ENG	3
2102392	ELEC ENG LAB I	1
2105333	TRANS PHENO	3
2105353	UNIT OP III	3
2105357	UNIT OP LAB II	1
2105362	CHEM PROC ECON ASSESS	3
XXXXXXX	GENERAL EDUCATION	3
		17

SUMMER SEMESTER

2100301	ENG PRACTICE	2

SEVENTH SEMESTER

2105458	UNIT OP LAB III	1
2105463	CHE PROC	3
2105464	CHEM PROC DSGN	3
2105472	PROC DYN CONTROL	3
2105480	SAFETY IN CHEM OPER	3
2105491	CHE PROJ I	1
21054XX	ELECTIVE COURSE	3
		17

EIGHTH SEMESTER

2105402	CHE SEM II	1
2105465	CHEM PLANT DSGN	3
2105482	ENV CHEM ENG	3
2105498	CHE PROJ II	3
OR2100499	ENGINEERING PROJECT	3
21054XX	ELECTIVE COURSE	3
XXXXXXX	FREE ELECTIVE	3
XXXXXXX	FREE ELECTIVE	3
		18

TOTAL CREDITS FOR GRADUATION = 146

NAME OF THE DEGREE

: Master of Engineering
: M.Eng.

PROFESSORS :

Paisan	Kittisupakorn,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Piyasan	Praserthdam,	B.Eng. (Chula), M.Sc. (P.I.N.Y.), Dr.Ing. (I.N.S.A.) (Toulouse)
Suttichai	Assabumrungrat,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)

ASSOCIATE PROFESSORS :

Artiwan	Shotipruk,	Ph.D. (Michigan, Ann Arbor)
Anongnat	Somwangthanaroj,	Ph.D. (Michigan)
Bunjerd	Jongsomjit,	Ph.D. (Pittsburgh)
Deacha	Chatsiriwech,	B.Eng. (Chula), D.I.C., Ph.D. (London)
Joongjai	Panpranot,	Ph.D. (Clemson)
Kasidit	Nootong,	Ph.D. (Pennsylvania)
Prasert	Pavasant,	B.Eng, (Chula), M.Sc., D.I.C., Ph.D. (London)
Sarawut	Rimdusit,	B.Eng. (Chula), M.S.,Ph.D. (CWRU)
Seeroong	Prichanont,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Siriporn	Damrongsukkul,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Soorathep	kheawhom,	Ph.D. (Tokyo)
Tawatchai	Charinpanitkul,	B.Eng. (Chula) M.Eng., D.Eng. (Tokyo)
Tharathon	Mongkhonsi,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Muenduen	Phisalaphong,	B.Sc. (Kasetsart), M.Eng. (Chula), M.Sc. (Lehigh), Ph.D. (Colorado State)
Varong	Pavarajarn,	Ph.D. (Oregon State)
Ura	Pancharoen,	B.S. (Newark), M.Sc., D.Eng.Sc. (NJIT)

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Nattaporn	Tonanon,	D.Eng. (Kyoto)
Sorada	Kanokpanont,	Ph.D. (Drexel)
Suphot	Phatanasri,	B.Sc. (Chiengmai), M.Eng. (Chula), D.Eng. (Kyoto)

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Jirdsak	Tscheikuna,	Ph.D. (OklahomaState)
Sirijutaratana	Covavisaruch,	Ph.D. (Michigan, Ann Arbor)
Sirikanya	Singcuna,	M.S. (Waterloo)
Varun	Taepaisitphongse,	Ph.D. (UCLA)
Pimporn	Ponpesh	Ph.D. (California)

ADMISSION

An applicant must hold a Bachelor's Degree in Chemical Engineering or equivalent and also meets the requirements of the Graduate School.

DEGREE REQUIREMENTS
(for bachelor degree of chemical engineering graduated)

Students with bachelor degree of chemical engineering are required to complete 24 credits of courses and a thesis of 12 credits. The course consists of 9 credits of required courses in 1,not less than 6 credits of approved elective course from the same group in 2, and 9 credits of free elective courses in 3 or from another groups in 2. Chemical engineering seminar I and II are no credit required courses (S/U) and not counted to fulfill the program.

COURSE REQUIREMENTS

1. Required Courses		2 credits	from
2105605	Seminar I	1(1-0-3)	
2105606	Seminar II	1(1-0-3)	

2) Core Course		15 credits	from
- Group I			
2105602	Advanced Transport Phenomena	3(3-0-9)	
2105685	Selected Topics in Transport Phenomena	3(3-0-9)	
- Group II			
2105603	Advanced Chemical Engineering Thermodynamics	3(3-0-9)	
2105686	Selected Topics in Chemical Engineering Thermodynamics	3(3-0-9)	
- Group III			
2105604	Advanced Chemical Engineering Kinetics and Chemical Reactor Design	3(3-0-9)	
2105687	Advanced Chemical Kinetics and Catalysis	3(3-0-9)	
2105688	Selected Topics in Chemical Engineering Kinetics	3(3-0-9)	
- Group IV			
2105601	Advance Engineering Mathematics for Chemical Engineers	3(3-0-9)	
2105607	Chemical Engineering Process Scale-up	3(3-0-9)	
2105612	Chemical Engineering Process and Product Development	3(3-0-9)	
2105617	Research Methodology and Statistical Analysis	3(3-0-9)	
2105618	Characterization and Instrumental Analysis	3(3-0-9)	
2105676	Instrumentation in Chemical Process	3(3-0-9)	

2105671	Process Dynamics	3(3-0-9)
2105623	Optimization of Chemical Processes	3(3-0-9)
2105689	Safe Process Operation and Design	3(3-0-9)
2105699	Multifunctional Reactor	3(3-0-9)

3) Elective Courses 9 credits from

- Chemical Engineering Fundamental Division

2105526	Total Productive Management for Chemical Process Industry	3(3-0-9)
2105608	Adsorption Process	3(3-0-9)
2105610	Membrane Technology	3(3-0-9)
2105611	Separation Technology Via Liquid Membrane And Application	3(3-0-9)
2105613	Mass Transfer Operation	3(3-0-9)
2105626	Advanced Heat Transfer	3(3-0-9)
2105663	Heat Transfer Operation	3(3-0-9)
2105682	Surface Technology	3(3-0-9)
2105684	Chemical Analysis for Chemical Process Control I	3(3-0-9)
2105690	Independent Study I	3(3-0-9)
2105691	Independent Study II	3(3-0-9)
2105692	Independent Study III	3(3-0-9)

- Process Control and System Engineering Division

2105522	Dynamic Process Simulation	3(3-0-9)
2105599	Batch Chemical Processes	3(3-0-9)
2105619	Advanced Automatic Process Control	3(3-0-9)
2105693	Special Problems in Process Control Engineering	3(3-0-9)

- Petrochemical Engineering Division

2105630	Heterogeneous Catalytic Reactor Modeling	3(3-0-9)
2105631	Advanced Catalysts for Polymers	3(3-0-9)
2105632	Petrochemical Technology	3(3-0-9)
2105634	Catalysis	3(3-0-9)
2105636	Heterogeneous Catalysis	3(3-0-9)
2105637	Design of Industrial Catalysis	3(3-0-9)
2105681	Catalyst Deactivation	3(3-0-9)
2105694	Special Problems in Petrochemical Engineering	3(3-0-9)

- Polymer Engineering Division

2105527	Polymer Characterization and Fracture	3(3-0-9)
2105638	Advanced Polymer Engineering	3(3-0-9)
2105643	Polymer Processing	3(3-0-9)
2105649	Polymer Blends and Composites	3(3-0-9)
2105675	Polymer Chemistry for Engineers	3(3-0-9)
2105695	Special Problems in Polymer Engineering	3(3-0-9)

- Biochemical Engineering Division

2105641	Biodegradable Material Engineering	3(3-0-9)
2105650	Biochemical Engineering	3(3-0-9)
2105652	Bioreactor Analysis and Control Design	3(3-0-9)
2105654	Biosensors	3(3-0-9)
2105655	Bioprocess Plant Design	3(3-0-9)
2105659	Biochemical Separation Technology	3(3-0-9)
2105679	Bioactive Compounds	3(3-0-9)

2105683	Bioenergy Technology	3(3-0-9)
2105696	Special Problems in Biochemical Engineering	3(3-0-9)

- Cleaner Production Engineering Division

2105666	Source Control of Particulate Emission	3(3-0-9)
2105667	Loss Prevention in Chemical Operations	3(3-0-9)
2105697	Special Problems in Cleaner Production Engineering	3(3-0-9)

- Particle Technology Division

2105572	Encapsulation Process	3(3-0-9)
2105609	Advanced Particulate Technology	3(3-0-9)
2105616	Fluid and Particle Mechanics	3(3-0-9)
2105672	Simulation of Particulate and Material Processing	3(3-0-9)
2105678	Introduction to Nanotechnology	3(3-0-9)
2105698	Special Problems in Particle Technology	3(3-0-9)

4) THESIS

2105811	THESIS	12	credits
2105816	THESIS	36	credits

Master of Chemical Engineering Program
First Year

First Semester

2105602	ADV TRANS PHENOM	3
2105603	ADV CHE THERMO	3
2105604	ADV CHE KINETICS	3
21056xx/5xx	Free Elective	3
		12

Second Semester

2105605	Seminar I	1
21056xx	Approved Elective	3
21056xx	Approved Elective	3
21056xx/5xx	Free Elective	3
21056xx/5xx	Free Elective	3
2105811	Thesis	2
		15

Second Year
First Semester

2105606	Seminar II	1
2105811	Thesis	6
21056xx/5xx	Free Elective(Option)	3
		7,10

Second Semester

2105811	Thesis	4
21056xx/5xx	Free Elective(Option)	3
		4,7

DEGREE REQUIREMENTS
(for non-bachelor degree of chemical engineering graduated)

Students with non-bachelor degree of chemical engineering are required to complete 30 credits of engineering and chemical engineering fundamental courses, 24 credits of courses and a thesis of 12 credits. The fundamental courses of 30 credits are lists in 5. The course consists of 9 credits of required courses in 1, not less than 6 credits of approved elective course from the same group in 2, and 9 credits of free elective courses in 3 or from another groups in 2. The fundamental, chemical Engineering Seminar I and II are non credit required courses (S/U) and not counted for in order to fulfill the program.

Master of Chemical Engineering Program

First Year
First Semester

2105373	Chemical Engineering Kinetics and Reactor Design	3
2105331	Chemical Engineering Mathematics II	3
2103106	Engineering Drawing	3
2105603	ADV CHE THERMO	3
21056xx/5xx	Free Elective	3
		6

Second Semester

2105333	Transport Phenomena	3
2105251	Unit Operations I	3
21056xx	Approved Elective	3
21056xx/5xx	Free Elective	3
2105605	Seminar I	1
		6

Second Year
First Semester

2105352	Unit Operations II	3
2105356	Unit Operations Laboratory I	1
2105602	ADV TRANS PHEHOM	3
2105604	ADV CHE KINETICS	3
2105606	Seminar II	1
		6

Second Semester

2105353	Unit Operation III	3
2105357	Unit Operations Laboratory II	1
21056xx	Approved Elective	3
21056xx/5xx	Free Elective	3
2105811	Thesis	2
		8

Third Year
First Semester

2105464	Chemical Process Design	3
2105472	Process Dynamics and Control	3
2105458	Unit Operations Laboratory III	1
2105811	Thesis	4
21056xx/5xx	Free Elective (Option)	3
		4,7

Second Semester

2105811	Thesis	6
21056xx/5xx	Free Elective (Option)	3
		6,9

COURSE REQUIREMENTS
Fundamental Courses

2103106	Engineering Drawing	3(1-4-4)
2105251	Unit Operations I	3(3-0-6)
2105331	Chemical Engineering Mathematics II	3(3-0-6)
2105333	Transport Phenomena	3(3-0-6)
2105352	Unit Operations II	3(3-0-6)
2015353	Unit Operations III	3(3-0-6)
2105356	Unit Operations Laboratory I	1(0-3-0)
2105357	Unit Operations Laboratory II	1(0-3-0)
2105373	Chemical Engineering Kinetics and Reactor Design	3(3-0-6)
2105458	Unit Operations Laboratory III	1(0-3-0)
2105464	Chemical Process Design	3(2-3-4)
2105472	Process Dynamics and Control	3(3-0-6)

2) Required Courses   9   credits

2105602	Advanced Transport Phenomena	3(3-0-9)
2105603	Advanced Chemical Engineering Thermodynamics	3(3-0-9)
2105604	Advanced Chemical Engineering Kinetics and Chemical Reactor Design	3(3-0-9)
2105605	Chemical Engineering Seminar I	1(1-0-3)
2105606	Chemical Engineering Seminar II	1(1-0-3)

3) Approved Elective   6   credits

2105601	Advanced Engineering Mathematics for Chemical Engineers	3(3-0-9)
2105607	Chemical Engineering Process Scale-up	3(3-0-9)
2105612	Chemical Engineering process and Product Development	3(3-0-9)
2105617	Research Methodology and Statistical Analysis	3(3-0-9)
2105618	Characterization and Instrumental Analysis	3(3-0-9)
2105622	Chemical Process Simulation and Optimization	3(3-0-9)
2105676	Instrumentation in Chemical Process	3(3-0-9)

4) Elective Courses   9   credits

Group 1 : Chemical Engineering Fundamental Division

2105526	Total Productive Management for Chemical Process Industry	3(3-0-9)
2105608	Adsorption Process	3(3-0-9)
2105610	Membrane Technology	3(3-0-9)
2105611	Separation Technology via Liquid Membrane and Application	3(3-0-9)
2105613	Mass Transfer Operations	3(3-0-9)
2150626	Advanced Heat Transfer	3(3-0-9)
2150661	Special Problems in Chemical Engineering	3(3-0-9)
2105662	Selected Topics in Chemical Engineering	3(3-0-9)
2150663	Heat Transfer Operation	3(3-0-9)
2105665	Cryogenic Engineering	3(3-0-9)
2105673	Design and Analysis of Experiments in Chemical Engineering	3(3-0-9)
2105680	Multifunctional Reactor	3(3-0-9)
2105682	Surface Technology	3(3-0-9)
2105684	Chemical Analysis for Chemical Process Control I	3(3-0-9)

Group 2 : Process Control and Systems Engineering Division

2105522	Dynamic Process Simulation	3(3-0-9)
2105599	Batch Chemical Process	3(3-0-9)
2105619	Advanced Automatic Process Control	3(3-0-9)
2105621	Multivariable Process Control	3(3-0-9)
2105623	Optimization of Chemical Processes	3(3-0-9)
2105624	Computer Process Control	3(2-3-7)
2105625	Process Control and Management	3(3-0-9)
2105628	Process Control Instrumentation	3(3-0-9)
2105629	Process Identification and Data Analysis	3(3-0-9)
2105671	Process Dynamics	3(3-0-9)
2105674	Computer-Aided Process and Product Engineering	3(3-0-9)

Group 3 : Petrochemical Engineering Division

2105630	Heterogeneous Catalytic Reactor Modelling	3(3-0-9)
2105631	Advanced Catalysts for Polymers	3(3-0-9)
2105632	Petrochemical Technology	3(3-0-9)
2105634	Catalysis	3(3-0-9)
2105636	Heterogeneous Catalysis	3(3-0-9)
2105637	Design of Industrial Catalysts	3(3-0-9)
2105681	Catalyst Deactivation	3(3-0-9)

Group 4 : Polymer Engneering Division

2105527	Polymer Characterization and Fracture	3(3-0-9)
2105638	Advanced Polymer Engineering	3(3-0-9)
2105643	Polymer Processing	3(3-0-9)
2105649	Polymer Blends and Composites	3(3-0-9)
2105675	Polymer Chemistry for Engineers	3(3-0-9)

Group 5 : Biochemical Engineering Division

2105641	Biodegradable Material	3(3-0-9)

	Engineering	
2105650	Biochemical Engineering	3(3-0-9)
2105652	Bioreactor Design Analysis and Control	3(3-0-9)
2105654	Biosensors	3(3-0-9)
2105655	Bioprocess Plant Design	3(3-0-9)
2105656	Bioremediation Engineering	3(3-0-9)
2105659	Biochemical Separation Technology	3(3-0-9)
2105679	Bioactive Compounds	3(3-0-9)
2105683	Bioenergy Technology	3(3-0-9)

Group 6 : Cleaner Production Engineering Division

2105666	Source Control of Particulate Emissions	3(3-0-9)
2105667	Loss Prevention in Chemical Operations	3(3-0-9)
2105668	Energy Conservation in Chemical Processes	3(3-0-9)
2105669	Cleaner Technology	3(3-0-9)

Group 7 : Particle Technology Division

2105571	Aerosol Engineering	3(3-0-9)
2105572	Encapsulation Process	3(3-0-9)
2105609	Advanced Particulate Technology	3(3-0-9)
2105616	Fluid and Particle Mechanics	3(3-0-9)
2105672	Simulation of Particulate and Material Processing	3(3-0-9)
2105678	Introduction to Nanotechnology	3(3-0-9)

4) Thesis

2105811	Thesis	12 Credits

NAME OF THE DEGREE

: Doctor of Engineering
: D.Eng.

PROFESSORS :

Paisan	Kittisupakorn,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Piyasan	Praserthdam,	B.Eng. (Chula), M.Sc. (P.I.N.Y.), Dr.Ing. (I.N.S.A.) (Toulouse)
Suttichai	Assabumrungrat,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)

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Bunjerd	Jongsomjit,	Ph.D. (Pittsburgh)
Deacha	Chatsiriwech,	B.Eng. (Chula), D.I.C., Ph.D. (London)
Joongjai	Panpranot,	Ph.D. (Clemson)
Kasidit	Nootong,	Ph.D. (Pennsylvania)
Prasert	Pavasant,	B.Eng, (Chula), M.Sc., D.I.C., Ph.D. (London)
Sarawut	Rimdusit,	B.Eng. (Chula), M.S.,Ph.D. (CWRU)
Seeroong	Prichanont,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Siriporn	Damrongsukkul,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Soorathep	kheawhom,	Ph.D. (Tokyo)
Tawatchai	Charinpanitkul,	B.Eng. (Chula) M.Eng., D.Eng. (Tokyo)
Tharathon	Mongkhonsi,	B.Eng. (Chula), M.Sc., D.I.C., Ph.D. (London)
Muenduen	Phisalaphong,	B.Sc. (Kasetsart), M.Eng. (Chula), M.Sc. (Lehigh), Ph.D. (Colorado State)
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Nattaporn	Tonanon,	D.Eng. (Kyoto)
Sorada	Kanokpanont,	Ph.D. (Drexel)
Suphot	Phatanasri,	B.Sc. (Chiengmai), M.Eng. (Chula), D.Eng. (Kyoto)

LECTURERS :

Akawat	Sirisuk,	Ph.D. (Wisconsin)
Chutimon	Satirapipathkul,	D.Eng (Tokyo Tech)
Jirdsak	Tscheikuna,	Ph.D. (OklahomaState)
Sirijutaratana	Covavisaruch,	Ph.D. (Michigan, Ann Arbor)
Sirikanya	Singcuna,	M.S. (Waterloo)
Varun	Taepaisitphongse,	Ph.D. (UCLA)
Pimporn	Ponpesh	Ph.D. (California) Ph.D.(UCD)

ADMISSION

The applicant must hold either a Bachelor's Degree in Chemical Engineering or equivalent with Second Class Honors, or a Master's Degree in Chemical Engineering, which is required for Pattern II. The additional requirement for Pattern I is the minimum grade point average of 3.5 on Master's Degree in Chemical Engineering.

COURSE REQUIREMENTS

1) *Required Courses for Pattern II (1)   12 credits*

2105601	Advanced Engineering Mathematics for Chemical Engineers	3(3-0-9)
2105602	Advanced Transport Phenomena	3(3-0-9)
2105603	Advanced Chemical Engineering Thermodynamics	3(3-0-9)
2105604	Advanced Chemical Engineering Kinetics and Chemical Reactor Design	3(3-0-9)
2105717	Seminar in Chemical Engineering III	1(1-0-3)
2105718	Seminar in Chemical Engineering IV	1(1-0-3)

2) *Elective Courses for Pattern II (2)   12 credits*

2105645	Polymer Extrusion Process and Design	3(3-0-9)
2105701	Advanced Process System Engineering	3(3-0-9)
2105702	Advanced Separation Technology	3(3-0-9)
2105703	Optimal Process Control	3(3-0-9)
2105709	Special Projects in Chemical Engineering	3(3-0-9)
2105710	Air Engineering and Control of Gaseous Air Pollutants	3(3-0-9)

Students may select other courses offered by the Graduate School, Chulalongkorn University, with approval from their academic advisor or Chemical Engineering Department.

There are two patterns of study as follows:

	Pattern I	Pattern II (1)	Pattern II (2)
	Master's Degree Holder	Bachelor's Degree Holder	Master's Degree Holder
Required Courses	0	12	0
Elective Courses	0	12	12
Seminar in Chem Eng.	2*	2*	2*
Dissertation	48	48	48
Total course requirements	48	72	60

* Seminar in Chemical Engineering III and IV are non credit required courses (s/u) and not counted   for in order to fulfill the program.

DOCTOR OF CHEMICAL ENGINEERING PROGRAM

Pattern I for Master's degree holder

First Semester

2105717	Seminar in Chemical Engineering III	1
		(s/u)**
2105829	Dissertation	<u>10</u>
		10

Second Semester

2105718	Seminar in Chemical Engineering IV	1
		(s/u)**
2105829	Dissertation	<u>10</u>
		10

Third Semester

2105894	Doctoral Dissertation Seminar	0
		(s/u)**
2105829	Dissertation	<u>10</u>
		10

Fourth Semester

2105894	Doctoral Dissertation Seminar	0
		(s/u)**
2105829	Dissertation	<u>10</u>
		10

Fifth Semester

2105894	Doctoral Dissertation Seminar	0
		(s/u)**
2105829	Dissertation	<u>10</u>
		10

Sixth Semester

2105894	Doctoral Dissertation Seminar	0
		(s/u)**
2105829	Dissertation	<u>10</u>
		10

Pattern II (1) for Bachelor's degree holder

First Semester

| 2105717 | Seminar in Chemical Engineering III | 1 |
| | | (s/u)** |

| 2105830 | Dissertation | <u>9</u> |
| | | *9* |

Second Semester

2105718	Seminar in Chemical Engineering IV	1
		(s/u)**
2105830	Dissertation	<u>9</u>
		9

Third Semester

2105894	Doctoral Dissertation Seminar	0
		(s/u)**
2105830	Dissertation	<u>9</u>
		9

Fourth Semester

2105894	Doctoral Dissertation Seminar	0
		(s/u)**
2105830	Dissertation	<u>9</u>
		9

Fifth Semester

2105894	Doctoral Dissertation Seminar	0
		(s/u)**
2105830	Dissertation	<u>9</u>
		9

Sixth Semester

2105894	Doctoral Dissertation Seminar	0
		(s/u)**
2105830	Dissertation	<u>9</u>
		9

Seventh Semester

2105894	Doctoral Dissertation Seminar	0
		(s/u)**
2105830	Dissertation	<u>9</u>

Eighth Semester

2105894	*Doctoral Dissertation Seminar*	*0*
		*(s/u)**
2105830	*Dissertation*	<u>*9*</u>
		9

Pattern II (2) for Master's degree holder

First Semester

21056xx	Elective in CHE	3
21056xx	Elective in CHE	3
2105717	Seminar in Chemical Engineering III	1 (s/u)**
2105828	Dissertation	<u>4</u>
		10

Second Semester

21056xx	Elective in CHE	3
21056xx	Elective in CHE	3
2105718	Seminar in Chemical Engineering IV	1 (s/u)**
2105828	Dissertation	<u>4</u>
		10

Third Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>10</u>
		10

Fourth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>10</u>
		10

Fifth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>10</u>
		10

Sixth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>10</u>
		10

Pattern II (2) for Bachelor's degree holder

First Semester

2105602	Advanced Transport Phenomena	3
2105603	Advanced CHE ENG Transport Phenomena	3
2105604	Advanced CHE ENG Kinetics and CHE Reactor Design	3
21056xx	Elective in CHE	3
2105717	Seminar in Chemical Engineering III	1 (s/u)**
		12

Second Semester

21056xx	Approve Elective in CHE	3
21056xx	Approve Elective in CHE	3
21056xx	Elective in CHE	3
21056xx	Elective in CHE	3
2105718	Seminar in Chemical Engineering IV	<u>1</u> (s/u)**
		12

Third Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>8</u>
		8

Fourth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>8</u>
		8

Fifth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>8</u>
		8

Sixth Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>8</u>
		8

Seven Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>8</u>
		8

Eight Semester

2105894	Doctoral Dissertation Seminar	0 (s/u)**
2105828	Dissertation	<u>8</u>
		8

COURSES DESCRIPTIONS
IN CHEMICAL ENGINEERING (B.ENG.)

2105220   Chemical Engineering Chemistry 3(3-0-6)
Principles of chemical analysis for chemical engineers for quality control, process control, and researches, utilization of quantitative analysis and interpretation, techniques of chemical analysis, using traditional methods, and use of analysis instruments, principles of organic chemistry to be applied in chemical industries and bio-engineering, properties and reactions of basic functional groups: hydrocarbons, hydroxyl, ether, carbonyl, carboxylic, and organic complexes.

**2105221   Chemistry for Chemical   1(0-3-0)
                  Engineering Laboratory**
Practice in chemical analysis using various techniques for quality control, process control, and research.

**2105222   Chemical Engineering   3(3-0-6)
                  Thermodynamics I**
Prediction of thermodynamic properties of single components, ideal gas law, equation of states of gas and liquid, gaseous and liquid mixtures, thermodynamic laws, relationships of thermodynamic properties, phase equilibrium of single components, refrigeration cycle.

**2105223   Chemical Engineering   3(3-0-6)
                  Thermodynamics II**
Prediction of thermodynamic properites of mixtures, phase equilibrium of mixtures, vapour-liquid equilibrium, liquid-liquid equilibrium, liquid-solid equilibrium, vapour-solid equilibrium, vapour-liquid-liquid equilibrium, chemical equilibrium, thermodynamics of chemical processes.

**2105230   Chemical Engineering   3(3-0-6)
                  Mathematics I**
Fundamental of line integration and surface integration, polar co-ordinates, calculus of real value multivariable functions and application, analysis principles for solving chemical engineering problems.

2105251   Unit Operations I   3(3-0-6)
Units for transporting liquid and gas, fluidized systems, pneumatic system for transport particles, unit operations for separating particles from gaseous and liquid system with centrifugal forces, filtration, and diffusion.

2105261   Chemicals Production Industries 3(3-0-6)
Industrial standard, law related to chemical industries, components of chemical plants, responsibilities of engineers.

2105262   Chemical Engineering Principles 3(3-0-6)
Principles of chemical engineering, relationship of mass with chemical reactions, conservation of mass and energy, use of phase equilibrium and thermodynamic properties.

2105301 Chemical Engineering Seminar I   1(0-3-0)
Softskill improvement for quality chemical engineer. Discussion of various topics relevant for recent chemical engineering development.

**2105331 Chemical Engineering   3(3-0-6)
                Mathematics II**
Numerical techniques for solving chemical engineering problems, application of computer for solving chemical engineering problems.

2105332 Chemical Engineering Statistics   3(3-0-6)
Elementary principles of statistics and probability, random variables and probability distributions, experimental data analysis, chemical process parameter estimation, linear regression and correlation, multiple regression, design and analysis of chemical experiments with single factor and with several factors, chemical process modeling with stochastic approach.

2105333 Transport Phenomena   3(3-0-6)
Viscosity, mathematical models of momentum transports in isothermal fluid systems, thermal conduction and convection, mathematical models of energy transports in solids and in fluids for isothermal systems and non-isothermal systems, diffusion in binary mixtures, mathematical models of mass transports in isothermal mixtures without chemical reactions and with chemical reactions, simultaneous mass and energy transports in fluid mixtures.

2105352 Unit Operations II   3(3-0-6)
Unit Operations for separating gaseous and liquid mixtures with distillation, absorption, extraction, adsorption and crystallization.

2105353 Unit Operations III   3(3-0-6)
Unit operations for exchanging heat, boilers, evaporators, condensers, dryers, and cooling water systems.

2105356 Unit Operations Laboratory I   1(0-3-0)
Condition: Prerequisite 2105251
Practice unit operations for momentum transports.

2105357 Unit Operations Laboratory II   1(0-3-0)
Condition: Prerequisite 2105352
Practice unit operations for mass transport and reaction kinetics.

**2105362 Chemical Process Economic   3(3-0-6)
                Assessment**
Cost components of chemical industries, chemical industrial cost indexes, capital cost components, capital investment estimates, purchase costs of process equipments, manufacturing cost components, manufacturing cost estimates, chemical process depreciation estimates, feasibility analysis, alternative investments and replacements

**2105373 Chemical Engineering Kinetics   3(3-0-6)
                and Reactor Design**
Fundamental principles of chemical kinetics; diffusion and catalysis; concepts of reactor design; the effect of reactor geometry, operating conditions, and flow characteristics on mass and energy conservation equations; single and multiple reactor systems.

2105385 Recycling of Agricultural and Agro 3(2-3-4)
Inductrial Waste

Wealth of Thailand, bio-diversity in Thailand, role of technology in full utilization of agri-waste or agro-industrial waste; cycles of agri-waste and agro-industrial waste; characterization of agri-waste and agro-industrial waste; utilization of agri-waste and agro-industrial waste; project/product evaluation.

2105402 Chemical Engineering Seminar II 1(0-3-0)

Softskill improvement for quality chemical engineer. Discussion of various topics relevant for recent chemical engineering development.

2105403 Special Topics in Chemical 3(3-0-6)
Engineering I
Condition: Consent of Faculty

Special topics in Chemical Engineering including new technology.

2105404 Special Topics in Chemical 3(3-0-6)
Engineering II
Condition: Consent of Faculty

Special topics in Chemical Engineering including new technology.

2105405 Study Abroad I 2(2-0-4)
Condition: Consent of Faculty

Knowledge in chemical engineering obtains during the study abroad.

2105406 Study Abroad II 2(2-0-4)
Condition: Consent of Faculty

Knowledge in chemical engineering obtains during the study abroad.

2105407 Study Abroad III 2(2-0-4)
Condition: Consent of Faculty

Knowledge in chemical engineering obtains during the study abroad.

2105409 Study Abroad IV 3(3-0-6)
Condition: Consent of Faculty

Knowledge in chemical engineering obtains during the study abroad.

2105410 Study Abroad V 3(3-0-6)
Condition: Consent of Faculty

Knowledge in chemical engineering obtains during the study abroad.

2105430 Particle Technology 3(3-0-6)

Particle characterization, transport of powder, selection of transport equipment (screw conveyor, belt conveyor, bucket elevator, pneumatic conveyor, air slide, etc.), storage of powder (hopper and silo design), powder feeding and discharging systems, classification of particles, granulation and agglomeration, comminution (size reduction), mixing and agitation of powder, kneading filter press (expression), extrusion.

2105445 Catalyst Reaction Engineering 3(3-0-6)

Fundamentals

Catalyst structures and functions; fundamentals of catalyst manufacturing processes and catalyst rection engineering; applications of catalysts in petrochemical and chemical engineering processes; catalyst reactor design.

2105452 Fermentation Processes 3(3-0-6)

Detailed study of the processes, operations, technology involved in selected industrial fermentation processes directed towards the production of pharmaceuticals and industrial chemicals.

2105453 Introduction to Biochemical 3(3-0-6)
Engineering

Importance of biochemical reactions in the industries, health & medicine, and daily life. A review of biochemical reaction kinetics for enzymes and cells including introduction to bioreactor design and downstream processing of the desire products. Separation of natural derived bioactive agents or cell components. Processes in pharmaceutical industry. Principles and instrumentation of the related techniques. Application of naturally derived biomaterial for various industries, especially for medical products, cosmetics, foods, agriculture, and environment. Molecular genetics, proteis, and metabolic engineering. Entrapeneurship and trends of technology related to biological engineering.

2105456 Introduction to Polymer Science 3(3-0-6)

Polymer structures and physical properties, technology and mechanical properties of polymers, applications of polymers, polymer processing, plastic technology; fibre technology and elastomer technology.

2105458 Unit Operations Laboratory III 1(0-3-0)
Condition: Prerequisite 2105353

Practice unit operations for heat transport, and simultaneous heat and mass transports.

2105463 Chemical Engineering Processes 3(3-0-6)

Development of industrial chemical processes, relationship of unit operations, with raw materials, products, and energy for production, process energy, by-products and wastes managements.

2105464 Chemical Process Design 3(2-3-4)

Design principles of reaction sections, selection of reactors, design principles of separation sections, development principles of process simulation model with commercial process simulator.

2105465 Chemical Plant Design 3(2-3-4)
Condition: Prerequisite 2105464

Design principles of heat exchanger network, process energy recovery principles, estimate equipment dimensions, selection principles of process equipment materials, and plant layout design.

2105466 Natural Gas and Petroleum Oil 3(3-0-6)
Conditioning

Condition: Senior Standing

Water content estimate, hydrate formation estimate, prevention of hydrate formation, dehydration methods, methods of acid gas removals, liquefaction of natural gas, petroleum oil refinery, reforming petroleum oil products, sulfur compound removals.

2105472   Process Dynamics and Control   3(3-0-6)

Mathematical modeling of chemical engineering systems; solution techniques and dynamics of these systems; introduction to automatic control; feedback control concept; stability analysis; frequency response and control system designs; introduction to measurement and control instrument characteristics.

**2105475   Total Productive Management for   3(3-0-6)
Chemical Process**

Related to Total Productive Management in Chemical Process Industries, Calculation of Key Management Index, Application of Chemical Engineering, such as Thermodynamics, Energy and Mass Transfer, and Statistics including Distribution Diagram, Control Chart.

**2105477   Computer Application in Chemical   3(3-0-6)
Engineering**

Computer software application for calculating and design related to chemical engineering.

**2105478   Petrochemical Engineering   3(3-0-6)
Processes**

Natural Gas Utilization Plan of Thailand; natural gas liquefaction plant; methanol plant; ethylene plant; gas separation plant; ammonia, urea, and phosphate plants; polypropylene plant; vinyl chloride monomer plant; polyvinyl chloride plant; polyethylene plant; ethylene oxide plant; polyester plant; polystyrene plant.

2105479   Polymer Engineering   3(3-0-6)

Definitions and concepts; crystalline and glassy polymers; molecular architecture: structure, steric factors, conformation and morphology; polymer synthesis: step and chain polymerization; transition phenomena, mechanical properties affected by the transition phenomena; elastomer, theory of rubber elasticity; Polymer rheology: types of mechanical deformations, simple rheological responses, viscoelastic properties of polymer, linear viscoelastic models; yielding and theories on yielding of glassy polymer.

2105480   Safety in Chemical Operations   3(3-0-6)
Condition: Senior Standing

Principles of industrial safety and loss control. Hazards of chemicals. Hazards of chemical operations, Hazards assessment. Prevention and control of hazards: Control system design for safe operation; Personal protective devices. Storage and transportation of hazardous materials. Industrial safety management. Emergency planning.

2105482   Environmental Chemical   3(3-0-6)

Engineering

Effects of pollutants on environments standard environmental qualities, sources and industrial wastewater characteristics and treatment methods, sources of air pollutants, control of particles and gaseous, compositions of solid wastes and hazardous wastes, method of treatments.

**2105486   Modern Techniques in Process   3(3-0-6)
Control**
Condition: Corerequisite 2105472

Principle and practice of modern control techiques in chemical processing; distributed control systems; computer integrated processing.

**2105487   Digital Process Control   3(1-4-2)
Laboratory**
*Condition: Prerequisite 2105472 or
Consent of Faculty*

Application of direct digital control principles of laboratory excercises supported by microcomputers; real time programming; data aquisition and control using simple and advanced control strategies; experiments in temperature, liquid level, pH controls; sequence control; term project.

2105491   Chemical Engineering Project I   1(0-2-1)

Data collection and assessment of suitable chemical industrial problems for chemical engineering projects.

2105492   Chemical Engineering Project II   2(0-4-2)
Condition: Prerequisite 2105491

A research on chemical engineering projects related to chemical industrial problems or innovations.

**COURSES DESCRIPTIONS
IN CHEMICAL ENGINEERING
(M.ENG, D.ENG.)**

2105522   Dynamic Process Simulation   3(3-0-9)

Fundamental of dynamic model development, lumped parameter systems, solution strategies for lumped parameter systems, distributed parameter systems, Solution strategies for distributed system, parameter system empirical model development, computer aided process modeling, static and dynamic simulation of chemical processes.

**2105526   Total Productive Management for   3(3-0-9)
Chemical Process Industry**

Total Productive Management, usage of Key Management Index, Key Performance Index, Key Activity Index, cascading of organizational resposibility autonomous management, productive maintenance, focused improvement, expansion based on knowledge transfer, quality management, initial phase management, management of safety, health and environment, management of social responsibility.

2105527   Polymer Characterization and   3(3-0-9)

Fracture

Structures-Properties-Performance relationship of polymers, the petrochemical and the plastic processing industrial approaches to polymer characterization, modification of polymers by compounding, blending & alloying and composites and their influences on fracture, transitions in polymers, thermal degradation of polymers, deformation in semi-crystalline and glassy polymers, shear yielding and crazing, fracture of polymers, modes of crack growth, brittle and ductile fracture of polymers, fracture morphology and fractography of polymers.

2105572   Encapsulation Process   3(3-0-9)

Encapsulation process, use of encapsualtion process in chemical industry and related industry, main techniques and methods in encapsualtion process, the selection of wall materials, the selection of appropriate technique for core materials, the application of encapsulation process in industries and their products.

2105599   Batch Chemical Processes   3(3-0-9)

Batch chemical processes: dynamics behavior, start-up, shut-down, batch distillation, batch reaction, batch mixing, batch extraction.

**2105601   Advanced Engineering   3(3-0-9)
            Mathematics for Chemical Engineers**

Matrices and solutions of sets of ordinary differential equations. Solution of partial differential equations using metod of infinite series and separation of variables. Bessel functions and legendre polynomials. Vector and tensor analysis. Complex variables. Analytic functions, harmonic functions, Cauchy's integral theorem, Laurent's expansion, and theory of residues. Calculus of variation.

2105602 Advanced Transport Phenomena   3(3-0-9)

Fundamentals of momentum, energy and mass transport. Determination of transport properties. Conservation of mass, momentum and energy in laminar flow and turbulent flow in microscopic approach. Equation of change for multicomponent systems. Dimensional analysis of equation of change. Simultaneous heat, mass, momentum transfer. Laminar and turbulent boundary layer theory.

**2105603 Advanced Chemical Engineering   3(3-0-9)
          Thermodynamics**

Introduction to molecular thermodynamics, equations of state, equations for activity coefficients, thermodynamic property determination, multicomponent phase equilibrium, process analysis.

**2105604 Advanced Chemical Engineering   3(3-0-9)
          Kinetecs and Chemical Reactor Design**

Review of fundamental principles. Order of reactions and rate equations. Theory of rate processes; diffusion, types of reactors, catalysis, mechanical arrangement of reactors for agitation, heat and mass transfer. Methods of designing chemical reactors with emphasis on continuous processing.

2105605 Chemical Engineering Seminar I   1(1-0-3)

Seminar and discussions on current research in chemical engineering for first year students.

2105606 Chemical Engineering Seminar II   1(1-0-3)

Seminar and discussions on current research in chemical engineering for second year students in the first semester.

**2105607 Chemical Engineering Process   3(3-0-9)
          Scale-up**

This course examines the technical isses associated with transforming a chemical process from small scale (e.g.lavoratory)tocommercial operation. The concepts underlying chemical principles, unit operations and transport phenomena are integrated to give students an understanding of the methodology involved in converting a laboratory experiment into a process with commercial potential. Specific topics include the effects of scale on the relative rates of mass, heat and momentum transfer, mixing effects, utility of various reactor operating modes (e.g. batch, semi-batch, continuous).

2105608   Adsorption process   3(3-0-9)

Adsorption phenomena, adsorption equilibrium, kinetics of mass transfers in porous particles, adsorption processes with steady-state and periodic operations, mathematical models of adsorption processes, chromatographic separation and gas separation with pressure swing adsorption

2105609   Advanced Particulate Technology 3(3-0-9)

Particle characterization and measurement of physical and chemical properties of powder; transport phenomena and related topics; advanced powder handling operations in the industry; detonation and dust explosion.

2105610 Membrane Technology   3(3-0-9)

Membrane structure and function; Production of membrane; characterization, selection and use of membrane system. Applications for membrane separations in various chemical and biochemical processes.

**2105611 Separation Technology Via Liquid   3(3-0-9)
          Menbrane And Application**

Variety of separation process via liquid membrane; selection of single/multiple extractant systems; design of a particular metal lon separation fromits mixture; the applications of hollow fiber supported liquid membrane in separation of toxic metals, precious metals, rare earth metals and radioactive metals.

**2105612 Chemical Engineering Process   3(3-0-9)
          and product Development**

Strategies for chemical product design: Needs, Ideas, Selection, Manufacture, Strategies for chemical process design: Process synthesis, Process simulation, selection and design of reactors, synthesis of separation system, energy recovery, environmental protection.

2105613 Mass Transfer operation 3(3-0-9)

Phase equilibrium, General selection criteria for processes. Fundamental principles and calculation methods, distillation, absorption, extraction and adsorption. Capacities and efficiencies of contracting devices. Energy requirements of mass transfer processes. Optimal design operation.

2105616 Fluid and Particle Mechanics 3(3-0-9)

Nature of two-phase gas-liquid flows. Flow regime maps. Flow with phase change. Modeling of regime transition, Conservation equations. Correlations and empirical models for two-phase flow. Annular flow. Slug flow. Bubble flow. Mechanical and surface properties of particles. Fundamentals of particle particle interaction. Powder flow and conveying. Agglomeration. Separation Process.

**2105617 Research Methodology and l 3(3-0-9)
            Statistica Analysis**

Steps employed in planning research and conducting research; Steps employed in writing a thesis or a research paper; Plagiarism; Presentation of the research; Test of statistical hypothesis; Analysis of variance; Design and analysis of experiments, Full and fractional factorial designs; Simple linear regression analysis; Multiple linear regression analysis; Basic nonlinear regression analysis.

**2105618 Characterization and Instrumental 3(3-0-9)
            Analysis**

Basic concepts of characterization and instrumental analysis: Thermal analysis, Crystallography, Surface analysis, Microscopy, FTIR, Raman spectroscopy, Chromatography, Mechanical testing.

**2105619 Advanced Automatic Process 3(3-0-9)
            Control**

Advanced control techniques, control of multiple-input multiple-output processes, discrete-time models. Dynamic response of discrete-time systems. Non-linear process control.

2105621 Multivariable Process Control 3(3-0-9)

Introduction to multivariable control, uncertainty and robustness for multivariable control system, controller design and control structure design.

**2105622 Chemical Process Simulation and 3(3-0-9)
            Optimization**

Process analysis and simulation: concept of model synthesis, model characterization based on behavioral principles and on mathematical properties, subsystems and systems analysis. To give a broad coverage of the field of computer applications to chemical engineering, with emphasis on steady-state flowsheeting and process simulation.

**2105623 Optimization of Chemical 3(3-0-9)
            processes**

Nature and organization of optimization problems. Fitting models to data. Formulation of objective functions.

Optimization of unconstrained functions. Unconstrained multivariable optimization. Linear programming and application. Nonlinear programming with constraints. Optimization of staged and discrete processes. Application of optimization to chemical processes.

2105624 Computer Process Control 3(3-0-9)

Computer hardware, interfacing, control algorithms and their implementation, distributed control system, predicitive control techniques, automatic tuning.

2105625 Process Control and Management 3(3-0-9)

Generalization concepts of process control; hierarchy in process concess control; planning and scheduling; manufacturing execution systems, plant information systems; process plan business function.

2105626 Advanced Heat Transfer 3(3-0-9)

Radiative heat transfer, radiative properties of real materials, radition exchange between black surfaces and between diffuse gray surfaces, special radiaive problems. Forced convection heat tranfer, convection processes, similarity theory, correlations of heat transfer coefficients, effect of viscous dissipation, non-continum effect. Analytical methods in conduction heat transfer. Bessel equation, the method of separation of variables, Laplace transforms, finite differences and finite elements. Heat transfer with vapourization, condensation and natural convection.

2105628 Process Control Instrumentation 3(3-0-9)

Sensors and actuators used in proess industries; signal conditioning and transmissionl analog and difital controllers; interfacing and communication; programmable logic controlers; distributed process control systems; safety in process automation.

**2105629 Process Identification and Data 3(3-0-9)
            Analysis**

Methods for modeling the dynamic behaviour of a process and its disturbances using data collected from the process; transfer function and time series modeling theory and techniques; statistical methods for structure determination parameter estimation, model validation, experiment design, and closed-loop data analysis, analysis and control, multivariate statistical methods including Principal Component Analysis (PCA), and Partial Least Squares (PLS) used for the efficient extraction of information from large databases typically collected by on-line process computer; analysis of process problems and on-line process improvement by using these model.

**2105630 Heterogeneous Catalytic Reactor 3(3-0-9)
            Modelling**

Introduction to catalytic reactor modelling; criterriafor selection a suitable model; mathematical models of different types of catalytic reactor; catalyst activity model; steady and transient state model.

2105631 Advanced catalysts for polymers 3(3-0-9)

Catalyst preparation and characterization of polymers : ziegler-natta catalysts, metallocene catalysts, and late transition metal complex catalysts the application of these catalysts in polymer production.

2105632 Petrochemical Technology   3(3-0-9)

The position today, the chemistry, the economics and where possible, the solid implications. The basis for petrochemicals: catalysts, economic and engineering Chemical components, or elements recovered from petroleum or natural gas. Petrochemical processes with emphasis on the chemical reactions and their kinetics.

2105634 Catalysis   3(3-0-9)

Adsorption and kinetics of surface reactions; poisoning, selectivity; and empirical activity patterns in catalysis; surface chemistry, catalytic mechanisms and modern experimental techniques in catalytic research; descriptive examples of industrial catalytic system.

2105636 Heterogeneous Catalysis   3(3-0-9)

Theory of adsorption and catalysis. Preparative methods for catalysts.Techniques for catalyst characterization. Chemical reaction in porous catalyst pellets. Effect of intraparticle diffusion, effect of temperature gradient, criteria for diffusion effect. Kientics of heterogenous catalytic reactions. Experimental methods for developing design data. General aspects of catalytic reactor design.

2105637 Design of Industrial Catalysis   3(3-0-9)

The overall design of catalysts, design of the primary and secondary constituents of the catalyst, choice of support materials, experimental testing, summary of some useful general information for catalyst designers, specific example of catalyst design.

2105638 Advanced Polymer Engineering   3(3-0-9)

Polymers and their applications as engineering materials. Structure and properties of polymers. Crystalline and glassy polymer. Polymerisation. Polymer solutions. Mechanical properties of polymers. Theory of rubber elasticity. Yielding of polymers. Polymers. Polymer rheology; viscoelastic properties of polymers and viscoelastic models. Polymer composites.

2105641 Biodegradable Material   3(3-0-9)
**   Engineering**

Types of biodegradable materials : synthetic and natural materials, sources and production, properties biocompatibility, biodegradation mechmism, test methods for biodegradable plastics; polysaccharides, biopolyester protein (collagen, gelatin), biodegradable polymers for tissue engineering and controlled release.

2105643 Polymer Processing   3(3-0-9)

Application of heat transfer, fluid mechanics and thermodynamics to the design and control of polymer processing equipment. Detailed consideration of extrusion, calendering, rotational molding, stamping and injection molding.

2105649 Polymer Blends and Composites   3(3-0-9)

Terms and Definitions in multicomponent Polymer Systems, Advantages, Interfaces, Polymer Blends, Thermodynamics of Polymer Blends, Phase Separation, Miscibility, Block Coploymers, Polymer Composites Including Filled Polymers and Reinforced Polymers, Processing and Rheology of Multicomponent Systems, Coatings.Microbial kinetics of growth. Barious fermentation reactors for pure cultures. Mass transfer in fermentors. Instrumentation and control of biochemical processes, downstream separation in biotechnology and their importance.

2105650 Biochemical Engineering   3(3-0-9)

Microbial kinetics of growth. Various fermentation reactors for pure cultures. Mass transfer in fermentors. Instrumentation and control of biochemical processes, downstream separation in biotechnology and their importance.

2105652 Bioreactor Design Analysis and   3(3-0-9)
**   Control**

Analysis of microbial kinetics for bioreactor design; Design and analysis of batch, continuous, and multiphase bioreactors; Advanced control strategies of bioreactors.

2105654 Bioreactor Design Analysis and   3(3-0-9)
**   Control**

Analysis of microbial kinetics for bioreactor design; Design and analysis of batch, continuous, and multiphase bioreactors; Advanced control strategies of bioreactors.

2105655 Bioprocess Plant Design   3(3-0-9)

Design and cost analysis of equipment and plant for bioprocess industries; process waste treatments; Case study of bioprocess design.

2105656 Bioremediation Engineering   3(3-0-9)

Concept of bioremediation engineering, use of microorganisms for pollution control; biodegradation kinetics, bioreaction design and insitu bioremediation.

2105659 Biochemical Separation   3(3-0-9)
**   Technology**

Separation technology in biological processing industries. Cell separation process. Recovery of intracellular and extracellular product. Technology in liquid-solid separation. Technology in liquid mixture separation. Technology in gas mixture separation. Current topics of research.

2105661 Special Problems in Chemical   3(3-0-9)
**   Engineering**

Study of investigation of special problems in chemical engineering assigned by the instructor with the consent of

the head of department. The work must be completed within one semester and an examination taken.

2105662 Selected Topics in Chemical   3(3-0-9)
           Engineering
Study of specialized topics of interest in chemical engineering assigned by the lecturer with the consent of the head of the department. Written report and oral examination are required.

2105663 Heat Transfer Operation   3(3-0-9)
Heat transfer phenomena in Chemical Process Equipment, Conduction, Convection, Radiation, Overall heat transfer coefficient, mean temperature different, heat exchanger in chemical process, design of double pipe heat exchanger, design of shell and tube heat exchanger, boiling and condensing heat transfer, industrial furnace, heat recovery in chemical process, rating of heat exchanger.

2105665 Cryogenic Engineering   3(3-0-9)
Basic principles involved in the production at low temperature and the separation of gases. Physical properties of cryogenic fluids and recent developments in their engineering applications.

2105666 Source Control of Particulate   3(3-0-9)
           Emissions
Contents of controlling air pollution emissions. Control of particulate emissions-mechanical collectors, filters, electrostatic precipitators, scrubbers, Modeling, design, equipment selection and cost.

2105667 Loss Prevention in Chemical   3(3-0-9)
           Operation
Identification of hazards. Risk assessment. Preventive measures: control system design for safe operation. Personal protective devices. Emergency Planning.

2105668 Energy Conservation in Chemical   3(3-0-9)
           Processes
Basic considerations and objective of energy conservation in chemical industry; Fundamentals of energy integration for chemical engineers; Synthesis, and optimization of heat exchanger networks in chemical processes; Other energy recovery technques; Alternative sources of energy.

2105669 Cleaner Technology   3(3-0-9)
Fundamental of clean technology; Pollution prevention in industrial processes: principles, approaches, application in process and equipment design; waste minimization: industrial waste reduction techniques; Life cycle analysis: concept, methods, application of pollution prevention.

2105671 Process Dynamics   3(3-0-9)
Dynamic modeling of chemical engineering process; control system design for chemical engineering process dynamic simulation of controlled manufacturing process.

2105672 Simulation of Particulate and   3(3-0-9)
           Material Processinf
Various approaches to mathematical modeling; modeling and simulation of industrial processes involved with particulate material, such as aerosol filtration with fibrous filters, capturing of suspended dust particles using liquid spraying, pneumatic conveying drying, spray drying, fluidization phenomena as well as multi-phase flow of particles using discrete simulation technique.

2105673 Design and Analysis of   3(3-0-9)
           Experiments in Chemical Engineering
Simple comparative experiments; experiments with a single factor; analysis of variance; randomized blocks and Latin squares designs; Factorial design, Tow-level factorial design; Three-level and mixed-level factorial design; Robustness experiments with random factors.

2105674 Computer-aided Process and   3(3-0-9)
           Product Engineering
Computer-aided modeling and simulation; Computer-aided process and product design; Computer-aided process operation, Modeling in the process life cycle.

2105675 Polymer Chemistry for Engineers   3(3-0-9)
Basic concepts and knowledge of polymer chemistry for engineers and their applications; mechanism of polymerizations, kinetics model of polymerization, chemical and physical characterization methods in polymer chemistry to understand polymerization from engineering basis.

2105676 Instrumentation in Chemical   3(3-0-9)
           Process
The types and fundamental concepts of instrumentation in chemical process and related industry such as temperature, pressure, flow rate, concentration and level. Sensors and actuators used in process industries; signal conditioning and transmission analog and digital controllers; interfacing and communication; programmable logic controllers; distributed process control systems; safety in process automation.

2105678 Introduction to Nanotechnology   3(3-0-9)
Fundamentals of nanotechnology, instrumentation in nanotechnology, nanopowders and nanomaterials, natural nanomaterials, nanobiometrics, preparation of nanomaterials, properties of nanomaterials, applications of nanomaterials mainly in materials technology mediums, energy, electronics and chemical engineering, preparation of carbon nanomaterials and its applications.

2105679 Bioactive Compounds   3(3-0-9)
Physical, chemical and biological properties of bioactive compounds from plants, animals and microorganisms with significant biological activity and important uses in pharmaceuticals, agriculture, cosmetic industries, including synthesis, extraction techniques and development of bioactive properties by bio/chemical/genetic engineering treatment.

2105680 Multifunctional Reactor   3(3-0-9)

Basic concepts and knowledge of different multifunctional reactors and their applications; mathematical modelling and simulation to understand effects of various operating parameters on the multifunctional reactors performance.

2105681 Catalyst Deactivation   3(3-0-9)

Physical and chemical knowledge of catalyst deactivation by fouling, poisoning and sintering, regeneration of fixed beds.

2105682 Surface Technology   3(3-0-9)

Basic concepts and surface chemistry; and inorganic chemistry, absorption and various techniques for surface analysis.

2105683 Bioenergy Technology   3(3-0-9)

Fundamental concepts for biofuel/bioenergy technology. Renewable feedstocks, availability and attributes for biofuel/bioenergy production, Thermochemical conversion of biomass to heat, power, and fuel. Thermal gasification of biomass, Biochemical engineering for conversion of biomass to fuel; ethanol, butanol, methane, hydrogen and biodiesel production, environmental impacts of biofuel production; value-added processing of biofuel residues; case studies on biofuel production.

2105684 Chemical Analysis for Chemical   3(3-0-9)
**   Process Control I**

Principles of chromatograph (gas and liquid) and spectroscopy, signal charactyeristic, factors affecting signal interpretation, appliaction in real-time process control.

2105685 Selected Topics in Transport   3(3-0-9)
**   Phenomena**

Study of specialized topics of interest in transport phenomena assigned by the lecturer with the consent of the head of the department. Written report and oral examination are required.

2105686 Selected Topics in Chemical   3(3-0-9)
**   Engineering Thermodynamics**

Study of specialized topics of interest in chemical engineering thermodynamics assigned by the lecturer with the consent of the head of the department. Written report and oral examination are required.

2105687 Advanced Chemical Kinetics and   3(3-0-9)
**   Catalysis**

Thermodynamics of chemical reaction; determination of rate expressions; reaction mechanisms; molecular theories of chemical kinetics; chemical systems involving multiple reactions; elements of heterogeneous catalysis; liquid phase reactions and homogeneous catalysis; mass and heat transport process in porous catalysts.

2105688 Selected Topics in Chemical   3(3-0-9)
**   Engineering Kinetics**

Study of specialized topics of interest in chemical engineering kinetics assigned by the lecturer with the

consent of the head of the department. Written report and oral examination are required.

2105689 Safe Process Operation and   3(3-0-9)
**   Design**

Design and operate chemical process with safety consideration. Preventive measures: control system design for safe operation. Emergency Planning.

2105690 Independent study I   3(3-0-9)

Independent studies course provides the platform for students to be involved in a research or industrial project. Students will need to work closely with a faculty member with the consent of the head of the department and external mentor who can guide them through the process of conducting a research study.

2105691 Independent study II   3(3-0-9)

Independent studies course provides the platform for students to be involved in a research or industrial project. Students will need to work closely with a faculty member with the consent of the head of the department and external mentor who can guide them through the process of conducting a research study.

2105692 Independent study III   3(3-0-9)

Independent studies course provides the platform for students to be involved in a research or industrial project. Students will need to work closely with a faculty member with the consent of the head of the department and external mentor who can guide them through the process of conducting a research study.

2105693 Special Problems in process   3(3-0-9)
**   control Engineering**

Study of investigation of special problems in process control engineering assigned by the instructor with the consent of the head of department. The work must be completed within one semester and an examination taken.

2105694 Special Problems in Petrochemical 3(3-0-9)
**   Engineering**

Study of investigation of special problems in petrochemical engineering assigned by the instructor with the consent of the head of department. The work must be completed within one semester and an examination taken.

2105695 Special Problems in Polymer   3(3-0-9)
**   Engineering**

Study of investigation of special problems in polymer engineering assigned by the instructor with the consent of the head of department. The work must be completed within one semester and an examination taken.

2105696 Special Problems in Biochemical 3(3-0-9)
**   Engineering**

Study of investigation of special problems in biochemical engineering assigned by the instructor with the consent of the head of department. The work must be completed within one semester and an examination taken.

2105697 Special Problems in Cleaner   3(3-0-9)
          Production Engineering
     Study of investigation of special problems in cleaner production engineering assigned by the instructor with the consent of the head of department. The work must be completed within one semester and an examination taken.

2105698 Special Problems in Particle   3(3-0-9)
          Technology
     Study of investigation of special problems in particle technology assigned by the instructor with the consent of the head of department. The work must be completed within one semester and an examination taken.

2105699 Multifunctional Reactor   3(3-0-9)
     Basic concepts and knowledge of different multifunctional reactors and their applications; mathematical modeling and simulation to understand effects of various operating parameters on the multifunctional reactors performance.

DEPARTMENT OF MINING AND PETROLEUM ENGINEERING

The Department of Mining and Petroleum Engineering currently offers two undergraduate programs namely Georesources Engineering and Petroleum Engineering. Mining Engineering program is replaced by Georesources Engineering Program where two majors mining, and resources engineering are conducted. These two existing programs are designed to prepare graduates for mining, resources, petroleum, and related industries both in Thailand and abroad. These programs also facilitate graduates to carry on to higher education.

Courses are designed to give students basic knowledge in both sciences and engineering fundamentals as well as professional subjects of the fields. Optional courses are also offered as electives to accommodate special interest of students or special need of the industry. Practical training is compulsory to familiarize students with industry. English, humanities, and social sciences courses are also requirement of the programs so that students have opportunity to broaden their views as well as English skill.

● Georesources Engineering Program

The undergraduate georesources engineering program provides foundation knowledge in all aspects of georesources development. After having broad background in sciences and basic engineering during the first and the second year, students will receive a thorough background in georesources engineering in the first semester of the third year, which will support advance georesources engineering courses in the third and fourth year. A broad interdisciplinary coverage of georesources development principles including mining geology, mineral exploration, ore reserve estimation, mine development, mining methods of both surface and underground operations, rock mechanics, geostatistics, georesources economics and management, mineral processing and utilization and environmental aspects of mining operation and recycling will be provided for junior and senior level.

● Petroleum Engineering Program

The Petroleum Engineering curriculum for undergraduate study provides core courses in all aspects of petroleum engineering including rock and fluid properties, reservoir engineering, well logging, drilling engineering, production engineering, production operations, natural gas processing, and petroleum economics. The Department also offers a master's degree program in petroleum engineering. The program is specially designed for Thai and foreign students using English as a program language. It is designed for students who graduate with B.Eng. or B.Sc. in petroleum engineering or other related disciplines.

The graduate study curriculum provides an extensive study in petroleum engineering which emphasizes on upstream activities, oil and gas exploration and production. This program will serve industrial demand of highly competent petroleum engineers who are able to conduct both scientific and engineering investigations to solve various problems related to exploration and production of oil and natural gas.

Due to the rapid progress in engineering and trend toward interdisciplinary environment in industries, the department also emphasizes on learning and communication skills of students. In addition, awareness in environmental problems related to engineering work is also an important element in the programs.

HEAD:

Thitisak Boonpramote, Ph.D. (Colorado school at Mines)

ASSOCIATE PROFESSORS:

| Dawan | Wiwattanadate, | Ph.D. (Osaka) |
| Somsak | Saisinchai, | M.Eng. (Chula) |

ASSISTANT PROFESSORS:

Jirawat	Chewaroungroaj,	Ph.D. (Texas at Austin)
Sunthorn	Pumjan,	Ph.D. (Michigan Tech)
Suwat	Athichanagorn,	Ph.D. (Stanford)
Kreangkrai	Maneeintr	Ph.D. (Regina)
Pipat	Laowattanabandit	Ph.D. (Colorado School of Mines)

LECTURERS:

Falan	Srisuriyachai	Ph.D. (Bologna)
Apisit	Numprasanthai	Ph.D. (Griffith)
Raphael	Bissen	Dr.rer.nat (Freiburg)
Kittiphong	Jongkittinarukorn	Ph.D. (Oklahoma)

GEORESOURCES ENGINEERING UNDERGRADUATE CURRICULUM
FIRST YEAR CURRICULUM
COMMON TO ALL ENGINEERING STUDENTS

COURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS
	THIRD SEMESTER			**SIXTH SEMESTER**	
2103213	ENG MECHANICS I	3	2103393	ME LAB NON ME	1
2301207	CALCULUS III	3	2108302	FIELD PRACTICE I	1
2106251	GENERAL GEOLOGY	3	2106441	GEOTECH	3
2106208	CHEM MAT	3	2106442	GEOTECH LAB	1
2106209	CHEM MAT LAB	1	2106412	RES ECON MGT	3
2106222	FUND GE	1	2106432	SEPARATION TECHNOLOGY	3
5500208	COM PRES SKIL	3	2106333	RES PROC LAB II	1
			5500308	TECH WRIT ENG	3
xxxxxxx	GENERAL EDUCATION	<u>3</u>	xxxxxxx	GENERAL EDUCATION	<u>3</u>
		20			**19**

COURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS
	FOURTH SEMESTER			**SUMMER SEMESTER**	
2101202	MECH MAT I	3	2100301	ENG PRACTICE	**2**
2108298	SURVEYING I	3			
2106458	MINING GEOLOGY	3		**SEVENTH SEMESTER**	
2106316	SUR MIN	3			
2106315	MIN ENG LAB	1	2102391	ELEC ENG I	3
2104253	ENG STAT I	3	2102392	ELEC ENG LAB I	1
xxxxxxx	GENERAL EDUCATION	<u>3</u>	2106462	PET PROC ENG	3
		19	xxxxxxx	ELECTIVE COURSE	6
			xxxxxxx	FREE ELECTIVES	<u>3</u>
					16

COURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS
	FIFTH SEMESTER			**EIGHTH SEMESTER**	
2100311	ENG ESSENTIALS	3	2106446	MIN PLAN DSGN	3
2103295	BASIC THERMO	3	2106413	RES ENV POLL PRVNT	3
2106310	MINERAL PROCESS ENG	3	2106489	GEO-RES ENG PROJ	3
2106332	RES PROC LAB I	1	OR		
2106444	ENG EXP ROCK BLAST	3	2100499	ENG PROJ	3
2106445	UNDERGROUND MIN	3	xxxxxxx	ELECTIVES COURSE	3
2112346	HYDRAULICS I	<u>3</u>	xxxxxxx	FREE ELECTIVES	<u>3</u>
		19			**15**

TOTAL CREDITS FOR GRADUATION = 146

PETROLEUM ENGINEERING UNDERGRADUATE CURRICULUM
FIRST YEAR CURRICULUM
COMMON TO ALL ENGINEERING STUDENTS

COURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS
	THIRD SEMESTER			**SIXTH SEMESTER**	
2103213	ENG MECHANICS I	3	2103393	ME LAB NON ME	1
2103295	BASIC THERMO	3	2106361	WELL LOGGING	3
2106261	PETROLEUM GEOLOGY	3	2106368	RESERVOIR ENG II	3
2106263	FUND PE	3	2106369	PROD TECH	3
2301207	CALCULUS III	3	2106462	PET PROC ENG	3
xxxxxxx	GENERAL EDUCATION	3	5500308	TECH WRIT ENG	3
		18	xxxxxxx	GENERAL EDUCATION	3
					19
	FOURTH SEMESTER			**SUMMER SEMESTER**	
2103231	MECH OF MAT I	3	2100301	ENG PRACTICE	**2**
2103351	FLUID MECHANICS I	3			
2104253	ENG STAT I	3		**SEVENTH SEMESTER**	
2106266	PETROPHYSICS	3			
2106267	PET FLUID PROP	3	2102391	ELEC ENG I	3
5500208	COM PRES SKIL	3	2102392	ELEC ENG LAB I	1
		18	2106465	PETROL ECONOMICS	3
			xxxxxxx	ELECTIVE COURSE	3
			xxxxxxx	ELECTIVE COURSE	3
			xxxxxxx	GENERAL EDUCATION	3
					16
	FIFTH SEMESTER			**EIGHTH SEMESTER**	
2100311	ENG ESSENTIALS	3	2106474	PETRO RES DEV	3
2106268	PET DRILL FLUID LAB	1	2106479	PETROLEUM PROJECT	3
2106362	DRILLING ENG	3	OR		
2106367	RESERVOIR ENG I	3	2100499	ENG PROJ	3
2106464	PRODUCTION ENG	3	xxxxxxx	ELECTIVE COURSE	3
2301312	DIFF EQUATIONS	3	xxxxxxx	FREE ELECTIVES	3
xxxxxxx	FREE ELECTIVES	3	xxxxxxx	GENERAL EDUCATION	3
		19			**15**

TOTAL CREDITS FOR GRADUATION = 143

STUDY PROGRAM FOR MASTER DEGREE IN GEORESOURCES AND PETROLEUM ENGINEERING
(MINING ENGINEERING)

First Semester

2186532	Geomechanics	3	Credits
2186608	Resources Environment and Life Cycle Pollution Prevention	3	Credits
2186670	Sustainable Mineral and Petroleum Resources Development	<u>3</u>	Credits
		9	

Second Semester

2186533	Mine Planning and Design	3	Credits
2186642	Resources Economics	3	Credits
	Elective Courses	3	Credits
2186756	Research Seminar	<u>1</u>	Credits (S/U)
		9	

Third Semester

	Elective Courses	6	Credits
2186811	Thesis	<u>3</u>	Credits
		9	

Fourth Semesters

2186811	Thesis	<u>9</u>	Credits
		9	

Graduate students with no mining engineering background must complete the following courses within the first year of study.

2186524	Basic Georesources Engineering	3	Credits
2186534	Basic Geology	<u>3</u>	Credits
		6	

**STUDY PROGRAM FOR MASTER DEGREE IN GEORESOURCES AND PETROLEUM ENGINEERING
(RESOURCES RECYCLING ENGINEERING)**

First Semester

2186509	Resources Process Technology and Utilization	3	Credits
2186608	Resources Environment and Life Cycle Pollution Prevention	3	Credits
2186670	Sustainable Mineral and Petroleum Resources Development		
		3	Credits
		9	

Second Semester

2186623	Process Separation for Resources Recovery	3	Credits
2186642	Resources Economics	3	Credits
	Elective Courses	3	Credits
2186756	Research Seminar	1	Credit (S/U)
		9	

Third Semester

	Elective Courses	6	Credits
2186811	Thesis	3	Credits
		9	

Fourth Semesters

2186811	Thesis	9	Credits
		9	

Graduate students with no resources recycling engineering background must complete the following courses within the first year of study.

2186524	Basic Georesources Engineering	3	Credits
2186535	Basic Minerals and Rocks	3	Credits
		6	

**STUDY PROGRAM FOR MASTER DEGREE IN GEORESOURCES AND PETROLEUM ENGINEERING
(PETROLEUM ENGINEERING)**

First Semester

2186651	Advanced Reservoir Engineering	3	Credits
2186667	Production System Analysis	3	Credits
2186670	Sustainable Mineral and Petroleum Resources Development		
		3	Credits
		9	

Second Semester

2186671	Advanced Natural Gas Engineering	3	Credits
	Elective Courses	6	Credits
2186756	Research Seminar	1	Credit (S/U)
		9	

Third Semester

2186664	Petroleum Well Construction	3	Credits
	Elective Courses	3	Credits
2186811	Thesis	3	Credits
		9	

Fourth Semester

2186811	Thesis	9	Credits
		9	

Graduate students with no petroleum engineering background must complete the following courses within the first year of study.

2186565	Basic Petroleum Geology	3	Credits
2186566	Petrophysics	3	Credits
2186567	Basic Reservoir Engineering	3	Credits
2186568	Basic Drilling Engineering	3	Credits
2186569	Basic Production Engineering	3	Credits
		15	

COURSE DESCRIPTION INS GEORESOURCES ENGINEERING (B.ENG.)

2106208   Chemical for Materials   3(3-0-6)
Condition: Concurrent 2106209
   Phase equilibria and physical properties of matter; and heterogeneous mixture; colligative properties of solution; colloid and surface chemistry; surface chemistry and application in materials separation; electrochemistry and corrosion; ore sampling and dissolution for analysis; separation and analysis of metal ions in solution.

2106209   Chemical for Materials Lab   1(0-3-0)
Condition: Concurrent 2106208
   Effects of temperature on liquid viscosity; effects of temperature and/or surfactant on liquid surface tension molecular weight determination via colligative properties of solution; preparation of standard solution and standardization; Ore dissolution and fusion; analysis of metal ion in solution oy redox titration; potentiometric titration; and spectrometry.

**2106222   Fundamental of Georesources
                    Engineering   1(1-0-2)**
   Introduction to mining industry and georesources development. exploration , evaluation and mineral deposit development; Environment , health and safety considerations in mine operations.

2106251   General Geology   3(2-3-4)
   Scope of geology; the universe and the earth; surface features of the earth's crust and the geological processes; deformation of the earth's crust; rock structures; problems of dip and strike, vein intersection, faulting and folding; geological maps and sections; field techniques in geological mapping; collection of field specimens; well logging and drill core; preparation of geological maps and reports.

2106252   Minerals and Rocks   3(2-3-4)
   Basic knowledge of mineralogy; crystallography ; crystal system; physical properties; identification of rock-forming and economic minerals; origin of igneous; sedimentary and metamorphic rocks; geological and engineering classification rocks.

2106296   Engineering Geology   3(2-3-4)
*Condition : Prerequisite 2103105 and
                    2108205 or 2108291*
   A general survey of geology with particular reference to civil engineering; common rockforming minerals; general characteristics and origins of rocks; features of the earth and geological process; structural features of the earth's crust; geology of water supply, reservoirs and dam sites, erosion and flood control; river and habour improvement; geological, factors affecting quarrying, tunnelling, landslide, land subsidence, foundations, and building materials.

2106310   Mineral Processing Engineering   3(3-0-6)
Condition: Concurrent 2106332
   Theory of Physical methods of mineral processing. Fundamental of mineral processing including sampling, comminution and liberation, screening, classification, size determination, gravity concentration, magnetic separation, electrostatic separation, introduction to flotation. Construction of simple flow sheets for mineral processing plants.

2106315   Mining Engineering Laboratory   1(0-3-0)
Condition: Consent of Faculty
   Laboratory experiments in mining development and mining operation.

2106316   Surface Mining   3(3-0-6)
   Exploration, evaluation and development of mineral deposits, classification and selection of various mining methods; mine planning and design concept; earth and rock excavation; drilling and bench blasting ; mine loading and haulage; environmental protection; mine welfare and safety.

2106331   Mineral and Process Engineering   3(3-0-6)
Condition: Concurrent 2106332
Theory of Physical methods of mineral processing. Fundamental of mineral processing including sampling, comminution and liberation, screening, classification, size determination, gravity concentration, magnetic separation, electrostatic separation, introduction to flotation. Construction of simple flow sheets for mineral processing plants.

2106332   Resources Process Laboratory I   1(0-3-0)
Condition: Concurrent 2106331
   Laboratory experiments in resources separation and recovery.

2106333   Resources Process Laboratory II   1(0-3-0)
Condition: Concurrent 2106331
   Laboratory experiments in resources separation and recovery.

**2106412   Resources Economics and   3(3-0-6)
                    Management**
   Mineral demand and supply; mineral trade and markets; mineral market forecasting techniques; government regulations and taxation; resources evaluation; economics of resources development; project management.

**2106413   Resources Environment and   3(3-0-6)
                    Pollution Prevention**
   Major environmental problems from production and utilization of resources; environmental technology to manage and control the problems; waste minimization and waste disposal, environmental planning for the development and utilization of resources.

2106414 Resources Process Technology and Utilization 3(3-0-6)

Extraction, processing and utilization of resources; review of fundamental principles of process technology and utilization of resources; concepts of technology application; processes of extraction and improvement of material quality; review of principles of process design.

2106415 Resources Recovery and Recycling 3(3-0-6)

Recyclable resources; recycling of non-metal, recycling of ferrous and non-ferrous metals; principles of recycling; criteria for recovery and recycling; potential benefits of recycling; recycling technology; limitation of recycling; markets for recycle, factors affecting recycle rates; environmental aspects of recycling.

2106428 Geostatistics 3(3-0-6)

Introduction to geostatistics; spatial data and geostatistical approach; problems and geostatistical solution; structure of regionalized variable and its applications on sampling analysis and optimization; kriging system and characteristic features; estimator and estimation variance; and use of computer codes.

2106432 Separation Technology 3(3-0-6)
Condition: Concurrent 2106333

General description of separation and classification efficiency; hydrocyclones, screens, electrostatic precipitators; mixing, granulation, crystallisation; comminution matrix description of size reduction, milling circuit simulation, size enlargement and agglomeration; motion of particles in fluids; flow of fluids through granular beds; incompressible and compressible cake filtration; gravity sedimentation and clarification; pneumatic and hydraulic transport of solids; surface chemistry and thermodynamics of particles-bubbles attachment; mechanisms of mineral flotation; kinetics of mineral flotation and mechanics; flotation processes of minerals and materials.

2106433 Material Characterization 3(3-0-6)

Theories and use of techniques in material analysis including mineralogy, microscopic techniques, differential thermal analysis, thermogravimetric analysis, x-ray refraction, x-ray fluorescence, atomic absorption spectrometry, inductively coupled electron analysis and chemical analysis.

2106434 Material Handling Engineering 3(3-0-6)

Theories and design of material handling processes; belt conveyor, chain, and bucket elevator; bin and bunker design; stock piling; blending and homogenizing; feed control of bulk solids; slurry pipeline transportation, tailing disposal.

2106438 Clean Coal Technologies 3(3-0-6)

Coal utilization; coal reserve; coal gasification; coal dust explosion; coal storage; combustion; pollution management; carbon capture and storage.

2106439 Particle Technologies for 3(3-0-6) Georesources Engineering

Particle characterization, grinding; powder separation; mixing; agglomeration; transport of powder; storage of powder; safety in operation; dust explosion; dust collection.

2106441 Geotechniques 3(3-0-6)

Engineering properties of soil and rock measurements and classification: stress-strain analysis : failure criteria : stability analysis : geotechnical application to soil and rock excavation.

2106442 Geotechniques Laboratory 1(0-3-0)

Laboratory experiments in rook properties.

2106443 Rock Engineering 3(3-0-6)

Basic rock mechanics; discontinuities; rock and rock mass; strength and failure criteria; in-situ stress; site investigation; rock mass classification; rock testing, in-situ testing; rock mechanics and engineering works; rock slope stability; rock excavation; geotechnical instrumentation and monitoring

2106444 Engineering Explosives and Rock 3(3-0-6) Blasting

Concepts of rock fragmentation, drilling and blasting; type of explosives and accessories; characteristics and properties of explosives; safety in the transportation, storage, and handling of explosives; rock blasting practices, delay blasting; bench blasting design; controlled blasting techniques; the control of ground vibration, airblast, fly rock, drilling and blasting cost evaluation,

2106445 Underground Mining 3(3-0-6)

Basic soil and rock mechanics; discontinuities; geological factors for underground excavation Site investigation for underground excavation; underground excavation in mining and civil engineering; underground mining methods, underground monitoring, explosive and blasting in underground excavation, rock support and rock reinforcement; underground mine planning and design, equipment and machine used in underground mining; basic mine ventilation, underground mine safety.

2106446 Mine Planning and Design 3(3-0-6)

Concepts of mine planning and design; application of relevant knowledge in mining on mine design; computer application and simulation in mine planning design; selection of heavy equipment; case studies on mine planning and design.

2106458 Mining Geology 3(3-0-6)
Condition : Prerequisite 2106252

Origin and Occurrence of mineral deposits; mineral associations, alterations and classification, geologic factors controlling characteristics of ore-body; surface and underground geological mapping principles and application of geological, geochemical and geophysical

prospecting; planning for exploration drilling, sampling techniques; ore reserve estimation; grade control; and fundamental of geostatistics.

2106481 Advanced Topics in Geo-Resources 3(3-0-6) Engineering I

Topics of current interest and/or new development in various fields of Geo-Resources Engineering.

2106482 Advanced Topics in Geo-Resources 3(3-0-6) Engineering II
Condition: Consent of Faculty

Topics of current interest and/or new development in various fields of Geo-Resources Engineering.

2106483 Special Problems in Geo-Resources 3(2-3-4) Engineering I
Condition: Consent of Faculty

Special problems in Geo-Resources Engineering and their solutions.

2106484 Special Problems in Geo-Resources 3(2-3-4) Engineering II
Condition: Consent of Faculty

Special problems in Geo-Resources Engineering and their solutions.

2106488 Practical Education for Resources 3(2-3-4) Engineering

Practical interesting projects/topics for resources and petroleum engineering.

2106489 Geo-Resources Engineering 3(3-0-6) Project
Condition : Consent of Faculty

Practical interesting projects of problems in various fields of Geo-Resource Engineering.

COURSES DESCRIPTIONS IN PETROLEUM ENGINEERING (B.ENG.)

2106261 Petroleum Geology 3(3-0-6)

Fundamental principles of petroleum regarding its origin, migration, and accumulation; chemical composition of petroleum; nature of source rocks, reservoirs, and traps; sedimentary environment and facies; geological field methods; characteristics of natural gas and oil fields of Thailand.

2106263 Fundamental of Petroleum 3(3-0-6) Engineering

Introduction to petroleum industry; economics and structure of petroleum industry; petroleum prospecting; drilling operation; petroleum production system; reservoir performance; oil and gas separation; oil and gas transportation; utilization of oil and natural gas.

2106266 Petrophysics 3(3-0-6)

Porosity, Permeability, Fluid Saturation, Resistivity, Wettability, Capillary Pressure, Relative Permeability, Application of Darcy's equation, Measurement of Particle Size Distribution, Measurement of Porosity and Permeability, Measurement of Formation Resistivity, Measurement of Fluid Saturation, Measurement of Wettability and Measurement of Relative Permeability.

2106267 Petroleum Fluid Properties 3(3-0-6)

Phase behavior; equations of state; and PVT properties and determination.

2106268 Petroleum and Drilling Fluid 3(3-0-6) Laboratory

Viscosity; specific gravity; composition analysis; pressure, volume, and temperature (PVT) analysis of petroleum fluids; physical and chemical properties of drilling fluids.

2106361 Well Logging 3(3-0-6)
Condition: Prerequisite 2106265

Principles, applications, and interpretation of openhole logs as used in petroleum exploration and reservoir evaluation.

2106362 Drilling Engineering 3(3-0-6)

Drilling fluids, drilling hydraulics; drilling bit and drill string; directional drilling; casing and cementing, and drilling well control.

2106367 Reservoir Engineering I 3(3-0-6)
Condition: Prerequisite 2106265

Petroleum reserves; reservoir drive mechanism; volumetric calculation; material balance; decline curve analysis; fluid flow in porous media; well performance; water and gas coning; and water influx.

2106368 Reservoir Engineering II 3(3-0-6)
Condition: Prerequisite 2106367

Oil and gas well tests; and numerical reservoir simulation.

2106369 Production Technology 3(3-0-6)
Condition: Prerequisite 2106362

Well completion; wireline and coiled tubing operation; perforating; formation damage mechanism and migration; sand production and its control; well stimulation; well surveillance and workover.

2106462 Petroleum Process Engineering 3(3-0-6)
Prerequisite: 2106267

Handling, separating of oil, natural gas and water from petroleum production; acid gas treating; gas dehydration; LNG; transmission and natural gas.

2106464 Production Engineering 3(3-0-6)
Condition : Prerequisite 2106265

Multiphase flow in pipe; inflow performance; restricted flow into a wellbore; artificial lift; and oil and gas production system and facilities.

2106465 Petroleum Economics 3(3-0-6)

Economic evaluation of petroleum projects, generating forecasts of key technical and economic parameters for the discounted cash flow(DCF) model of petroleum development projects, world oil markets and price mechanisms, petroleum fiscal system analysis; expected value and decision tree analysis for petroleum exploration projects, Baysian analysis and value of information.

2106466   Improved Oil Recovery   3(3-0-6)
Condition : Prerequisite 2106367
Secondary recovery; mobility-control processes; miscible displacement; chemical flooding; and thermal recovery; microbial flooding; screening criteria for improved oil recovery.

2106472   Well Design and Operations   3(3-0-6)
Planning
Condition: Prerequisite 2106362
Petroleum well design and construction; drilling procedures and well completion practices; well cost estimation; drilling program; wellsite operation and logistics; well operation planning and reporting.

2106473   Reservoir Management   3(3-0-6)
Condition: Prerequisite 2106367
Numerical reservoir simulation; enhanced oil recovery techniques; field development planning; reservoir management procedures.

2106474   Petroleum Resources   3(2-3-4)
Development
Condition : Prerequisite 2106361,
2106367, 2106464
Integrated approaches to petroleum resources exploration and development; application of geological and petroleum engineering methods in designing petroleum production / injection wells with emphasis on teamwork.

2106475   Advanced Topics in Petroleum
Engineering I   3(3-0-6)
Topics of current interest and/or new development in various fields of petroleum engineering.

2106477   Special Problems in Petroleum
Engineering I   3(2-3-4)
Study or investigation of special problems in petroleum engineering.

2106479   Petroleum Engineering Project   3(0-6-3)
Practical interesting projects or problems in various fields of petroleum engineering.

2106488   Practical Education for Resources
Engineering   3(2-3-4)
Practical interesting projects/topics for resources and petroleum engineering.

COURSE DESCRIPTIONS IN
GEORESOURCES AND PETROLEUM ENGINEERING
(M.ENG.)

2186509   Resources Process Technology
and Utilization   3(3-0-9)
Extraction, separation and utilization of resources; review of fundamental principles of process technology and utilization of resources; concepts of technology application; processes of extraction and improvement of material quality; review of principles of process design.

2186510   Materials Handling   3(3-0-9)
Materials handling involving storage and stockpiling; theory of flow solids in bins and bankers; design of bins and bankers; conveyors and feeders; homogenization; hydraulic transport in pipe, pneumatic transport and waste sorting and disposal.

2186512   Chemical Process Separation   3(3-0-9)
Chemical separation of materials; solid state and solution chemistry; thermodynamics and kinetics; stability of compounds; oxidation and reduction; roasting; calcination and sintering; dissolution and mechanisms; effects of thermal treatment; leaching reactions, including halogenation and cyanidation; leaching process variables; recovery from solution and purification; ion exchange and solvent extraction applications; chemical process flowsheets and case studies.

2186522   Materials Characterization   3(3-0-9)
Theories and techniques in material analysis, including mineralogy, microscopy, differential thermal analysis, x-ray diffraction, x-ray fluorescence, spectrometry, electron microanalysis.

2186524 Basic Georesources Engineering   3(3-0-9)
Basic principles in mining industry and georesources development; exploration, evaluation of mineral deposits; mining method; mineral processing and recycling; development of mineral resources; environment, health and safety considerations in mine operation.

2186531   Advanced Geostatistics   3(3-0-9)
Geostatistics principle, non-linear geostatisics; cokriging and cross validation; indicator kriging; principle of stochastic simulation; simulation with Gaussian-related algorithms and indicator based approaches.

2186532   Geomechanics   3(3-0-9)
Engineering properties of rock; rock measurement and classification; stress – strain analysis; in-situ stress; failure criteria; rock stability and well bore stability analysis; geomechanics application to rock excavation; hydraulic fracturing; geomechanical monitoring.

2186533   Mine Planning and Design   3(3-0-9)
Review of surface and underground mining methods; stages of mining activities; ore modeling and reserve estimation; concept of mine planning and design to maximize profit with less environmental impact; various

elements in mine planning and design processes; planning and design by using a mining software.

2186534 Basic Geology   3(3-0-9)
The universe and the earth; surface feature of the earth's crust and the geological processes; plate tectonic; structural geology, including problems of dip and strike, vein intersection, faulting and folding; minerals and rocks; geological maps and sections; hydrogeology and geophysical prospecting.

2186535 Basic Minerals and Rocks   3(3-0-9)
Basic knowledge in mineralogy; crystallography; crystal system; physical properties; identification of rock-forming and economic minerals; origin of igneous, sedimentary and metamorphic rocks; geological and engineering classification of rocks.

**2186550 Numerical Methods for   3(3-0-9)
                Georesources Engineer**
Cases of mathematical calculation and modeling in georesources engineering; error analysis; various approaches to numerical methods; application of finite element method (FEM), finite difference method (FDM), and boundary element method (BEM) to solve problems in geo-engineering works.

2186565 Basic Petroleum Geology   3(3-0-9)
Surface features of the earth's crust and the geological processes; deformation of the earth's crust; rock structures, dip and strike, faulting and folding, geological maps and sections; petroleum origin, migration, and accumulation; chemical composition of petroleum; stratigraphy; nature of source rocks; reservoirs and traps; geological field methods.

2186566 Petrophysics   3(3-0-9)
Rock mineralogy; porosity; permeability; rock-fluid properties; spontaneous potential logs; resistivity logs; gamma ray logs; porosity logs; porosity crossplots.

2186567 Basic Reservoir Engineering   3(2-3-7)
Reservoir drive mechanisms; classification of petroleum reserves; volumetric reserve calculation; material balance; decline curve analysis; fluid flow in porous media.

2186568 Basic Drilling Engineering   3(3-0-9)
Mechanics of rotary drilling; drilling fluids and their hydraulics; directional drilling; formation pore pressure and fracture resistance; casing and cementing design; well control.

2186569 Basic Production Engineering 3(3-0-9)
Well completion; subsurface and wellhead equipment; perforating; sand control; formation damages and production stimulation; surface production processes; production problems and remedies; well intervention and workover.

**2186608 Environment and Pollution   3(3-0-9)
                Prevention in the Life Cycle of Resources**

Major environmental problems from production and utilization of resources; technology in managing and controlling environmental effects; waste minimization, waste storage and disposal; environmental management planning for sustainable resource development and utilization; relevant environmental issues in the global arena.

**2186623 Process Separation for Resources 3(3-0-9)
                Recovery**
Review of fundamentals of separation processes; mass balance and mass balance adjustment; separation efficiency; separation by physical properties; comminution and classification; gravity separation; separation by magnetic and electrical properties; flocculation and coagulation; flotation. introduction to chemical processing.

2186635 Industrial Minerals Technology   3(3-0-9)
Technology in industrial minerals: extraction, separation and utilization of some major industrial minerals and dimension stones and improvement of their quality to meet industrial requirements; discussion of advanced technology in industrial minerals and case studies.

2186636 Fuel Minerals Technology   3(3-0-9)
Technology in fuel minerals; mineral resource evaluation or assessment, mining processing and utilization of fuel minerals and their quality improvement to meet industrial requirements; discussion of advanced technology in industrial minerals and case studies.

2186637 Quarry Technology   3(3-0-9)
Quarry technology: rock resource evaluation, quarrying, size reduction to various industrial applications; economic aspects of the technology; quality improvement of products according to industrial requirements; discussion of advanced technology in quarry and case studies.

2186638 Advanced Geotechnique   3(3-0-9)
Review of soil and rock mechanics; investigation and data collection; application of soil mechanics theory to both mining and civil engineering works; grouting in engineering works; rock support and reinforcement; various analysis methods in geotechnique; case studies in either rock slope engineering or underground excavations.

**2186639 Resources Recovery and Waste   3(3-0-9)
                Recycling**
Classification of resources: renewable and non-renewable resources; resources utilization and recycling; waste utilization; waste-to-raw materials and waste-to-energy; life cycle and sustainable resource management; concepts and case studies of sustainable production and consumption.

2186642 Resources Economics   3(3-0-9)
Mineral demand and supply; mineral trade and markets minerals market model forecasting techniques; time series forecasting; government regulations and mineral taxation; specification of boundaries and

distribution of earth resources; resources evaluation; utilization; cost-benefit analysis; optimal control of the development of earth resources.

2186651   Advanced Reservoir Engineering   3(3-0-9)
Oil and gas well tests; waterflooding; water and gas coning; reservoir management.

2186652   Reservoir Simulation   3(3-0-9)
Principles and mathematical techniques in numerical simulation for multiphase, multidimensional flow in porous media; applications of reservoir simulation; history matching techniques; data preparation.

2186656   Carbon Capture and Storage   3(3-0-9)
Climate change; fundamental of carbon capture; carbon storage; storage capacity assessment.

**2186657   Unconventional Resources   3(3-0-9)
            Production**
Properties of heavy oil; recovery of heavy oil; thermal recovery; steam flooding; gas injection; steam assisted gravity drainage; in-situ combustion; tar sand or oil sand; oil shale; coalbed methane; gas hydrate.

2186662   Enhanced Oil Recovery   3(3-0-9)
Fundamental of Enhanced Oil Recovery (EOR); miscible flooding, thermal flooding, chemical flooding, current technology in EOR, and stages of EOR screening.

2186664   Petroleum Well Construction   3(3-0-9)
Well planning process; well design and drilling program; well completion; perforating; sand control; well stimulation and workover.

2186666   Advanced Petrophysics   3(3-0-9)
Electrical property of reservoir rock; surface properties of different lithologies; reversal of rock wettability by natural mechanism; oil recovery mechanism related to surface properties, petrophysical properties in complex rock formation; shaly sand interpretation, carbonate interpretation; abnormally overpressure; fractures.

2186667   Production System Analysis   3(3-0-9)
Single- and multiple-phase horizontal and vertical flows; inflow and outflow performances; nodal analysis; restricted flow into wellbore; artificial lift methods.

**2186670 Sustainable Mineral and Petroleum 3(3-0-9)
            Resource Development**
Mineral and petroleum resource development for economic growth; concept of sustainable development (SD); overview of resource development technology; future availability of resources; implications of sustainable development of mining and petroleum industry; community relationship in the resource development project.

2186671   Advanced Natural Gas Engineering 3(3-0-9)
Phase behavior of the natural gas system; natural gas properties; gas flow in pipe; gas compression calculations; field separation; dehydration; gas processing and transportation; gas production and production problems.

2186676   Advanced Petroleum Economics   3(3-0-9)
Petroleum exploration and production investment analysis; deterministic models of petroleum development project; modeling of petroleum fiscal system; project evaluation criteria and basic risk assessment; probabilistic models of petroleum exploration projects; expected value; decision tree analysis; and value of information.

**2186721   Advanced Resources Recovery and 3(3-0-9)
            Recycling**
Principle of resource recovery and recycling; types of secondary resources; criteria for resource recovery and recycling; benefits and limitations of recycling; rate of recycling and resource depletion; energy conservation from recycling; review of separation processes including physical, chemical and bacterial processes; recycling of ferrous and non ferrous metals, non metals, industrial waste, electrical and electronic equipment waste, end of life vehicles, packaging waste, construction and demolition waste, liquid and waste water from processes recovery in the form of energy, sub-marginal mineral deposit and low grade tailings; energy recovery from waste; unconventional resources; economic aspects in resource recovery and recycling; environmental considerations; current legislation and management for resource recovery and recycling in Thailand and international communities; trade and market for recycling; planning and design of separation for resource recovery project; feasibility case studies.

2186756 Research Seminar   1(1-0-3) (S/U)
Condition: - Consent of faculty
Presentation and discussion of the topics to the researched into or current interesting research topics.

2106811   Thesis   12 Credits

DEPARTMENT OF ENVIRONMENTAL ENGINEERING

The aim of the Department of Environmental Engineering is to teach and train students to be engineers with a competent knowledge (theoretical and practical) of surveying, planning and design, consulting and operating in the following fields :
1. water supply and treatment
2. drainage system and wastewater treatment
3. environmental sanitation
4. industrial environment
5. air pollution control
6. water pollution control and management
7. urban and rural sanitation
8. solid waste management
9. hazardous wastes treatment
10. environmental management

Moreover, students are obliged to use their own creative idea and self-responsibility. They are also encouraged to take an interest in techniques, foresee problems in the future and develop a sustainability of man and nature

HEAD :

Khemarath Osathaphan,   Ph.D. (Oregon State)

ASSOCIATE PROFESSORS:

Chavalit   Ratanatamskul,   Ph.D. (Tokyo)
Chanathip Pharino,   Ph.D. (MIT)
Orathai   Chavalparit,   Ph.D. (Chula)
Petchporn Chawakitchareon,   Ph.D. (ENTPE-LYONI)
Pisut   Painmanakul,   Ph.D. (INSA-Toulouse)
Sutha   Khaodhiar,   Ph.D. (Oregon State)
Sirima   Panyametheekul,   Ph.D. (Imperial College)
Thares   Srisatit,   Ph.D. (Savoie)
Khemarath Osathaphan,   Ph.D. (Oregon State)
Viboon   Sricharoenchaikul, Ph.D. (Georgia Tech)
Wiboonluk Pungrasmi,   Ph.D. (Tokyo)

Patiparn   Punyapalakul,   Ph.D. (Tokyo)
Tawan   Limpiyakorn,   Ph.D. (Tokyo)

ASSISTANT PROFESSORS :

Achariya   Suriyawong,   Ph.D. (Washington)
Benjaporn Suwannasilp   Ph.D. (Stanford)
Chaiyaporn Puprasert,   Ph.D. (INSA-Toulouse)
Manaskorn Rachakornkij,   Ph.D. (New Jersey)
Pichaya   Rachdawong,   Ph.D. (Wisconsin-Milwaukee)
Sarun   Tejasen,   Ph.D. (Oregon State)
On – anong Lavrpparisudthi Ph.D. (Coventry)

LECTURERS :

Dao Suwansang Jancharoen   Ph.D. (Illinois at Urbana-Champaign)
Jenyuk Lohwacharini   Ph.D. (Tokyo)

ENVIRONMENTAL ENGINEERING CURRICULUM
FIRST YEAR CURRICULUM
COMMON TO ALL ENGINEERING STUDENTS

COURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS
FIRST SEMESTER			**FIFTH SEMESTER**		
2103106	ENG DRAWING	3	2107313	UNIT PROC ENV ENG	3
2301107	CALCULUS I	3	2107445	AIR POL CONT & DESIGN	4
2302127	GEN CHEM	3	2104203	ENG MANAGEMENT	3
2302163	GEN CHEM LAB	1	2108298	SURVEYING	3
2304103	GEN PHYS I	3	2107484	SOLID WASTE ENG	3
2304183	GEN PHY LAB I	1	2100311	ENGINEERING ESSENTIALS	3
5500111	EXPERIENTIAL ENGLISH I	3	2503312	INTRO URB REG PLAN	3
2100111	EXPLORING ENGINEERING WORLD	3			**22**
		20			
SECOND SEMESTER			**SIXTH SEMESTER**		
2109101	ENG MATERIALS	3	2107452	PHYSICO-CHEMICAL TREATMENT	3
2110101	COMPUTER PROGRAMING	3	2107462	HAZ WASTE TREAT	3
2301108	CALCULUS II	3	2107481	INT ENV IMP ASSESSMENT	3
2304104	GEN PHYS II	3	2108302	FIELD PRACTICE I	1
2304184	GENPHYSIC LAB II	1	2112344	HYDRAULICS LAB I	1
5500112	EXPERIENTIAL ENGLISH II	3	2112342	PRIN HYDROLOGY	3
		16	xxxxxxx	GENERAL EDUCATION	3
					17
THIRD SEMESTER			**SUMMER SEMESTER**		
2103213	ENG MECH I	3	2100301	ENGINEERING PRACTICE	2
2107311	BIO ENV ENG	3			
2107214	AQUA CHEM ENV ENG	3	**SEVENTH SEMESTER**		
2301312	DIFF EQUATIONS	3			
2107448	NOISE/VIB CTRL	2	2107412	WASTE ENG DES	4
Xxxxxxx	GENERAL EDUCATION	3	2107444	BUILDING SAN	3
xxxxxxx	FREE ELECTIVE	3	2107482	ENV ENG PROJ I	1
		20	2112440	HYDRAULIC ENGINEERING	3
			5500208	COM PRES SKIL	3
			xxxxxxx	GENERAL EDUCATION	3
					17
FOURTH SEMESTER			**EIGHTH SEMESTER**		
2107215	WASTE CHEM ENV ENG	2			
2107312	UNIT OP ENV ENG	3	2107411	WAT SUPP ENG DES	4
2107253	ENG STAT I	3	2107450	ENV SYS MANAGE	3
2112346	HYDRAULICS I	3	2107483	ENV ENG PROJ II	2
2107449	IND SAFE MANAGE	2	5500308	TECHNICAL WRITING FOR	3
2107451	PRIN PUB HLTH	2	xxxxxxx	FREE ELECTIVE	3
xxxxxxx	GENERAL EDUCATION	3			**15**
		18			

TOTAL CREDITS FOR GRADUATION = 147

NAME OF THE DEGREE

: Master of Engineering
: M.Eng.

DEPARTMENT STAFFS

Khemarath Osathaphan,   Ph.D. (Oregon State)

ASSOCIATE PROFESSORS:

Chavalit	Ratanatamskul,	Ph.D. (Tokyo)
Chanathip	Pharino,	Ph.D. (MIT)
Orathai	Chavalparit,	Ph.D. (Chula)
Petchporn	Chawakitchareon,	Ph.D. (ENTPE-LYONI)
Pisut	Painmanakul,	Ph.D. (INSA-Toulouse)
Sutha	Khaodhiar,	Ph.D. (Oregon State)
Sirima	Panyametheekul,	Ph.D. (Imperial College)
Thares	Srisatit,	Ph.D. (Savoie)
Khemarath	Osathaphan,	Ph.D. (Oregon State)
Patiparn	Punyapalakul,	Ph.D. (Tokyo)
Tawan	Limpiyakorn,	Ph.D. (Tokyo)
Wiboonluk	Pungrasmi,	Ph.D. (Tokyo)
Viboon	Sricharoenchaikul,	Ph.D. (Georgia Tech

ASSISTANT PROFESSORS :

Achariya	Suriyawong,	Ph.D. (Washington)
Benjaporn	Suwannasilp	Ph.D. (Stanford)
Chaiyaporn	Puprasert,	Ph.D. (INSA-Toulouse)
Manaskorn	Rachakornkij,	Ph.D. (New Jersey)
Pichaya Rachdawong,		Ph.D. (Wisconsin-Milwaukee)
Sarun	Tejasen,	Ph.D. (Oregon State)
On – anong	Lavrpparisudthi	Ph.D. (Coventry)

LECTURERS :

Dao Suwansang Jancharoen	Ph.D. (Illinois at Urbana-Champaign)
Jenyuk Lohwacharini	Ph.D. (Tokyo)

ADMISSION

The applicant must hold either a Bachelor's Degree in Engineering or related degrees and met the requirements of the Graduate School.

DEGREE REQUIREMENTS

This program consists of 24 credits of course work, of which 17 are required and 7 are electives.

A student must present an acceptable thesis and pass an oral examination in the field of specialization for a quantity of not less than 12 credits.

COURSE REQUIREMENTS

1) Prerequisite Courses

Students with bachelor's degree other than environmental engineering degree must take and pass these following four prerequisite courses with S/U grade or obtain the exemption from the department:

2107667	Fundamental Engineering for Environmental Engineering	3(3-0-9)

All Students must take and pass the following prerequisite course with S/U grade:

2107701	Seminar in Environmental Engineering I	1(1-0-3)

2) Required Courses   20   credits

2107658	Theory and Design of Advanced Water Treatment Processes	4(3-3-10)
2107659	Theory and Design of Advanced Wastewater Treatment Processes	4(3-3-10)
2107670	Air Quality Management and Engineering	4(3-3-10)
2107671	Solid and Hazardous Waste Management	4(3-3-10)
2107673	Principles for Environmental Engineering Management	3(3-0-9)
2107702	Seminar in Environmental Engineering II	1(1-0-3)

3) Elective Courses   74   credits

Students must choose at least two elective courses from one particular field and at least another elective course from any fields with consent from the advisor.

2107530	Advanced Techniques In Physical And Chemical Treatment	3(3-0-9)
2107607	Environmental Analysis	3(3-0-9)
2107608	Technology of Solid and Hazardous Waste Treatment	3(3-0-9)
2107616	Air Quality Management	3(3-0-9)
2107622	Environmental Control Planning	2(2-0-6)
2107626	Stream Sanitation	2(2-0-6)
2107627	Advanced Sanitary Engineering Laboratory	3(1-6-5)
2107628	Design of Water Retaining Structures	3(1-6-5)
2107630	Treatment and Disposal of Industrial Waste	3(2-3-7)
2107632	Environmental Impact Assessment	2(2-0-6)
2107633	Water Quality and Agriculture Practice	3(3-0-9)
2107634	Advances in Environmental Pollution Research	2(2-0-6)

2107635	Reading in Environmental Engineering	1(1-0-3)
2107638	Plumbing Design	3(3-0-9)
2107639	Atmospheric Chemistry	3(3-0-9)
2107641	Air Polluting Control Technology	3(3-0-9)
2107642	Engineering Practices for Solid Waste Disposal	3(3-0-9)
2107644	Advanced Study in Environmental Engineering I	3(3-0-9)
2107645	Advanced Study in Environmental Engineering II	3(3-0-9)
2107646	Chemistry for Water and Wastewater Treatment	3(3-0-9)
2107654	Sampling and Analysis of Air Pollutants	3(2-3-7)
2107656	Thermal Processes for Waste Minimization and Utilization	3(3-0-9)
2107657	Energy and Environment	3(3-0-9)
2107660	Industrial and Hazardous Waste Management	3(3-0-9)
2107663	Industrial Waste Management	3(3-0-9)
2107664	Anaerobic Wastewater Treatment Technology	3(3-0-9)
2107665	Mass Transfer and Separation Processes in Environmental Engineering	3(3-0-9)
2107668	Clean-up of Contaminated Sites by Biological Processes	3(3-0-9)
2107669	Environmental Impact Assessment	3(3-0-9)
2107672	Adsorption for Water and Wastewater Treatment	3(3-0-9)
2107674	Treatment of Wastewater Contaminated with Oil and Small Particles in Environmental Engineering	3(3-0-9)

4) Thesis

| 2107811 | Thesis | 12 | credits |
| 2107816 | Thesis | 36 | credits |

NAME OF THE DEGREE

: Doctor of Philosophy
: Ph.D.

DEPARTMENT STAFFS

HEAD :

Chaiyaporn Puprasert,   Ph.D. (INSA-Toulouse)

ASSOCIATE PROFESSORS :

Chavalit	Ratanatamskul,	Ph.D. (Tokyo)
Orathai	Chavalparit,	Ph.D. (Chula)
Petchporn	Chawakitchareon,	Ph.D. (ENTPE-LYONI)
Pisut	Painmanakul,	Ph.D. (INSA-Toulouse)
Thares	Srisatit,	Ph.D. (Savoie)
Sutha	Khaodhiar,	Ph.D. (Oregon State)

Sirima   Panyametheekul,   Ph.D. (Imperial College)

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Khemarath	Osathaphan,	Ph.D. (Oregon State)
Pichaya Rachdawong,		Ph.D. (Wisconsin-Milwaukee)
Sarun	Tejasen,	Ph.D. (Oregon State)
Tawan	Limepiyakorn	Ph.D. (Tokyo)
Wiboonluk	Pungrasmi,	Ph.D. (Tokyo)
Patiparn	Punyapalakul,	Ph.D. (Tokyo)
Manaskorn	Rachakornkij,	Ph.D. (New Jersey)
Viboon	Sricharoenchaikul,	Ph.D. (Georgia Tech)
Achariya	Suriyawong,	Ph.D. (Washonton)
On – anong	Lavrpparisudthi	Ph.D. (Coventry)

LECTURERS :

| Dao Suwansang Jancharoen | Ph.D. (Illinois at Urbana-Champaign) |
| Jenyuk Lohwacharini | Ph.D. (Tokyo) |

ADMISSION

1) The applicant must have a Bachelor's Degree in Engineering with a minimum of second class honors
or
2) The applicant must have a Master's Degree in Environmental Engineering or Sanitary Engineering.

DEGREE REQUIREMENTS

Pattern 1 for a Master's Degree student who has a grade point average minimum of 3.5
- require 48 credits of doctoral dissertation
Pattern 2(1) for a Bachelor's Degree student
- require 72 credits of which 24 credits are course work and 48 credits are doctoral dissertation
Pattern 2(2) for a Master's Degree student who has a grade point average less than 3.5
- require 60 credits of which 12 credits are course work and 48 credits are doctoral dissertation

COURSE REQUIREMENTS

1) Required Courses   6   credits
2107791	Advanced seminar in Environmental Engineering I	1(1-0-3)
2107792	Advanced seminar in Environmental Engineering II	1(1-0-3)
2107793	Advanced seminar in Environmental Engineering III	1(1-0-3)
2107794	Advanced seminar in Environmental Engineering IV	1(1-0-3)

2107795	Advanced seminar in Environmental Engineering V	1(1-0-3)
2107796	Advanced seminar in Environmental Engineering VI	1(1-0-3)

2) Elective Courses   12 or 24   credits

2107607	Environmental Analysis	3(3-0-9)
2107608	Technology of Solid and Hazardous Waste Technology	3(3-0-9)
2107615	Advanced Environmental Biology	2(1-3-4)
2107616	Air Quality Management	3(3-0-9)
2107618	Water and Wastewater Treatment Plant Operation	3(2-3-7)
2107622	Environmental Control Planning	2(2-0-6)
2107626	Stream Sanitation	2(2-0-6)
2107627	Advanced Sanitary Engineering Laboratory	3(1-6-5)
2107630	Treatment and Disposal of Industrial Waste	3(2-3-7)
2107631	Environmental System Engineering	3(3-0-9)
2107633	Water Quality and Agriculture Practice	3(3-0-9)
2107634	Advances in Environmental Pollution Research	2(2-0-6)
2107635	Reading in Environmental Engineering	1(1-0-3)
2107636	Industrial Hygiene Practices	3(3-0-9)
2107637	Advanced Wastewater Technology	3(3-0-9)
2107638	Plumbing Design	3(3-0-9)
2107639	Atmospheric Chemistry	3(3-0-9)
2107641	Air Polluting Control Technology	3(3-0-9)
2107642	Engineering Practices for Solid Waste Disposal	3(3-0-9)
2107643	Public Health Engineering	3(3-0-9)
2107644	Advanced Study in Environmental Engineering I	3(3-0-9)
2107645	Advanced Study in Environmental Engineering II	3(3-0-9)
2107646	Chemistry for Water and Wastewater Treatment	3(3-0-9)
2107647	Process Chemistry of Water Treatment	3(3-0-9)
2107648	Industrial Water Conditioning	3(3-0-9)
2107649	Treatment Plant Hydraulics for Environmental Engineers	1(1-0-3)
2107650	Process Design for Nitrogen Control in Wastewater Treatment Plants	2(2-0-6)
2107652	Upgrading Wastewater Treatment Plants	2(2-0-6)
2107653	Modeling of Biochemical Reactors	3(3-0-9)
2107654	Sampling and Analysis of Air Pollutants	3(2-3-7)
2107655	Statistics for Environmental Engineers	3(3-0-9)
2107656	Thermal Processes for Waste Minimization and Utilization	3(3-0-9)
2107657	Energy and Environment	3(3-0-9)

2107658	Theory and Design of Advanced Water Treatment Processes	4(3-3-9)
2107659	Theory and Design of Advanced Wastewater Treatment Processes	4(3-3-9)
2107660	Industrial and Hazardous Waste Management	3(3-0-9)
2107669	Environmental Impact Assessment	3(3-0-9)
2107663	Industrial Waste Management	3(3-0-9)

3) Dissertation

2107828	Dissertation	48 credits
2107894	Doctorial Dissertation Seminar	0(0-0-0)
2107897	Qualifying Examination	0(0-0-0)

COURSE DESCRIPTIONS IN ENVIRONMENTAL ENGINEERING (B.ENG.)

**2107211   Introduction to Environmental   3(3-0-6)
             Sanitation and Engineering**

An introduction course to the field of Sanitary and Environmental   Engineering for rural and urban development; topics include the communicable diseases and methods of communication, control of disease vectors, excreta disposal, refuse collection and disposal, building sanitation, industrial hygiene, air and noise pollution, sources of water supply and treatment, wastewater collection, treatment and disposal.

**2107212   Chemistry for Environmental   2(1-3-2)
             Engineering I**
Condition : Prerequisite 2302127, 2302163

Chemical and physical characteristics of water, general considerations, methods for determination and application of data to environmental engineering practice; instrumentation; laboratory analysis of water; interpretation of water analysis results   as   related   to   their   treatment: neutralization, precipitation, coagulation, water softening, ion exchange, corrosion, adsorption, chlorination.

**2107213   Chemistry for Environmental   2(1-3-2)
             Engineering II**
Condition : Prerequisite 2302127,2302163

Chemical and physical characteristics of wastewater, general   considerations,   methods   for   determination   and application of data to Environmental Engineering practice; sample collection and preservation; determinations of solids, DO, BOD, COD, Nitrogen (in all forms related to Environmental   Engineering   practice),   phosphorus   and phosphates, grease and oil, volatile acids and sulfides; instrumentation for wastewater analysis.

**2107214   Aquatic Chemistry for   3(2-3-4)
             Environmental Engineering**

Chemical and physical characteristics of water, general considerations, methods for determination and application of   data   to   environmental   engineering   practice;

instrumentation; laboratory analysis of water; interpretation of water analysis results as related to their treatment; neutralization, precipitation, coagulation, water softening, ion exchange, corrosion, absorption, chlorination; basic principles of acid-base equilibria, solubility equilibria, oxidation-reduction equilibria, fundamentals of process kinetics, fundamental of surface and colloidal chemistry, water stabilization, water softening and neutralization.

2107215 Wastewater Chemistry for   2(1-3-2)
Environmental Engineering

Chemical and physical characteristics of wastewater, general considerations, methods for determination and application of data to environmental engineering practice; sample collection and preservation; determinations of solids, DO, BOD, COD, nitrogen (in all forms related to environmental engineering practice), phosphorus and phosphates, grease and oil, volatile acids, sulfides and gas analysis; instrumentation for wastewater analysis.

2107219* Urban Environments   3(3-0-6)
Engineering

Urban environments in general, pollution problems in urban area : wastewater, solid waste, noise pollution, air pollution, and hazardous waste : sources of pollution; destruction of the urban environment; especially solution to its urban problems in such scientific, especially engineering aspect; management of pollution, especially pollution control and treatment; improvement guidelines for urban development; regulations and laws related to buildings in urban area, participation of people living in urban are, and case studies.

(* Elective course for non Environmental Engineering Students)

2107220 Environments and Daily life   3(3-0-6)

A learning process of environment in daily life; the un of case studies and social knowledge which are key information in analyzing the importance of in dairy life; integrated ecological system; natural resources and related environment; integration the of outcome of the study with related disciplines in order to understand and realize the importance of environment and guidelines for participation for better environment.

2107221 Environmenal Studies   3(3-0-6)

Basic knowledge and important perspectives on global environment with emphasis on case studies; ecosystem; biogeochemical cycles; population studies; energy; wetland; water pollution; air pollution; noise pollution; solid waste disposal; hazardous waste; waste treatment system design; environmental responsibility.

2107311 Biology for Environmental   3(2-3-7)
Engineering

Cell and its structure, principles of bacteriology, population growth, roles of bacteria in public health, coliform bacteria, methods of collection and bacteriological examination of water & sewage, principles of immunization, disinfection and sterilization, actions of enzymes as related to stabilization of organic matter, biodegradation of organic compounds, fundamental concepts related to energy, food chain, productivity and limiting factors, positive and negative interactions among microbial populations, basic concept of ecology, habitat and ecological niche, Nitrogen, Carbon, Sulfur, Phosphorus cycles, freshwater ecology and biota dynamics in wastewater treatment environments.

2107312 Unit Operations for Environmental   3(3-0-6)
Engineering

An overview of unit processes and application of unit operations in water and waste treatment as well as air pollution control: aeration and gas transfer, mixing, sedimentation, aerosol separation, filtration, coagulation, precipitation, ion exchange, adsorption.

2107313 Unit Process for Environmental   3(2-3-4)
Engineering

Reactor design, flow model, reaction kinetics, screening, sedimentation, filtration, coagulation-flocculation, absorption, stripping, sorption, stoichiometry of biological process, microbial growth kinetics, activated sludge system.

2107411 Water Supply Engineering and   4(3-3-6)
Design
Condition : Prerequisite 2107212,2107312

Sources of public water supply, quality and quantity requirements: water standards, population prediction, water consumption and flow variation; design of water distribution systems; design of water treatment plant; planning.

2107412 Wastewater Engineering and   4(3-3-6)
Design
Condition : Prerequisite 2107311, 2107312,
2107213

Wastewater flow rates and characteristics; collection, transportation and pumping; wastewater treatment objectives; methods and design fundamental of process analysis; facility design of physical, chemical and biological treatment for primary and secondary processes; land treatment and disposal.

2107441 Air Pollution Control   3(3-0-6)

Basic knowledge in air pollution: major pollutions, sources, effects on health and welfare, meteorological transport. Sampling and analysis, techniques for control of emissions of particulates and gas, air pollution control regulations and standards, air quality management, enforcement systems.

2107444 Building Sanitation   3(3-0-6)

Fundamentals of Building Sanitation; law & regulations; design of building water supply (hot, cold & drinking water), building drainage and vent systems; fire protection; site drainage; building wastewater and solid wastes disposal and treatment, swimming pool system design.

2107445   Air Pollution Control and Design   4(3-3-6)
Basic knowledge in air pollution: major pollutions, sources, effects on health and welfare, meteorological transport, sampling and analysis, techniques for control of emissions of particulates and gas, air pollution control regulations and standards, air quality management, enforcement systems.

2107446   Treatment of Industrial   3(3-0-6)
**   Wastewater**
Condition : Prerequisite 2107412
Industrial wastewater effluent standards; laws and regulations; industrial wastewater monitoring systems; sources, quantity and qualification characteristics of industrial wastewater; industrial wastewater treatment technology; water pollution control and management in major industries; case studies on wastewater reuse and product recovery.

2107448   Noise and Vibration Control   2(2-0-4)
Behavior of sound waves; instrumentation; practical measurements; environmental impact of noise and vibration; regulations and criteria for noise and vibration control in environmental systems; use of acoustic materials, noise and vibration barriers.

2107449   Industrial Safety Management   2(2-0-4)
Nature of accident in industry and need of accident prevention; planning for safety such as plant layout, machine guarding and maintenance, etc; safety in industry; management of safety program; safety training; case studies in accident analysis.

2107450   Environmental Systems and   3(3-0-6)
**   Management**
Basic interrelating effects on environmental in terms of environmental engineering aspects; the functions of government and other agencies in environmental management; an analysis for decision making in environmental protection programs; public policy and action; arrangement of organizations and institutes related to environmental management including   their structures and roles; policy development; management approaches and program implementation; case studies of specific environmental protection.

2107451   Principles of Public Health   2(2-0-4)
Health aspects of environmental quality; some principles of epidemiology with special emphasis on community and occupational environment; environmental health standards and requirements; engineering control of some urban and rural pollution problems; other topics in application of engineering principles in environmental protection.

2107452   Physico-chemical Treatment   3(3-0-6)
Theoretical approach to physico-chemical treatment processes : Chemical reaction treatment, Oxidation-reduction treatment, Floculation, Sedimentation, Precipitation, Separation units, Floatation, Adsorption, Membrane Processes.

2107453   Public Health Engineering   3(3-0-6)
Public health and safety in different environmental quality settings; principles, of managing the environment and safety of working places; managing and promoting the safety during work; law and regulations related to public health; Implementation of engineering principles to manage and minimize environmental problems in working places, communities and metropolitan.

2107460   Introduction to Hazardous Waste 3(3-0-6)
**   Treatment**
An introduction course to hazardous waste treatment technology : topics include definition, classification, regulations, sources, impacts on environment, chemical, biological, thermal, stabilization/solidification treatment, and final disposal method.

2107462   Hazardous Waste Treatment   3(3-0-6)
Basic principles of management and treatment of both organic and inorganic hazardous waste; the treatment system includes physical, chemical, biological, or thermal process as well as final disposal method.

2107480   Sanitary System in Architecture   2(2-0-4)
Fundamentals of building sanitary engineering ; conceptual design and installation of building water supply and hot water supply, wastewater collection, rain water drainage, wastewater treatment, fire protection, swimming pool water treatment , solid wastes collection and disposal.

2107481   Introduction to Environmental   3(3-0-6)
**   Impact Assessment**
Development of environmental impact study with exphasis on environment parameters including physical resources, ecological resources, human use values and quality of life values. Interrelationship between engineering aspects and environmental parameters and case studies.

2107482   Environmental Engineering   1(0-3-1)
**   Project I**
Practical interesting project on problems in various fields of Environmental Engineering.

2107483   Environmental Engineering   2(0-3-2)
**   Project II**
Practical interesting project on problems in various fields of Environmental Engineering.

2107484 Solid Waste Engineering   3(3-0-6)
Condition : Prerequisite 2107213
Quantity and composition of solid wastes; impacts to environment; disposal methods - alternatives and selection; leachate problem; volume and size reduction; transportation; components separation; landfilling; incineration; composting; integrated process and management.

2107491* General Water Supply Engineering 3(3-0-6)
Sources of Water supply; drinking water standards; quantity required, ground water collection; water transmission and distribution; water treatment technique: screening, coagulation and flocculation, sedimentation, filtration, disinfection, softening, iron removal, taste and odor removal.

**2107494* Industrial Water Supply and   3(3-0-6)
          Wastewater Treatment**
Sources of water supply; industrial water standards; water treatment techniques: screening, coagulation and flocculation, sedimentation, filtration, softening, demineralization and disinfection; industrial wastewater characterization; effluent standards; industrial wastewater treatment processes.

**2107495 Advanced Topics in Environmental 3(3-0-6)
          Engineering I**
Condition : Senior Standing
Study topics of current inerest and new developments in various fields of environmental engineering.

**2107496 Advanced Topics in Environmental 3(3-0-6)
          Engineering II**
Condition : Senior Standing
Study topics of current interest and new developments in various fields of environmental engineering.

**2107497 Special Problems in Environmental 3(2-3-4)
          Engineering I**
Condition : Senior Standing
Study or investigation of special problems in Environmental Engineering.

**2107498 Special Problems in Environmental 3(2-3-4)
          Engineering II**
Condition : Senior Standing
Study or investigation of special problems in Environmental Engineering.

**2107499 Environmental Engineering   3(0-6-3)
          Project**
Condition : Senior Standing
Practical interesting project on problems in various fields of Environmental Engineering.

(* Elective course for non Environmental Engineering Students)

**COURSE DESCRIPTIONS IN
ENVIRONMENTAL ENGINEERING (M.ENG., PH.D.)**

**2107530 Advanced Techniques in Physical   3(3-0-9)
          and Chemical Treatment**
Applications of theoretical approaches to the following physical and chemical treatment processes: absorption, adsorption, stripping, distillation, sedimentation, flotation, coagulation, flocculation, neutralization, gas / liquid transfer, heavy metal removal, membrane filtration.

**2107551 Environmental management   3(3-0-6)
          System ISO 14000**
Environmental management system and ISO 14000 series; ISO 14001 criteria and requirements; environmental situation review; search for environmental aspect, policy and action plans; environmental management system auditing and management review.

2107607 Environmental Analysis   3(3-0-9)
Procedures and details of environmental sample analysis; methods of sample collection, sample handling; analytical method selection; details of analysis and data presentation.

**2107608 Technology of Solid and Hazardous 3(3-0-9)
          Waste Treatment**
Basic principles of solid and hazardous materials; atom structure and chemical reaction; combustion mechanisms of reactive materials; laws governing gas temperature, pressure and volume; behavior of compressed and cryogenic gases; explosive mechanism; shock waves; toxicity, corrosive and radiation; hazardous waste treatment technologies, physical chemical and biological treatments; precipitation, sedimentation, chemical oxidation, neutralization, extraction, incineration, landfill, land treatment, ocean disposal; sources, types and composition of waste to be treated and utilized; advantages and disadvantages in recycling waste; processes of basic technologies; processes of utilizing; organic and inorganic waste.

**2107611 Advanced Water Treatment   3(3-0-9)
          Processes**
*Condition : Prerequisite 2107212 or
Consent of Faculty*
Water sources. Water chemistry and quality. Aeration, Coagulation, Sedimentation, Filtration, Ion exchange, membrane processes, disinfection, adsorption, neutralization and stabilization.

**2107612 Advanced Wastewater Treatment   3(3-0-9)
          Processes**
*Condition : Prerequisite 2107213, 2107311
or Consent of Faculty*
Development in wastewater technology: wastewater collection and transportation, design of sewers and appurtenances, advanced wastewater treatment, treatment by microbial and biological control techniques,

laws relating to effluent disposal, wastewater treatment plant organization and management.

2107613   Design of Water Treatment Plant   3(1-6-5)
and Distribution System
Condition : Prerequisite 2107611
or Consent of Faculty

Development of design criteria for water sources, pipe lines distribution and storage facilities, water treatment and softening, engineering design of water distribution system, functional and hydraulic design of complete water treatment plant.

2107614   Design of Wastewater Treatment   3(1-6-5)
Plant and Collection System
Condition : Prerequisite 2107612
or Consent of Faculty

Combined and separate system: pumping stations, functional and hydraulic design of complete wastewater treatment plant.

2107616   Air Quality Management   3(3-0-9)

Interaction among air, water and land pollutions, effects of air pollutants, standards and regulations, technical aspects of air pollution control programs, the organization and management of control programs in governmental and private sectors.

2107617   Solid Wastes and Hazardous Wastes
Management   3(3-0-9)

Quantity and composition of solid wastes and hazardous wastes; impacts to environment; legislation; collection and transportation system; disposal technique; choice of disposal site; planning and management; case study.

2107622   Environmental Control Planning   2(2-0-6)

Fundamental of comprehensive environmental planning; planning for environmental health : program planning process; rural and urban development; ecosystem concepts; energy; toxicology; environmental health standards; economic principles of pollution control; social cost and pollution damage functions and their economic, social and health implication; problems associated with environmental management.

2107626   Stream Sanitation   2(2-0-6)

Patterns of pollution and natural purifications; bacterial self purification; deoxygenation rate; reoxygenation rate; DO sag curve; detection and measurement of pollution; pollution of tidal & coastal waters; BDO loading of receiving waters.

2107627   Advanced Sanitary Engineering   3(1-6-5)
Laboratory

Laboratory and pilot plant techniques used to obtain design data, to control plant operation, and to investigate processes for the treatment of water, sewage and wastes.

2107628   Design of Water Retaining   3(1-6-5)
Structures

General design principles of water retaining structures; cylindrical and rectangular tanks; open and covered reservoirs; tanks with conical and pyramidal bottoms; swimming pools and tanks with sloping floors; water tower storage; some special design problems

2107630   Treatment and Disposal of   3(2-3-7)
Industrial Wastes

Industrial waste problems; categories of waste; nature and characteristics of liquid waste; effect of waste on environment; laws for disposal of waste in Thailand and other countries; method of treatment of various kinds of waste; preventive measures.

2107632   Environmental Impact Assessment   2(2-0-6)

Environmental changes and its impact on communities; assessment methodology; environmental planning and decision making; case studies.

2107633   Water Quality and   3(3-0-9)
Agriculture Practice

Water pollution from agricultural practices; sediment, plant nutrients, pesticides, and animal waste; implications of agricultural pollution; control policy and methods.

2107634   Advances in Environmental   2(2-0-6)
Pollution Research

Selected research topics in water and wastewater treatment, air pollution control and abatement, and solid waste disposal and management.

2107635   Reading in Environmental   1(1-0-3)
Engineering

Selected topics in environmental engineering issues and discussion.

2107638   Plumbing Design   3(3-0-9)

Plumbing systems, materials, and flow in pipes. Design of water supply systems, hot water supply systems, sanitary drainage and vent systems, storm drainage, fire protection system, public swimming pools, valves, pumps. Installation and testing a system.

2107639   Atmospheric Chemistry   3(3-0-9)

Photochemistry of small quantity gas; surface reaction and adsorption phenomena; physical and chemical of aerosol; origin; coagulation and precipitation of dust in ambient and reaction with gas.

2107641   Air Pollution Control Technology   3(3-0-9)

Overview of air pollution control methods. Control of particulates and gaseous emissions by settling chambers, cyclones, scrubbers, filters and electrostatic precipitators. esign of equipment, maintenance and evaluation of control of efficiency.

**2107642   Engineering Practices for   3(3-0-9)
            Solid Waste Disposal**

Municipal and industrial solid wasters, their volume and characteristics; heat value methods of handling, storage and disposal. Size and volume reduction. Separation of components. landfill and leachate effects. Ocean disposal. Incineration.

**2107644   Advanced Study in   3(3-0-9)
            Environmental Engineering I**

Study of recent topic and technology development in various fields of environmental engineering.

**2107645   Advanced Study in   3(3-0-9)
            Environmental Engineering II**

Study of recent topic and technology development in various fields of environmental engineering.

**2107646   Chemistry for Water and   3(3-0-9)
            Wastewater Treatment**

Basic principles, acid-base equilibria, solubility equilibria, oxidation - reduction equilibria, fundamentals of process kinetics fundamental of surface and colloidal chemistry, coagulation in water treatment, water stabilization, water softening and neutralization, ion exchange, carbon adsorption.

**2107647   Process Chemistry of   3(3-0-9)
            Water Treatment**

Criteria and standards of water quality, organic compounds in raw and finished water, tastes and odors in drinking water, removal of particulate matter by coagulation, removal of particulate matter by filtration, removal of hardness and other scale. Foaming substances, removal of inorganic contaminants, removal of corrosive substances, removal of pathogenic bacteria and viruses.

**2107654   Sampling and Analysis of   3(2-3-7)
            Air Pollutants**

Sampling of particulate and gaseous pollutants from source and atmosphere, flow measuring devices and their calibration techniques of pollutant identification and analysis, particle measurement, use of techniques in performance test of air control equipment.

**2107655   Statistics for Environmental   3(3-0-9)
            Engineers**

Review of basic statistics; sampling methods for quantitative and qualitative data collection, sample size determination; statistics for data quality control in laboratory; design of experiments, and basic model building techniques.

**2107656   Thermal Processes for Waste   3(3-0-9)
            Minimization and Utilization**

Introduction to potential agricultural and industrial wastes for thermal conversion processes; kinetics in thermal pyrolysis and gasification; innovative heat source systems including plasma and microwave; low and high temperature processes; short and long residence time processes; potential pollution problems and amendment; design considerations of different types of thermal conversion reactors; treatment and conversion of immediate products into useful chemicals and fuel; ash and tar formation and their remediation.

2107657   Energy and Environment   3(3-0-9)

Energy resources and utilization in the global context and a case studies in Thailand; fossil-based energy, environmental impact of mining and fuel processing; air pollution, greenhouse gas, and global warming from fuel utilization; energy conservation and renewable energy technologies; hydro energy harnessing and its environmental impact and mitigation; other non-fossil fuel options: biomass, solar, and wind energy; synthetic fuel conversion technology including pyrolysis and gasification; biogas from fermentation; prospect of hydrogen economy.

**2107658   Theory and Design of Advanced 4(3-3-10)
            Water Treatment Processes**
            Condition : Prerequisite: 2107661 or C.F.

Water sources; water chemistry and quality, aeration, coagulation, sedimentation, filtration, ion exchange, membrane processes, disinfection absorption, neutralization and stabilization; water conditioning for boiler and cooling system; design criteria for water sources, lines distribution and storage facilities, water treatment and softening, engineering design of water distribution system, functional and hydraulic design of complete water treatment.

**2107659   Theory and Design of Advanced 4(3-3-10)
            Wastewater Treatment Processes**
            *Condition : Prerequisite: 2107311,
            2107661 or C.F.*

Development of wastewater technology; wastewater collection and transportation; design of sewers and appurtenances; advanced wastewater treatment by microbial and biological control techniques, law related to effluent disposal; wastewater law relating to effluent disposal, wastewater treatment plant organization and management; combined and separate system pumping stations; functional and hydraulic design of complete wastewater treatment system.

**2107660   Industrial and Hazardous Waste 3(3-0-9)
            Management**

Terms and definitions, types and sources of waste, law, regulations, disposal and management standards, related organizations; reduction of waste and case studies, unit operations for waste management; reuse and recycle of industrial waste and case studies; treatment of industrial

waste; sample collection and characterization of waste; physical and chemical treatment of industrial waste, stabilization and solidification; disposal of industrial waste and monitoring, disposal guidelines; design of industrial waste landfill, monitoring and checking of the landfill; international industrial waste management, transport of hazardous waste across international borders, case studies, Basel accord.

2107661   Fundamental Chemistry for   3(2-3-7)
           Environmental Engineering

Chemical and physical characteristics of water and wastewater, general considerations, methods for determination and application of data to environmental engineering practice; instrumentation; sample collection and preservation; laboratory analysis of water; interpretation of water analysis results as related to their treatment; neutralization, precipitation, coagulation, water softening, ion exchange, corrosion, absorption, chlorination; determinations of solids, DO, BOD, COD, nitrogen (in all forms related to environmental engineering practice), phosphorus and phosphates, grease and oil, volatile acids, sulfides and gas analysis.

2107662   Unit Processes for   3(3-0-9)
           Environmental Engineering

An overview of unit processes and application of unit operations in water and waste treatment by physical, chemical and biological processes as well as air pollution control processes.

2107663   Industrial Waste Management   3(3-0-9)

Analysis of material and energy flow in industrial system to enhance eco-efficiency; relationships between industrial production and economic development; waste minimization, pollution prevention, prevention, design for environment, life cycle analysis (LCA) and waste exchange; linkage of Industrial activity with environmental and social sciences; integration of environmental management and environmental ethics; environmental policies and laws.

2107664   Anaerobic Wastewater Treatment 3(3-0-9)
           Technology

Types of biological wastewater treatment; Theory and basic mechanism of anaerobic wastewater treatment; microbiology and biochemistry of anaerobic fermentation; Kinetics of anaerobic treatment system; various types of anaerobic wastewater treatment system; design and operation of anaerobic treatment processes; current status of anaerobic technology; consideration and selection of anaerobic process in industrial, municipal and agricultural wastewater treatment.

2107665   Mass Transfer and Separation   3(3-0-9)
           Processes in Environmental Engineering

Theory of molecular diffusion and mass transfer; fundamental of phase equilibrium; mass transfer operation

and separation process; interface mass transfer; absorption and desorption; adsorption and ion exchange; distillation; physical separation process; membrane separation process; finishing process.

2107666   Fundamental Biology for   3(2-3-7)
           Environmental Engineering

Cell and its structure, principles of bacteriology, population growth, roles of bacteria in public health, coliform bacteria, methods of collection and bacteriological examination of water and sewage, principles of immunization, disinfection and sterilization, actions of enzymes as related to stabilization of organic matter, biodegradation of organic compounds, fundamental concepts related to energy, food chain, productivity and limiting factors, positive and negative interactions among microbial populations, basic concept of ecology, habitat and ecological niche; nitrogen, carbon, sulphur, phosphorus cycles; freshwater ecology and its inhabitants, lake stratification, river pollution, roles of inhabitants and biota dynamics in wastewater treatment environments.

2107667   Fundamental Engineering for   3(3-0-9)
           Environmental Engineering

Basic principles of mathematics, statistics, calculus, ordinary differential equation, mechanic, hydraulics and hydrology required for environmental engineering.

2107668   Clean-up of Contaminated Sites 3(3-0-9)
           by Biological Processes

Pollutants and their properties: site characterization: physical and chemical properties of a site: risk assessment: fate and transport of pollutants: fundamental of microbiology: microbial metabolism process: microbial destruction of pollutants process: bioremediation approach: factors influencing bioremediation: bioremediation technology: design of bioremediation systems: detection of microorganisms by molecular tools: phytoremediation: case studies.

2107669   Environmental Impact Assessment 3(3-0-9)

Selection of feasible projects by engineering, socio-economic and environment; environmental changes and its on communities, assessment methodology; environmental planning and decision making; risk assessment caused by chemical of hazardous waste; case studies.

2107670   Air Quality Management and   4(3-3-10)
           Engineering

Effects of air pollutants, standards, law and regulations, the organization and management of mitigation programs, emission source inventory, pollutant dispersion and mathematical modeling, principles and design of air pollution control system, measurement and monitoring system.

2107671   Solid and Hazardous Waste   4(3-3-10)
           Management

Overview of management schemes, sources and generation of solid and hazardous wastes, important physical, chemical, and biological characteristics of wastes, regulations, international laws and standards, collection and transfer, transport of hazardous wastes and code of practices, resource recovery of solid wastes, treatment procedures and stabilization of hazardous wastes, thermal processes, various disposal means of solid and hazardous wastes including landfill.

2107672　Adsorption for Water and　3(3-0-9)
**　　　　　Wastewater Treatment**

Adsorption theory in aqueous phase; type of adsorbents; characterization adsorbents of physico-chemical adsorption phenomena; adsorption kinetics; adsorption isotherm; effects of water and wastewater characteristics on adsorption effciency; adsorption processes design for water production and wastewater treatment; adsorbent regeneration; case studies on adsorption phenomena of pollutants in aqueous phase.

2107673　Principles for Environmental　3(3-0-9)
**　　　　　Engineering Management**

Principles of planning and setting policies for environmental management; example of policy application in working; principles of using economic instruments in setting policies for natural resource conservation and environmental protection; methods of cost survey and estimation; effectiveness and advantages of policies for environmental management; comparison of advantages and disadvantages of each type of policies in order to achieve the objective as planned; analysis and comparison of current guidelines and policies for environmental management by using case studies in Thailand and abroad; related projects.

2107674　Treatment of Wastewater　3(3-0-9)
**　　　　　Contaminated with Oil and Small**
**　　　　　Particles in Environmental Engineering**

Oil and small particles in environment; analysis of oil and small particles: overview of treatment and separation processes; fundamental knowledge of separation process; oil skimmer; gravity separation (decantation); coalescer; flotation; hydrocyclone; membrane processes; thermal processes; chemical treatment processes; electro-chemical processes; hybrid treatment processes; finishing process.

2107701　Seminar in Environment　1(1-0-3)
**　　　　　Engineering I**

A once a week seminar series on work done in sanitary engineering points of view. Invited speakers from government industry and various professionals will present these seminar. Every student is expected to present paper on his own research.

2107702　Seminar in Environment　1(1-0-3)
**　　　　　Engineering II**

A once a week seminar series on work done in sanitary engineering points of view. Invited speakers from

government industry and various professionals will present these seminar. Every student is expected to present paper on his own research.

2107791　Advanced Seminar in　1(1-0-3)
**　　　　　Environmental Engineering I**

Seminar on recent and interesting topics in the field of environmental engineering, and report presentation.

2107792　Advanced Seminar in　1(1-0-3)
**　　　　　Environmental Engineering II**

Seminar on recent and interesting topics in the field of environmental engineering, and report presentation.

2107793　Advanced Seminar in
**　　　　　Environmental Engineering III　1(1-0-3)**

Seminar on recent and interesting topics in the field of environmental engineering, and report presentation.

2107794　Advanced Seminar in
**　　　　　Environmental Engineering IV　1(1-0-3)**

Seminar on recent and interesting topics in the field of environmental engineering, and report presentation.

2107795　Advanced Seminar in　1(1-0-3)
**　　　　　Environmental Engineering V**

Seminar on recent and interesting topics in the field of environmental engineering, and report presentation.

2107796　Advanced Seminar in　1(1-0-3)
**　　　　　Environmental Engineering VI**

Seminar on recent and interesting topics in the field of environmental engineering, and report presentation

2107811	**Thesis**	**12 Credits**
2107816	**Thesis**	**36 Credits**
2107826	**Dissertation**	**36 Credits**
2107828	**Dissertation**	**48 Credits**
2107830	**Dissertation**	**72 Credits**
2107894	**Doctorial Dissertation Seminar**	**0(0-0-0)**
2107897	**Qualifying Examination**	**0(0-0-0)**

DEPARTMENT OF SURVEY ENGINEERING

The objective of the department is aimed at providing theoretical principles and practical techniques on surveying mapping and geoinformation necessary for various engineering and development projects. Courses offering in the department both at undergraduate and graduate levels cover broad fields of surveying, photogrammetry and remote sensing, cartography, geodesy, and spatial information technology.

The department currently have three curriculums:
1. The bachelor degree in survey engineering
2. The master of engineering program in survey engineering
3. The doctor of philosophy program in geomatic engineering

The bachelor degree curriculum which is four years is designed such that the student will have basic knowledge in engineering in general and a more intensive knowledge of surveying mapping and geoinformation technology in particular. The curriculum is blended with theories and practices. Students will have experiences on various surveying instruments , computer mapping and geoinformation technology. Confidence and competence to solve practical problems in the domain of survey engineering is strengthened through field practices and on the job training. A more insight to the subject is possible, upon the department's approval, through senior project, special study, and approved elective courses according to the student's interest. It is expected that the program would enable the students to
1. understand the structures and   requirements   of surveying, mapping and geoinformation technology;
2. apply the theories and techniques to general surveying and mapping tasks effectively, efficiently, and economically;
3. Analyse and make use the instrumental mechanics for evaluating the accuracy and precision attained;
4. follow new technology and development in the field of surveying and mapping and geoinformation technology.

The master of engineering in survey engineering program (revised curriculume 1994) is a two-year program designed to respond social needs which keep changing according to technological advances. The program objectives are
1. To allow more flexible curriculum structure in order to be more responsive to social needs and;
2. To produce graduates highly capable in both theory and practice;
3. To study and research in fields related to survey engineering and mapping, in order to improve the quality of the graduates.

The program of master of science in spatial information in engineering is a two-year program commenced in academic year 1999. The curriculum is designed to respond social needs of people highly capable in spatial information technology or geographic information system. The program objectives are:
1. To produce graduates who have a deep understanding of spatial information technology for engineering enterprises in both business and public sector;
2. To generate new body of knowledge in spatial information system for the research and development of the department and the university.

Ph.D. in survey engineering is a three-years program for full-time candidates with the possibility of two years extensions. Candidates undertake a research program which is supervised normally through a supervisory panel with one principle supervisor. The program objectives are:
1. To generate new body of knowledge in the specifie field of survey engineering through a research work;
2. To produce graduates.

HEAD :

Chalermchon   Satirapod,   Ph.D. (New South Wales)

PROFESSORS:

Chalermchon   Satirapod,   Ph.D. (New South Wales)

ASSOCIATE PROFESSORS :

Banjerd	Phalakarn,	Doctorat (Denis Diderot)
Itthi	Trisirisatayawong,	Ph.D. (Melbourne)
Chanin	Tinnachote,	D.Eng. (AIT)
Phisan	Santitamnont,	Dr.-Ing. (Leibniz Hannover)
Vichai	Yiengveerachon,	M.Eng. (Chula)

ASSISTANT PROFESSORS :

Sanphet Chunithipaisarn,	Ph.D. (Newcastle upon Tyne)
Colonel Kanok Weerawong	Ph.D. (Purdue)
Somchai Kriengkraiwasin	M.Eng. (Chula)

LECTURERS :

Chaichoke Vaiphasa.	Ph.D. (ITC)
Thongthit Chayakula,	Ph.D. (London)
Teetat Charoenkalunyuta,	Ph.D. (Chula)
Garavig Tanaksaranond,	Ph.D. (London)

SURVEY ENGINEERING CURRICULUM
FIRST YEAR CURRICULUM
COMMON TO ALL ENGINEERING STUDENTS

COURSE	SUBJECT	CREDITS
	THIRD SEMESTER	
2301207	CALCULUS III	3
2103213	ENGINEERING MECHANICS I	3
2108205	FUNDAMENTAL OF GEOMATICS	3
2104223	ENGINEERING STATISTICS I	3
5500208	COMMUNICATION AND PRESENTATION SKILLS	3
xxxxxxxx	GENERAL EDUCATION (I)	3
		18
	FOURTH SEMESTER	
2101344	FUNDAMENTAL OF CIVIL ENGINEERING	3
2106251	GENERAL GEOLOGY	3
2108202	SURVEYING ENGINEERING	3
2108234	NUMERICAL ANALYSIS IN GEOMATICS	3
2112343	HYDROLOGY FOR SURVEY ENGINEER	3
xxxxxxxx	GENERAL EDUCATION (II)	3
		18
	FIFTH SEMESTER	
2108301	SURVEYING WITH CONSTRUCTION APPLICATIONS	3
2108371	PHOTOGRAMMETRY AND REMOTE SENSING SYSTEM	3
2108311	GLOBAL GEODESY	3
2108325	GEOGRAPHIC INFORMATION SYSTEM AND APPLICATIONS	3
2108332	ADJUSTMENT COMPUTATION	3
2100311	ENGINEERING ESSENTIALS	3
		18
	SIXTH SEMESTER	
2108372	ADVANCED REMOTE SENSING	3
2108373	ADVANCED PHOTOGRAMMETRY	3
2108306	FIELD PRACTICE ON TOPOGRAPHIC SURVEYING	1
2108307	FIELD PRACTICE ON ROUTE SURVEYING	1
2108342	MATHEMATICAL CARTOGRAPHY	3
2108412	SATELLITE SURVEYING	3
2108326	GEOSPATIAL INFORMATION ANALYSIS AND VISUALIZATION	3
5500308	TECHNICAL WRITING FOR ENGINEERING	3
		20

COURSE	SUBJECT	CREDITS
	SUMMER SEMESTER	
2100301	ENGINEERING PRACTICE	2
	SEVENTH SEMESTER	
2108415	GEODETIC SURVEYING	3
xxxxxxxx	APPROVED ELECTIVES (I)	3
xxxxxxxx	APPROVED ELECTIVES (II)	3
xxxxxxxx	GENERAL EDUCATION (III)	3
Xxxxxxxx	FREE ELECTIVES (I)	3
		15
	EIGHTH SEMESTER	
2108416	*FIELED PRACTICE ON GEODETIC SURVEYING*	*1*
2108414	*FIELD PRACTICE ON DIGITAL MAPPING*	*1*
2108499	SURVEY ENGINEERING PROJECT	3
	-OR -	
(2104499	ENGINEERING PROJECT	3)
xxxxxxxx	APPROVED ELECTIVES (III)	3
xxxxxxxx	APPROVED ELECTIVES (IV)	3
xxxxxxxx	GENERAL EDUCATION (IV)	3
xxxxxxxx	FREE ELECTIVES (II)	3
		17

TOTAL CREDITS FOR GRADUATION   =   144

NAME OF THE DEGREE

: Master of Engineering
: M.Eng.

PROFESSORS :

Chalermchon Satirapod,   Ph.D. (New South Wales)

ASSOCIATE PROFESSORS :

Banjerd	Phalakarn,	Doctorat (Denis Diderot)
Itthi	Trisirisatayawong,	Ph.D. (Melbourne)
Chanin	Tinnachote,	D.Eng. (AIT)
Phisan	Santitamnont,	Dr.-Ing. (Leibniz Hannover)
Vichai	Yiengveerachon,	M.Eng. (Chula)

ASSISTANT PROFESSORS :

Sanphet Chunithipaisarn,	Ph.D. (Newcastle upon Tyne)
Colonel Kanok Weerawong	Ph.D. (Purdue)
Somchai Kriengkraiwasin	M.Eng. (Chula)

LECTURERS :

Octavian Andrei,	Ph.D (TUI, Romania)
Chaichoke Vaiphasa.	Ph.D. (ITC)
Thongthit Chayakula,	Ph.D. (London)
Teetat Charoenkalunyuta,	Ph.D. (Chula)
Garavig Tanaksaranond,	Ph.D. (London)

ADMISSION

An applicant must hold a Bachelor's Degree in Survey Engineering or a Bachelor's Degree in other fields of study as approved by the Department. The applicant must also meet the requirements of the Graduate School.

DEGREE REQUIREMENTS

Students are required to fulfill the following specific requirements
A. A minimum of 24 credits of courses which consists of
    1. 18 credits of the required courses.
    2. At least 6 credits of elective course approved by the department.
B. An acceptable thesis of 12 credits
A student who fulfilled the requirements of the program with a cumulative grade point average not less than 3.00 with a period of study not less than 4 regular semesters and not more than 8 regular semesters will be awarded the Degree of Master of Engineering**.**

COURSE REQUIREMENTS

1) Required Courses   **(18 credits)**

2108511	Numerical Techniques in Geomatics	3(2-3-7)
2108512	Adjustment Computation in Geomatics	3(2-3-7)
2108532	Satellite Surveying and Modern Techniques	3(2-3-7)
2108557	Spatial Data Structure and Models	3(3-0-9)
2108592	Seminar in Geoinformatic	3(3-0-9)

	Technology	
2108627	Geoimage Processing	3(2-3-7)

2) Elective Courses   **(21 credits)**

2108502	Fundamentals of Positioning and Mapping	3(2-3-7)
2108513	Geodesy and Geodetic Methods	3(3-0-9)
2108556	Online Spatial Information Technoloties	3(2-3-7)
2108558	Spatial Data Handling and Analysis	3(2-3-7)
2108601	Advanced Adjustment Computation	3(2-3-7)
2108628	Radar Remote Sensing	3(2-3-7)
2108629	Advanced Geoimage Processing	3(2-3-7)
2108632	Advanced GNSS Surveying	3(2-3-7)

3) Thesis

2108811	Thesis	12 credits

NAME OF THE DEGREE

: Doctor of Philosophy
: Ph.D.

PROFESSORS :

Chalermchon Satirapod,   Ph.D. (New South Wales)

ASSOCIATE PROFESSORS :

Banjerd Phalakarn,	Doctorat (Denis Diderot)
Itthi Trisirisatayawong,	Ph.D. (Melbourne)
Chanin Tinnachote,	D.Eng. (AIT)
Phisan Santitamnont,	Dr.-Ing. (Leibniz Hannover)
Vichai Yiengveerachon,	M.Eng. (Chula)

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Teetat Charoenkalunyuta,	Ph.D. (Chula)
Garavig Tanaksaranond,	Ph.D. (London)

SPEACIAL LECTURERS :

Dr.Chaowalit	Silpathong,	Ph.D. (Toulouse III)
Dr.Chris	Rizos, Professor,	Ph.D. (UNSW)
Dr.Clive	Frasser, Professor,	Ph.D. (Wash)
Dr.Shunji	Murai, Professor,	D.Eng. (Univ. of Tokyo)
Dr.Wicha	Jiwalai,	Ph.D. (Ohio State U.)
Dr.Sukit	Viseshsin,	D.Eng. (Univ.of Tokyo)
Dr.Suvit	Vibulsresth,	D.Eng. (Univ. of Tokyo)

COURSES DESCRIPTIONS IN SURVEY ENGINEERING
(B.ENG.)

2108202   Surveying Engineering   3(2-3-4)
Concepts of surveying and mapping; theory of measurements and errors; basic survey measurements:- distance and angle measurements, theodolite and total station, traversing and computation, vertical distance measurements:- leveling; reciprocal leveling and trigonometric leveling, contours, topographic mapping procedure:- control and topographic surveying; map accuracy; specification, profile and cross section, areas and volumes.

2108205   Fundamental of Geomatics   3(3-0-6)
Roles of geospatial information in society; overview of geospatial data capturing, processing, and utilizing procedures; representing the Earth digitally; modeling reality into spatial database, geospatial data model: concept of coordinate system; mapping the Earth; Earth figure and its impact on position; map scale and accuracy of geospatial data; surveying and mapping techniques for geospatial data acquisition; applications of geospatial information technology.

2108234   Numerical Analysis in Geomatics   3(2-3-4)
Condition : Prerequisite 2108233
Numerical Techniques for Solving Set of Linear Equations; Algorithmic Solutions to Non-Linear System; Interpolation and Curve Fitting; 2-D and 3-D Coordinate Transformations; Purposes and Necessity of Coordinate Transformation, Affine Transformation, Polynomial and Rational Polynomial Transformation, Introduction to Spherical Trigonometry, Solving Direct Problem and Inverse Problem.

2108298   Surveying   3(2-3-4)
Introduction to surveying work; basic field works, leveling; principles and applications of theodolites and total stations; distance and direction measurements; errors in surveying, acceptable errors, data correction, triangulation; precise determination of azimuth; precise traverse; plane coordinate system, precise leveling; topographic survey; map plotting.

2108301   Surveying with Construction   3(2-3-4)
         Applications
Condition : Prerequisite 2108202
Alignment, grade and equipment for construction surveys, route location and design; horizontal curve; spiral curve; vertical curve; earth work, tunnel surveying, hydrographic surveying, survey project planning and management.

2108306   Field Practice on   1(field practice)
         Topographic Surveying
Condition : Prerequisite 2108202or 2108298
Field practices at surveying camp to complete fair drawing of planimetric and topographic maps of given areas; third order levelling and traverse; topographic detailing.

2108307   Field Practice on Route   1(field practice)
         Surveying
Condition : Prerequisite 2108301

Planning, scheduling, and carrying out a complete strip topographic map for feasibility study of route location; design and staking-out; earthwork computation.

2108311   Global Geodesy   3(3-0-6)
Condition : Prerequisite 2108234
Figure of the earth, geodetic datums, gravity field of the earth, reference coordinate systems, astro-geodetic method, computation on the ellipsoid, gravimetric method, satellite method.

2108325   Geographic Information System   3(2-3-4)
         and Applications
Condition : Prerequisite 2108201
Definition, basic principles and components of Geographic Information System (GIS); geospatial data models : vector, raster, and surface(3D) data models; different types of data sources and data input techniques; basic geospatial data management and query; basic geospatial data analysis and manipulation; spatial analysis of discrete entities in space; spatial analysis using continuous fields; applications of Geo-Information Systems in various fields; introduction to web GIS and location-based services; quality and metadata of geospatial data; geospatial data standards.

2108326   Geospatial Information Analysis   3(2-3-4)
         and Visualization
Condition : Prerequisite 2108325
Geospatial data analysis functions; spatial interpolation and surface modeling; exploratory spatial data analysis; process modeling and simulation; cartographic fundamentals; principles of graphic design; scientific visualization; animation and virtual worlds; cognitive basis of visualization; cartographic communication; cartographic symbolization and map design; map annotation and name placement; geo-spatial data generalization; web cartography.

2108332   Adjustment Computation   3(2-3-6)
Condition : Prerequisite 2108233, 2108234
Statistical concepts; principle of propagation ; least squares adjustment methods; post adjustment analysis.

2108342   Mathematical Cartography   3(2-3-6)
Condition : Prerequisite 2108311
Rectangular and Polar Coordinate Systems, Horizontal Datum, Geodetic Coordinate System; General Transformation Formulae, The First Gaussian Fundamental Quatitites on Sphere and Plane, Differential Parallelograms; Theory of Map Projection, Computation of Distortions on Map Plane, Properties of Map Projections; Analysis of Map Projections, Scale Factor, Principal Direction, Tissot's Indicatrix, Analytical Construction of Map Projections; Conformal Projections and National Plane Coordinate System, The Importance of Conformal Projections, UTM and UPS Coordinate System, Reduction of Survey Measurements onto Plane, Georeferencing Spatial Data to National Plane Coordinate System; Reprojection and Transformation of Geo-spatial Data.

2108371   Photogrammetry and Remote   3(2-3-6)
         Sensing System
Condition : Prerequisite 2108202
Concepts and basic principles of remote sensing, electromagnetic energy, sources and radiation principles,

energy interaction with atmosphere and earth surface features, sensors and digital image characteristics, multispectral-thermal-hyperspectral sensing, radar imagery, Earth observation satellite, an ideal remote sensing system, characteristics of real remote sensing systems, elements of photographic systems, history of aerial photography, basic principles of photogrammetry, geometry of aerial photographs, monoscopic measurement, stereoscopic of photogrammetry, mapping with photogrammetry.

2108372   Advanced Remote Sensing   3(2-3-6)
Condition : Prerequisite 2108371
Digital imagery, vector and raster data, Image rectification and restoration, image enhancement, contrast manipulation, multi-image manipulation, Image classification, fourier analysis for image processing, hyperspectral image analysis, radar image analysis, feature extraction, pattern recognition, colour systems, colour image processing.

2108373   Advanced Photogrammetry   3(2-3-6)
Condition : Prerequisite 2108302
Imaging air-borne and high-resolution sensor systems, geometry on single image frame, information from stereo images, aerial triangulation, sensor modeling and its orientation, mapping and other data products from photogrammetry, applications of photogrammetric products.

2108374   Close-range Photogrammetry   3(3-0-6)
Introduction to close-range photogrammetry. calibration of cameras, geometric and non geometric factors of projects, accuracy and reliability, 3D models, visualization. applications of close-range photogrammetry in civil engineering, industry, architecture, archeology.

**2108408   Computer Aided Surveying and   3(2-3-4)
Design**
Condition : Prerequisite 2108202
Survey automation system:- field code system, triangulated irregular network, earth work; road design and civil works.

2108411   High Precision Surveying   2(1-3-2)
Condition : Prerequisite 2108311 ,2108332
High precision Instruments:- calibration and testing, target, benchmark; Horizontal measurement methods, vertical measurement methods, 3D measurement methods, computation technique, modern surveying technology.

2108412   Satellite Surveying   3(2-3-6)
Condition : Prerequisite 2108311
Concept of satellite positioning, global positioning systems, NAVSTAR GPS concept, errors in GPS measurements, observables in GPS, survey planning, field methods, data processing, practical applications.

**2108413   Field Practice on Precise   1(field practice)
Surveying**
Condition : Prerequisite 2108411, 2108412
Field practice on geodetic horizontal and vertical controls surveying, computation, photo control surveying.

**2108414   Field Practice on Digital   1(field practice)
Mapping**

Condition : Prerequisite 2108325, 2108371
Rectification of Satellite and Aerial Images; Various Techniques for Detail Survey and Field Data Acquisition; Map Updating; GIS Database Construction.

2108415   Geodetic Surveying   3(2-3-4)
*Condition : Prerequisite 2108201, 2108301
and 2108311*
Introduction to physical geodesy, Height systems, Height from GNSS (GPS), High precision instruments:- calibration and testing, target, benchmark and geodetic control point; Datum transformation, Horizontal measurement methods, Vertical measurement methods, 3D measurement methods, computation technique on UTM.

**2108421   Modern Integrated Surveying   3(2-3-4)
Technology**
Condition : Senior Standing
Concepts of integrating modern surveying technologies to speed up survey: robotic theodolite, laser ranging, laser scanner, GNSS receiver, inertial surveying system, digital camera and video.

2108436   Spatial Database   3(2-3-6)
Condition : Prerequisite 2108326
Introduction to Spatial Database; spatial concept and data model; spatial query language; simple feature for SQL; spatial storage and indexing; query processing and optimization; introduction to spatial data mining; trends in DBMS.

2108450   Advanced GIS Techniques   3(2-3-6)
Condition : Prerequisite 2108326
Overview of GIS and spatial data base management system; review of spatial data models; GIS data management functions; data analysis modeling and functions; output presentation functions; data applications in natural resources and environmental management; applications in disaster management; applications in socio-economic and business problems; GIS development processes; GIS development in Thailand; standard and data quality; trends of future GIS technology.

2108455   GIS Application Development   3(2-3-6)
Condition : Prerequisite 2108326
Types of GIS application; GIS application environment; software development technologies; VBA; Python; .NET; Web application development; opensource tools and software; Software customization**.**

2108457   Seminar in Survey Engineering   1(1-0-2)
Condition : *Senior Standing*
Presentation and discussion on topics of interest in survey engineering.

**2108495   Advanced Topics in Survey   3(3-0-6)
Engineering I**
*Condition : Senior Standing or
Consent of Faculty*
Topics of current interest and new developments in various fields of survey engineering.

**2108496   Advanced Topics in Survey   3(3-0-6)
Engineering II**

Topics of current interest and new developments in various fields of survey engineering.

**2108497   Special Problems in Survey   3(2-3-7)
            Engineering** I
*Condition : Senior Standing or
Consent of Faculty*
Study or investigation of special problems in survey engineering.

**2108498   Special Problems in Survey   3(2-3-7)
            Engineering II**
*Condition : Senior Standing or
Consent of Faculty*
Study or investigation of special problems in survey engineering.

2108499   Survey Engineering Project   3(0-6-3)
*Condition : Senior Standing or
Consent of Faculty*
Practice interesting project or problem in various fields of survey engineering.

COURSES DESCRIPTIONS IN SURVEY ENGINEERING (M.ENG., PH.D.)

**2108502 Fundamentals of Positioning and   3(2-3-7)
          Mapping**
Figure of earth, geodetic datum, earth coordinate reference frame, map projection, general techniques of positioning, 2-D and 3-D coordinate transformation, measurement sampling and interpolation, position determination by modern ground-based instruments, mapping from digital satellite/aerial imagery.

2108511 Numerical Techniques in Geomatics 3(2-3-7)

Overview of matrix and linear systems, solutions of non-linear systems, overdetermined system, functional and stochastic model, measurement error and error propagation, statistical analysis of observation and parameters.

2108512   Adjustment Computation in Geomatics 3(2-3-7)
Review of statistical concepts and linear algebra; principle of covariance propagation; non-linearity, linearization and iteration procedure; math models for least-squares adjustment computation; unified least-squares adjustment; statistical analysis of adjustment results; reliability of networks; data snooping and blunder detection.

2108513   Geodesy and Geodetic Methods   3(3-0-9)
Earth's gravity field; geoid, reference ellipsoid and geodetic datum; geodetic survey, astronomic observations; direction, distance and calculation on the ellipsoid; geodetic height and elevation; satellite orbit, positioning.

2108516   Engineering Geodesy   3(2-3-7)
Condition : Senior Standing
The course build on student active participation by integration of theory and practice. The main objective is to demonstrate how four different geomatic technologies (Global Navigation Satellite System, Total Station, Digital Levelling and Terrestrial Laser Scanning) may be integrated to resemble the technical measurement design and precise positioning production in engineering projects. The course does not teach details of any of the above-mentioned technologies but rather how to use them in an integrated approach.

**2108532 Satellite Surveying and Modern   3(2-3-7)
          Techniques**
Satellite datum, coordinate systems, concept of satellite positioning, global positioning system, observable in GPS, errors in GPS measurements, survey planning, field procedures, data processing, principle of inertial navigation system (INS), practical applications of GPS, principles of electronics, electronic surveying systems and basic components, geometry of electronic surveying, instrumentation and modern surveying technology.

2108533 Remote Sensing of Environment   3(3-0-6)
Condition : Senior Standing
Remote Sensing of Environment brings the student through recent publication on theory, science, applications and technology of remote sensing of earth resources and environment.

2108534 Microwave Remote Sensing   3(3-0-6)
Condition : Senior Standing
Fundamental of microwave, microwave and human health, microwave in remote sensing, SLAR, SAR, InSAR, Lidar, basic SAR data processing, basic Lidar processing, SAR and Lidar applications and case studies.

2108536 Spatial Database   3(3-0-6)
Condition : Senior Standing
Introduction to Spatial Database; spatial concept and data model; spatial query language; simple feature for SQL; spatial storage and spattial indexing; query processing and optimization; introduction to spatial data mining; trends in DBMS.

2108556   Online Spatial Information Technology 3(2-3-7)
Condition : Senior Standing
Introduction to GIS, and internet GIS, fundamental of computer networking, client/server computing, technology evolution of web GIS, DHTML, standards for distributed geospatial services (ISO & OGC), XML, GML and SVG, mobile GIS, case studies and web GIS applications.

2108557 Spatial Data Structure and Models   3(3-0-9)
Conceptual model of space: entities & fields; vector data model, raster data model; data organization in raster: chain, block, run length, quadtrees, binary; data organization in vector: point, line, network, polygon, topology; comparisons of vector and raster data; database structure; file and data access; hierarchical structure; network structure, relational structure, object-oriented structure; introduction to geo-spatial relational database system, graph theory; optimal path.

2108558 Spatial Data Handing and Analysis   3(2-3-7)
Data capture technique, coordinate systems, data quality; intersections of lines and curves, calculation of length and area, coordinate adjustment, geometric searching; range searching; proximity searching; buffering; rubber sheeting, edge matching, image warping, conflation, feature editing; feature alignment; generalization; densification; topology reconstruction;

surface modeling; viewsheds; intervisibility; contouring; linear referencing, mapping accuracy standard and determination method.

2108559 Geospatial Database and OpenGIS   3(2-3-7)

Introduction to relational database management system (RDBMS), Data Model: Entity Relationship Model, Normalizatioin of Database Tables, Introduction to Structured Query Language(SQL), Data Types, SQL Commands, Function and Operation, OGC/ISO Simple Feature (SF), OGC SF Object and Structure, Spatial Database and Table, Simple Feature Access using SQL/SF and SQL for Multimedia (SQL/MM), attribute and spatial querying, OpenGIS Functions, Procedural Language / Structure Query Language (PL/SQL), database optimization and spatial indexing, interface to geospatial RDBMS via web-based applications, Roles of geo-spatial RDBMS in information services and Open Geospatial Information System

2108560 Advanced Map Design and   3(2-3-7)
Prototyping

Condition : Senior Standing

Introduction to various types of maps focusing on user-centered design, including generating new ideas, system analysis, user requirement analysis, prototyping, evaluation and improving; interaction design principle; the effects of interactive functions to map design principle; map prototyping methods, including drawing and using software.

2108592 Seminar in Geoinformatic Technology   3(3-0-9)

Case studies in geoinformation technology, special lectures on advanced/emerging geoinformation technology, experimental design, research topic development.

2108601 Advanced Adjustment Computation 3(2-3-7)

Sequential least-squares adjustment; Helmert-Wolf blocking; generalizied inverse matrics; Kalman filter for geomatics; approximation, interpolation and prediction; least-squares collocation.

2108627 Geoimage Processing   3(2-3-7)

Concepts of digital image: air borne, space borne; electromagnetic wave; optical and microwave sensor; digital image processing; classification; image coordinate and photo coordinate; sensor orientation; Stereo-photogrammetry; photogrammetric triangulation; orthorectification, mosaic, photo map production.

2108628 Radar Remote Sensing   3(2-3-7)

Characteristics of Microwave, Microwave Interaction with Atmosphere and Target, Radar Equation and Radar Cross Section, Principles of Imaging Radar, Measureable Phase/Amplitude/Polarization in Radar Imagery, Geometric and Radiometric Properties of Radar Imagery, Synthetic Aperture Radar, Airborne/Spaceborne SAR Systems, Interferometric SAR, Processing Stages in Inteferogram Generation, Differential Interferometric SAR, InSAR/DInSAR as Measurement Tools, Geodetic and Geophysical Applications of InSAR/DInSAR, Polarimetric SAR, Classification/Analysis of Polarimetric SAR, Landuse/Landcover Mapping Applications using Polarimetric SAR.

2108629 Advanced Geoimage Processing   3(2-3-7)
and Applications

Digital photogrammetry, digital photogrammetric workstation and workflow, digital sensor types: line, area/frame and TDI/staggered CCD, sensor models and sensor orientation, airborne digital camera systems, mapping from space, Digital Elevation Model (DEM), light detection and ranging (Lidar), high-resolution satellites imageries, high-resolution satellite imageries processing, relief displacement, orthorectification, geo-image compression, tile and pyramid image structure, oblique photogrammetry and 3-D geoinformation system, orthophoto service and mash-up mapping, tile-caching management service, acquisition of panorama view and information service.

2108632 Advanced GNSS Surveying   3(2-3-7)

GPS system, coordinate and reference systems, GPS observations and equations, GPS error mitigation techniques, computation of GPS satellite positions, principles of least-squares estimation, mathematical models for GPS positioning, standard format of GPS data, GPS data processing by least-squares method, interpretation of baseline results, GPS network adjustment, quality control for GPS surveying, GPS heighting, trends and applications in GNSS technology.

2108502   Fundamentals of Positioning and 3(2-3-7)
Mapping

Figure of earth, geodetic datum, earth coordinate reference frame, map projection, general techniques of positioning, 2-D and 3-D coordinate transformation, measurement sampling and interpolation, position determination by modern ground-based instruments, mapping from digital satellite/aerial imagery.

2108511   Geodetic Astronomy   3(2-3-7)

Precise determination of time, astronomic latitude, longitude and azimuth.

2108512   Physical Geodesy   3(3-0-9)

The gravity and its potential; the disturbing potential and its representation; Applications and current methods.

2108513   Geodesy and Geodetic Methods   3(3-0-9)

Earth's gravity field; geoid, reference ellipsoid and geodetic datum; geodetic survey, astronomic observations; direction, distance and calculation on the ellipsoid; geodetic height and elevation; satellite orbit, positioning.

2108514   Mathematical Projections in   3(3-0-9)
Geodesy

Use of analytic functions; representation of the ellipsoid on a sphere; geometry of the projected geodesic; mercator, transverse mercator, bolique mercator, conformal comic projections.

2108515   Introduction to Advance Geodetic 3(3-0-9)
Surveying

Geometry of reference ellipsoid; triangulations and trilaterations, Traverses and levelling for major geodetic control; position determination of points by geometric, gravimetric and astronomical methods.

2108521   Aerial Triangulation   3(1-6-5)

Ground control points; aeropolygon aerial triangulation, graphical and numerical strip adjustment and independent model aerial triangulation.

2108522   Analytical Photogrammetry   3(2-3-7)

Comparator, measurement of plate coordinates; transformation of plate coordinates and corrections; relative and absolute orientations; computation of ground coordinates from plate coordinates.

2108523   Terrestrail and Close-Range
Photogrammetry   2(1-3-4)

Introduction ; terrestrial and closed-range cameras and their orientations; geometry of photographs ; control surveys ; graphical and analytical determination of horizontal and vertical positions of point; parallax equations; space coordinates of point by direction cosines.

2108532   Satellite Surveying and Modern   3(2-3-7)
Techniques

Satellite datum, coordinate systems, concept of satellite positioning, Global Positioning System (GPS), observable in GPS, errors in GPS measurements, survey planning, field procedures, data processing, principles of inertial navigation system (INS), practical applications of GPS, principles of electronics, electronic surveying systems and basic components, geometry of electronic surveying, instrumentation and modern surveying technology.

2108551   Spatial Data Structures and   2(2-0-6)
Algorithms

n-depth examination of geographic information system components; representation of spatial data; storage and retrieval techniques; algorithms for spatial data manipulation and analysis ; aster/vector conversion algorithms; advanced spatial data models; user interface; knowledge-based system.

2108552   GIS Design and Evaluation   2(2-0-6)

Nature of design ; feasibility studies & requirements analysis ; software engineering techniques; detailed system design; program design & implementation; design of spatial database; system selection.

2108556   Online Spatial Information   3(2-3-7)
Technology
*Prerequisite : 2108352 or 2108453
or 2108460*

Introduction to GIS; introduction to Internet GIS; fundamental of computer networking, client/servey computing, technology evolutions of web GIS; standards for distributed geospatial services (ISO & OGC), GML and SVG, Mobile GIS; case studies and web GIS applications.

2108557   Spatial Data Structure and Models 2(3-0-9)

Conceptual models of space: entities and fields; vector data model, raster data model; data organization in raster: chain, block, run length, quadtrees, binary; data organization in vector: point, line, network, polygon, topology; comparisons of vector and raster data; database structure; file and data access; hierarchical structure; network structure, relational structure, object-oriented structure; graph theory; optimal path.

2108558   Spatial Data Handling and   2(2-3-7)
Analysis

Data capture techniques, coordinate systems, data quality; intersections of lines and curves, calculation of length and area, coordinate adjustment, geometric searching; range searching; proximity searching; buffering; rubber sheeting, edge matching, image warping, conflation, feature editing; feature alignment; generalization; densification; topology reconstruction; surface modeling; viewsheds; intervisibility; contouring.

2108559   Geospatial Database and   3 (2-3-7)
OpenGIS

Introduction to relational database management system (RDBMS), data model: Entity Relationship model, normalizatioin of database tables, Structured Query Language (SQL), data types, SQL commands, function and operation, OGC/ISO Simple Feature (SF), OGC SF object and structure, spatial database and table, Simple Feature Access using SQL/SF and SQL for multimedia (SQL/MM), attribute and spatial querying, OpenGIS functions, Procedural Language / Structure Query Language (PL/SQL), database optimization and spatial indexing, interface to geospatial RDBMS via web-based applications, roles of geospatial RDBMS in information services and open geospatial information system

2108592   Seminar in Geoinformatic   2(2-3-7)
Technology

Advanced and emerging geoinformation technology; case studies; experimental design, research topic development.

2108601   Advanced Adjustment   3(3-0-9)
Computation
Prerequisite :2108331 or Consent of Faculty

Generalized minimum variance solution for hybrid measuring systems, constraints, statistical tests, empirical fitting of polynomials, correlations, inner adjustment, multivariate statistical analysis, advanced least squares, generalized matrices in adjustment.

2108604   System Engineering and   3(3-0-9)
Management for Survey Engineer

A study of methodologies and processes of system engineering. A discipline concerned with the planning, organization and management of programs for designing and operating systems. Application of systems engineering to surveying projects.

2108606   Development Planning Survey   3(3-0-9)

Function of surveyor in a multidisciplinary investigations for development planning; the concepts and working methods in related disciplines, their possibilities and limitations; interdisciplinary execution of surveys and for the presentation of collected data.

2108621   Analog Photogrammetry   3(2-3-7)

Theory of orientation, method and accuracy; review of various plotting instruments; testing of instrument; rectification and orthophotography.

2108622   Metric Photography   2(1-3-4)

Properties, design and calibration of various photogrammetric cameras; physical characteristics and

quality control of photography; navigation and auxiliary devices; image evaluation.

2108623   Photogrammetry in Practice   3(3-0-9)
Prerequisite : 2108621 and 2108625
Photogrammetric planning; digital terrain model; applications to various fields, e.g. cadastral survey, highway planning and design, damsite study, architecture, museum and monument preservations, biostereometric and medicine, etc.

**2108624   Advanced Analytical   3(2-3-7)
          Hotogrammetry**
Systematic errors, system calibration and self-calibration, analytical strip and block triangulation with and without auxiliary data, constraints, structure and solution of the normal matrix. Reseau photography and specialized comparator techniques.

2108625   Remote Sensing I   3(3-0-9)
A study on theory, instrumentation, and techniques employed in remote sensing.

2108626   Remote Sensing II   3(2-3-7)
*Prerequisite : 2108625 and
          Consent of Faculty*
Applications and interpretation of remote sensing data, in general and in particular. An indepth study of an application chosen by individual participant.

2108627   Geoimage Processing   3(2-3-7)
Concepts of digital image: air borne, space borne; electromagnetic wave; optical and microwave sensor; digital image processing; classification; image coordinate and photo coordinate; sensor orientation; stereo-photogrammetry;   photogrammetric   triangulation; orthorectification.

2108628   Radar Remote Sensing   3(2-3-7)
Characteristics of microwave, microwave interaction with atmosphere and target, radar equation and radar cross section, principles of imaging radar, measurable phase/amplitude/polarization in radar imagery, geometric and radiometric properties of radar imagery, synthetic aperture radar, airborne/spaceborne SAR systems, interferometric SAR, processing stages in interferogram generation,   differential   interferometric   SAR, InSAR/DInSAR as measurement tools, geodetic and geophysical applications of InSAR/DInSAR, polarimetric SAR,   classification/analysis   of   polarimetric   SAR, landuse/landcover   mapping   applications   using polarimetric SAR**.**

2108629   Advanced Geoimage Processing   3(2-3-7)
Special problems to be carried out under staff direction.   Digital   photogrammetry,   digital photogrammetric workstation and workflow, digital sensor types: line, area/frame and TDI/staggered CCD, sensor models and sensor orientation, airborne digital camera systems, mapping from space, digital elevation model (DEM), light detection and ranging (Lidar), high-resolution satellites imageries, high-resolution satellite imageries processing, relief displacement**,** orthorectification, geo-image compression, tile and pyramid image structure, oblique photogrammetry and 3-D geoinformation system, orthophoto service and mash-up mapping**,** tile-caching

management service, acquisition of panorama view, data collection and information service.

2108632   Advanced GNSS Surveying   3(2-3-7)
GPS system, coordinate and reference systems, GPS observations and equations, GPS error mitigation techniques, computation of GPS satellite positions, principles of least-squares estimation, mathematical models for GPS positioning, standard format of GPS data, GPS   data   processing   by   least-squares   method, interpretation   of   baseline   results,   GPS   network adjustment, quality control for GPS surveying, GPS heighting, trends and applications of GNSS technology.

2108691   Special Studies   3(2-3-7)
Special   problems to be   carried out   under staff direction.

**2108790   Seminar in Geomatic
          Engineering I   3(0-9-3)**
Review of and discussion on special topics related to problems and progress in Geomatic engineering.

**2108791   Seminar in Geomatic
          Engineering II   3(0-9-3)**
Condition : PRER 2108790
Discussion on special topics related to progress in Geomatic engineering; analysis of related data, conclusion, data presentation and report of findings.

**2108792   Seminar in Geomatic   3(0-9-3)
          Engineering III**
Prerequisite : 2108791
Discussion on special topics related to progress in Geomatic engineering concerning research projects; analysis of related data, conclusion, data presentation and report of findings.

2108811   Thesis 12 credits

2108828   Dissertation   48(0-0-0)
(S/U)(1/2548)

2108894   Doctoral Dissertation Seminar   0(0-0-0)
(S/U)(1/2548)

**COURSE DESCRIPTIONS IN SPATIAL INFORMATION
SYSTEM (M.SC.)**

**2108501   Fundamentals of Surveying and
          Mapping   3(2-3-7)**
Shape of earth; reference ellipsoids; positioning on earth surface; map projections; scale and distortion; 2-D and   3-D   coordinate   transformation;   model   of measurements; error and error propagation; Mapping and map updating techniques.

**2108502   Fundamentals of Positioning and   3(2-3-7)
          Mapping**
Figure of earth, geodetic datum, earth coordinate reference frame, map projection, general techniques of positioning, 2-D and 3-D coordinate transformation, measurement sampling and interpolation, position determination by modern ground-based instruments, mapping from digital satellite/aerial imagery.

2108511   Numerical Techniques in Geomatics 3(2-3-7)

Overview of matrix and linear systems, solutions of non-linear systems, overdetermined system, functional and stochastic model, measurement error and error propagation, statistical analysis of observation and parameters.

**2108512   Adjustment Computation in   3(2-3-7)
            Geomatics**

Review of statistical concepts and linear algebra; principle of covariance propagation; non-linearity, linearization and iteration procedure; math models for least-squares adjustment computation; unified least-squares adjustment; statistical analysis of adjustment results; reliability of networks; data snooping and blunder detection.

2108513   Geodesy and Geodetic Methods   3(3-0-9)

Earth's gravity field; geoid, reference ellipsoid and geodetic datum; geodetic survey, astronomic observations; direction, distance and calculation on the ellipsoid; geodetic height and elevation; satellite orbit, positioning.

**2108524   Analysis of Aerial and Satellite   3(2-3-7)
            Imageries**

Operations on image, point operations, local operations, geometric operations; image segmentation by clustering, theresholding, spectral classification, spatial classification, edge detection; iterative segmentation by probabilistic relaxation, fuzzy relaxation.

2108531   GPS Satellite Surveying   3(2-3-7)
Condition : PRER 2108501 or C.F.

Fundamental of satellite orbit motion; global positioning system; GPS observables and errors; surveying method; data processing; applications in Thailand.

2108541   Computer Assisted Cartography   3(2-3-7)
Condition : PRER 2108501 or C.F.

Development, production and application of computer-assisted mapmaking ; survey of computer cartography terms , concepts and equipment; conceptual and development aspects of computer-produced maps; digitizing; coordinate data structures; spatial databases; computer map design; turnkey cartographic systems; computer map production.

2108553   Spatial Data Model   3(3-0-9)

Vector data model, vector data organization, spaghetti model, topological models; raster data model, representation of raster data, runs, binary trees, blocks, quadtrees, borders; comparisons of vector and raster data model; conversion between raster and vector data.

2108554   Spatial Data Handling   3(2-3-7)

Data capture techniques; coordinate systems; intersections of lines and curves; calculation of length and area; coordinate adjustment; rubber sheeting; edge matching; image warping; conflation; feature editing; feature alignment; generalization; densification; topology reconstruction; surface modeling; viewsheds; intervisibility; contouring.

**2108532   Satellite Surveying and Modern   3(2-3-7)
            Techniques**

Satellite datum, coordinate systems, concept of satellite positioning, global positioning system, observable in GPS, errors in GPS measurements, survey planning, field procedures, data processing, principle of

inertial navigation system (INS), practical applications of GPS, principles of electronics, electronic surveying systems and basic components, geometry of electronic surveying, instrumentation and modern surveying technology.

**2108556   Online Spatial Information   3 (2-3-7)
            Technology**

Introduction to GIS, Introduction to Internet GIS, Fundamental of Computer Networking, Client/Server Computing, Technology Evolutions of Web GIS, DHTML, Standards for Distributed Geospatial Services (ISO & OGC), XML, GML and SVG, Mobile GIS, Case Studies and WebGIS Applications.

2108557   Spatial Data Structure and Models   3(3-0-9)

Conceptual model of space: entities & fields; vector data model, raster data model; data organization in raster: chain, block, run length, quadtrees, binary; data organization in vector: point, line, network, polygon, topology; comparisons of vector and raster data; database structure; file and data access; hierarchical structure; network structure, relational structure, object-oriented structure; introduction to geo-spatial relational database system, graph theory; optimal path.

2108558   Spatial Data Handing and Analysis   3(2-3-7)

Data capture technique, coordinate systems, data quality; intersections of lines and curves, calculation of length and area, coordinate adjustment, geometric searching; range searching; proximity searching; buffering; rubber sheeting, edge matching, image warping, conflation, feature editing; feature alignment; generalization; densification; topology reconstruction; surface modeling; viewsheds; intervisibility; contouring; linear referencing, mapping accuracy standard and determination method.

2108559   Geospatial Database and OpenGIS   3(2-3-7)

Introduction to relational database management system (RDBMS), Data Model: Entity Relationship Model, Normalizatioin of Database Tables, Introduction to Structured Query Language(SQL), Data Types, SQL Commands, Function and Operation, OGC/ISO Simple Feature (SF), OGC SF Object and Structure, Spatial Database and Table, Simple Feature Access using SQL/SF and SQL for Multimedia (SQL/MM), attribute and spatial querying, OpenGIS Functions, Procedural Language / Structure Query Language (PL/SQL), database optimization and spatial indexing, interface to geospatial RDBMS via web-based applications, Roles of geo-spatial RDBMS in information services and Open Geospatial Information System

**2108592   Seminar in Geoinformatic   3(3-0-9)
            Technology**

Case studies in geoinformation technology, special lectures on advanced/emerging geoinformation technology, experimental design, research topic development.

2108601   Advanced Adjustment Computation   3(2-3-7)

Sequential least-squares adjustment; Helmert-Wolf blocking; generalizied inverse matrics; Kalman filter for geomatics; approximation, interpolation and prediction; least-squares collocation.

2108627   Geoimage Processing   3(2-3-7)

Concepts of digital image: air borne, space borne;

electromagnetic wave; optical and microwave sensor; digital image processing; classification; image coordinate and photo coordinate; sensor orientation; Stereo-photogrammetry; photogrammetric triangulation; orthorectification, mosaic, photo map production.

2108628   Radar Remote Sensing   3(2-3-7)

Characteristics of Microwave, Microwave Interaction with Atmosphere and Target, Radar Equation and Radar Cross Section, Principles of Imaging Radar, Measureable ase/Amplitude/Polarization in Radar Imagery, Geometric and Radiometric Properties of Radar Imagery, Synthetic Aperture Radar, Airborne/Spaceborne SAR Systems, Interferometric SAR, Processing Stages in Inteferogram Generation, Differential Interferometric SAR, InSAR/DInSAR as Measurement Tools, Geodetic and Geophysical Applications of InSAR/DInSAR, Polarimetric SAR, Classification/Analysis of Polarimetric SAR, Landuse/Landcover Mapping Applications using Polarimetric SAR.

2108629   Advanced Geoimage Processing   3(2-3-7)
**   and Applications**

Digital photogrammetry, digital photogrammetric workstation and workflow, digital sensor types: line, area/frame and TDI/staggered CCD, sensor models and sensor orientation, airborne digital camera systems, mapping from space, Digital Elevation Model (DEM), light detection and ranging (Lidar), high-resolution satellites imageries, high-resolution satellite imageries processing, relief displacement**,** orthorectification, geo-image compression, tile and pyramid image structure, oblique photogrammetry and 3-D geoinformation system, orthophoto service and mash-up mapping**,** tile-caching management service, acquisition of panorama view and information service

2108632 Advanced GNSS Surveying   3(2-3-7)

GPS system, coordinate and reference systems, GPS observations and equations, GPS error mitigation techniques, computation of GPS satellite positions, principles of least-squares estimation, mathematical models for GPS positioning, standard format of GPS data, GPS data processing by least-squares method, interpretation of baseline results, GPS network adjustment, quality control for GPS surveying, GPS heighting, trends and applications in GNSS technology.

2108555   Spatial Analysis   3(3-0-9)

Data quality; measures of dispersion; measures of arrangements; geometric searching; range searching; proximity searching; buffer generation; polygon overlays; spanning trees and graph travesal; shortest part routing.

2108591   Seminar in AM/FM/GIS   3(3-0-9)

Group discussion, special lectures on various topics, research paper, presentation of research paper, site visits.

2108623   Photogrammetry in Practice   3(3-0-9)

Photogrammetric planning; digital terrain model; applications to various fields, e.g. cadastral survey, highway planning and design, damsite study, architecture, museum and monument preservations, biostereometric and medicine, etc.

2108625   Remote Sensing I   3(3-0-9)

A study on theory, instrumentation, and techniques employed in remote sensing

2108626   Remote Sensing II   3(2-3-7)
Condition : PRER 2108625 or C.F.

Applications and interpretation of remote sensing data, in general and in particular. An indepth study of an application chosen by individual participant.

2108631   Advanced GPS Satellite   3(2-3-7)
**   Surveying**
Condition : Prerequisite : 2108531

GPS system; coordinate and reference systems, computation of GPS satellite position; GPS observations and equations; principles of least-squares estimation; mathematical models for GPS positioning; standard format of GPS data; GPS error mitigation techniques; GPS data processing by least-squares method; interpretation of baseline results; GPS network adjustment; quality control for GPS surveying; GPS heighting; trends and applications of GNSS technology.

2108651   Implementation of Spatial   3(3-0-9)
**   Information System**
Condition : Prerequisite 2108501 and
*   2108553 or C.F.*

Components of a spatial information system; roles of spatial information system; development cycle of spatial information system; characteristics of GIS software; applications of spatial informations system; investment issues; data warehousing; data standard; copyright issues; trend and future of spatial technology.

2108671   Geoinformation Technologies for   3(3-0-9)
**   Infrastructure Development**

Overview of geoinformation technologies for infrastructure planning construction, monitoring and maintenance; coordinate system and map projection; GPS and GNSS, mapping by remote sensing and photogrammetry techniques; GIS technologies for infrastructure project planning and management; emerging geoinformation technologies for infrastructure development.

2108691   Special Studies   3(2-3-7)

Special problems to be carried out under staff direction.

2108790   Seminar in Geomatic   3(0-9-3)
**   Engineering I**

Review of and discussion on special topics related to problems and progress in Geomatic engineering.

2108791   Seminar in Geomatic   3(0-9-3)
**   Engineering II**

Discussion on special topics related to progress in Geomatic engineering; analysis of related data, conclusion, data presentation and report of findings.

2108792   Seminar in Geomatic   3(0-9-3)
**   Engineering III**
2108828   Dissertation   48 Credits

2108894   Doctoral Dissertation Seminar   S/U

2108897   Qualifying Exam   S/U

2108811   Thesis   12 Credits

DEPARTMENT OF METALLURGICAL ENGINEERING

Department of Metallurgical Engineering provides a program of metallurgical and materials engineering. The program is designed to give a broad understanding of all types of materials, including metals, ceramics, and polymers, with the emphasis on metals. The undergraduate course covers the fundamental techniques of science and engineering used in the profession. There are subjects concerning with the basic principles of materials science and engineering, materials processings and formings, materials properties and applications, and designing of materials and processes. The course also has many engineering practice subjects such as various laboratories, engineering project, engineering practice, and industrial visit.

HEAD :

Gobboon	Lothongkum,	Dr.-Ing. (F.A.F. Hamburg)

ASSOCIATE PROFESSORS :

Gobboon	Lothongkum,	Dr.-Ing. (F.A.F. Hamburg)
Ekasit	Nisaratanaporn,	Ph.D. (I.C. London)
Tachai	Luangvaranunt,	Ph.D. (Tokyo)
Seksak	Asavavisithchai,	Ph.D. (Nottingham)
Patama	Visuttipitukul,	Ph.D. (Tokyo)

ASSISTANT PROFESSORS :

Panyawat	Wangyao,	Ph.D. (T.U. Kosice)
Suvanchai	Pongsugitwat,	M.Eng. (Tokyo)
Mawin	Supradist Na Ayudhaya,	
		Ph.D. (Carnegie-Mellon)
Boonrat	Lohwongwatana,	Ph.D. (Caltech)

LECTURERS:

Chedtha	Puncreobutr,	Ph.D. (I.C. London)
Jirapon	Khamwannah,	Ph.D. (U.C. San Diego)

METALLURGICAL AND MATERIALS ENGINEERING CURRICULUM
FIRST YEAR CURRICULUM
COMMON TO ALL ENGINEERING STUDENTS

COURSE NO.	SUBJECT	CREDITS

THIRD SEMESTER

COURSE NO.	SUBJECT	CREDITS
2103213	ENG MECH I	3
2109210	THERMO MAT	3
2109211	PRIN ENG MAT I	3
2109276	ENG MAT LAB	1
2301207	CALCULUS III	3
xxxxxxx	GENERAL EDUCATION	6
		19

FOURTH SEMESTER

COURSE NO.	SUBJECT	CREDITS
2103231	MECH OF MAT I	3
2109212	PRIN ENG MAT II	3
2109213	TRAN PHEN MAT PROC	3
2109277	MAT MANU LAB	1
2603284	STAT PHYS SCIENCE	3
xxxxxxx	GENERAL EDUCATION	3
xxxxxxx	FREE ELECTIVES	3
		19

FIFTH SEMESTER

COURSE NO.	SUBJECT	CREDITS
2102391	ELEC ENG I	3
2102392	ELEC ENG LAB I	1
2109310	CHEM ENG MAT	3
2109321	QC QM MAT	3
2109333	MET MAT	3
2109377	MICROSTRUC LAB	1
xxxxxx	GENERAL EDUCATION	3
xxxxxxx	FREE ELECTIVES	3
		20

SIXTH SEMESTER

COURSE NO.	SUBJECT	CREDITS
2109334	POLY MAT	3
2109335	CERAMIC MAT	3
2109341	MAT CHAR	3
2109399	IND VISIT	1
2100311	ENGINEERING ESSENTIALS	3 OR
2109336	MAT DAILY LIFE	3
5500208	COM PRES SKIL	3 OR
2109400	COM PRES MET	3
xxxxxxx	ELECTIVES	3
		19

SUMMER SEMESTER

COURSE NO.	SUBJECT	CREDITS
2100301	ENGINEERING PRACTICE	2

SEVENTH SEMESTER

COURSE NO.	SUBJECT	CREDITS
2109411	MECH BEHAV MAT	3
2109478	MECH TEST LAB	1
2109428	MAT PROC	3
2109430	CORROSION OF METAL	3
xxxxxxx	ELECTIVES	6
		16

EIGHTH SEMESTER

COURSE NO.	SUBJECT	CREDITS
5500308	TECH WRIT ENG	3 OR
2109300	CON VOC MAT	3
2109445	FAIL ANAL	3
2109450	MAT SELECT DESIGN	3
2109488	MET MAT ENG PROJ	3
xxxxxxx	ELECTIVES	3
		15

Applicants must take at least 12 credits of electives in which they must select at least one course offered in both two groups including Advanced Processing group and Advanced Materials group . If seminar (2109480) course is chosen, the applicant has to take another course offered in the advance processing group.

TOTAL CREDITS FOR GRADUATION = 146

METALLURGICAL ENGINEERING

NAME OF DEGREE

: Master of Engineering
: M. Eng.

HEAD :

Gobboon   Lothongkum,   Dr.-Ing.(F.A.F. Hamburg)

ASSOCIATE PROFESSORS :

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Patama   Visuttipitukul,   Ph.D. (Tokyo)
Seksak   Asavavisithchai,   Ph.D. (Nottingham)
Tachai   Luangvaranunt,   Ph.D. (Tokyo)
Ekasit   Nisaratanaporn,   Ph.D.(I.C. London)

ASSISTANT PROFESSORS :

Suvanchai   Pongsugitwat,   M.Eng. (Tokyo)
Mawin   Supradist Na Ayudhaya,
                                          Ph.D.
                                          (Carnegie Mellon)
Boonrat   Lohwongwatana,   Ph.D. (Caltech)
Panyawat   Wangyao,   Ph.D.(T.U. Kosice)

LECTURERS:

Chedtha   Puncreobutr   Ph.D. (I.C.London)
Jirapon   Khamwannah   Ph.D. (U.C. San Diego)

ADMISSION

The applicant must hold a Bachelor's Degree in Engineering or consent of faculty.

The admitted students whose degrees are not Metallurgical Engineering are required to take at least 15 credits of undergraduate courses in Engineering as approved by the Graduate Program Committee during their studies.

DEGREE REQUIREMENTS

The Program consists of 36 credits of coursework and thesis. Candidates must earn a minimum of 24 credits of graduate coursework and 12 credits of thesis. The candidate is required to maintain at least a "B" average.

COURSE REQUIREMENTS

1) *Required Courses*   6 *credits*

2109601	Thermodynamics and Phase Equilibria in Multicomponent System	3(3-0-9)
2109602	Transport Phenomena in Solids	3(3-0-9)
2109603	Concepts in Metallurgical and Materials Engineering	3(3-0-9)
2109604	Applications of Metallurgical and Materials Theories in Industries	3(3-0-9)
2109711	Seminar in Metallurgical and Materials Engineering I	S/U

2109712	Seminar in Metallurgical and Materials Engineering II	S/U
2109713	Seminar in Metallurgical and Materials Engineering III	S/U

2) *Elective Courses*   18 *credits*

2109504	Advanced Physical Metallurgy I	3(2-3-7)
2109507	Advanced Mechanical Metallurgy.	3(2-3-7)
2109508	Rate Phenomena and Modelling in Process Metallurgy.	3(3-0-9)
2109509	Stainless Steel Technology	3(3-0-9)
2109510	Instrumental Analysis	3(2-3-7)
2109514	Advanced Corrosion	3(3-0-9)
2109515	Quantitative Analysis of Microstructure	3(3-0-9)
2109516	Advanced Topics in Physical Metallurgy	3(3-0-9)
2109517	Composite Materials I	3(3-0-9)
2109518	Surface Technology	3(3-0-9)
2109519	Solidification of Casting	3(3-0-9)
2109520	Physical Ceramics	3(3-0-9)
2109525	Welding Engineering	3(3-0-9)
2109526	Advanced Topics in Chemical Metallurgy	3(3-0-9)
2109527	High Temperature Materials	3(3-0-9)
2109528	Properties of Solids	3(3-0-9)
2109530	Physical Metallurgy of Steels	3(3-0-9)
2109533	Powder Metallurgy	3(3-0-9)
2109535	Cellular Metal	3(3-0-9)
2109536	Advanced Topics in Production Metallurgy	3(3-0-9)
2109537	Tribology of Materials	3(3-0-9)
2109555	Nano and Amorphous Materials	3(3-0-9)
2109605	Physical Chemistry of Iron and Steel Manufacture	3(3-0-9)
2109610	Physical Chemistry of Chemical Metallurgy	3(3-0-9)
2109617	Composite Materials II	3(3-0-9)
2109620	Solution Concentration and Purification	3(3-0-9)
2109623	Fracture Analysis	3(3-0-9)
2109630	Forming Process Analysis	3(3-0-9)
2109659	Aluminium Technology	3(3-0-9)
2109811	Thesis	12 credits

METALLURGICAL ENGINEERING

MAME OF DEGREE

: Doctor of Engineering
: D. Eng.

HEAD :

| Gobboon | Lothongkum, | Dr.-Ing.(F.A.F. Hamburg) |

ASSOCIATE PROFESSORS :

Gobboon	Lothongkum,	Dr.- Ing.(F.A.F. Hamburg)
Ekasit	Nisaratanaporn,	Ph.D.(I.C.London)
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Boonrat	Lohwongwatana,	Ph.D. (Caltech)
Mawin	Supradist Na Ayudhaya,	
		Ph.D. (Carnegie Mellon)

LECTURERS:

| Chedtha | Puncreobutr | Ph.D. (I.C.London) |
| Jirapon | Khamwannah | Ph.D. (U.C. San Diego) |

ADMISSION

1. The applicant must hold a Degree of Master of Engineering or consent of faculty.
2. The other qualifications must meet the regulations of the Graduate School, Chulalongkorn University, which will be annually announced or earned approval to be the candidate by the graduate committee of the Faculty of Engineering.

DEGREE REQUIREMENTS

Number of credit units for graduation not less than 48 credits : 4 credits for core courses and 48 credits for Dissertation.

A student who has fulfilled the requirement of the program and of the Graduate School and satisfactorily pass an oral examination, will be awarded the Degree of Doctor of Engineering.

COURSE REQUIREMENTS

| 1) | *Core Courses* | *4 credits* |

2109714	Seminar in Metallurgical and Materials Engineering IV	1(1-0-3)
2109715	Seminar in Metallurgical and Materials Engineering V	1(1-0-3)
2109716	Seminar in Metallurgical and Materials Engineering VI	1(1-0-3)
2109717	Seminar in Metallurgical and Materials Engineering VI	1(1-0-3)

| 2) | *Dissertation* |

| 2109828 | Dissertation | 48 credits |

Study Program for Doctoral Degree in Metallurgical Engineering

First Semester

| 2109828 | Dissertation | 8 | Credits |
| 2109714 | Seminar in Metallurgical and Materials Engineering IV | 1 | Credits |

Second Semester

| 2109828 | Dissertation | 8 | Credits |
| 2109715 | Seminar in Metallurgical and Materials Engineering V | 1 | Credits |

Third Semester

| 2109828 | Dissertation | 8 | Credits |
| 2109716 | Seminar in Metallurgical and Materials Engineering VI | 1 | Credits |

Fourth Semester

| 2109828 | Dissertation | 8 | Credits |
| 2109717 | Seminar in Metallurgical and Materials Engineering VII | 1 | Credits |

Fifth Semester

| 2109828 | Dissertation | 8 | Credits |

Sixth Semester

| 2109828 | Dissertation | 8 | Credits |

| | **Total credits for graduation** | 48 | Credits |

COURSE DESCRIPTIONS IN METALLURGICAL AND MATERIALS ENGINEERING (B.ENG.)

2109101   Engineering Materials   3(3-0-6)
Relationship between structures, properties, production processes and applications of main groups of engineering materials; crystal structure of solids; crystal defects; mechanical properties of materials; dislocation and strengthening mechanism of metals; mechanical failure of materials; phase diagram and solid state reaction; fabrication and applications of metals; structure, properties and applications of ceramic; structure, properties and applications of polymers; structure, properties and applications of composite materials; corrosion and degradation of materials; properties and applications of electronic materials; electrical properties of materials; magnetic properties of materials; innovation in material technology.

2109210   Thermodynamics of Materials   3(3-0-6)
First and second laws of thermodynamics; criteria for equilibria in constant pressure processes; free energies as a function of temperature, pressure and chemical potential; numerical calculation of free energies from available thermodynamic data; equilibrium in gas mixtures; equilibrium between condensed phases and gas phases; Richardson's free energy diagram; reduction of oxides and sulphides; activities of various substances in metals and slags; application of thermodynamics to extractive metallurgical processes, smelting and refining, solution behavior.

2109211   Principles of Engineering   3(3-0-6)
            Materials I
Electron; atomic structure; molecules and bonding; crystal structure; x-ray diffraction in crystalline solid; crystal defects; crystal interfaces and microstructure; solid solution and compound; thermodynamics and phase diagrams; solidification.

2109212   Principles of Engineering   3(3-0-6)
            Materials II
            Condition : *PRER 2109211*
Diffusion; principles of solid-state phase transformation; plastic deformation in crystalline solid recovery, recrystallization, grain growth; strengthening mechanism and microstructural control.

2109213   Transport Phenomena in Materials 3(3-0-6)
            Processing
Fluid flow: laminar and turbulent flow, flow and vacuum production; materials and energy balance; energy transport; mass transport.

2109276   Engineering Materials Laboratory   1(0-3-0)

Crystal structure; metallographic sample preparation; macro and microstructure; structure examination; cooling curve.

2109277   Material and Manufacturing   3(3-0-9)

Processes Laboratory
Heat treatment of steels; hardening, tempering, full annealing and normalizing; practice in sand mold casting of metals; welding practice.

2109300   Basic Concepts and Vocabulary   3(2-2-5)
            in Metallurgical and Materials Engineering
Introduction to concepts and technical terminologies of materials used for different machines and industries: automotive, aerospace, ship, power plant and petrochemical; working mechanism of machine components produced from different materials.

2109310   Chemistry of Engineering   3(3-0-6)
            Materials
Thermodynamics of aqueous solutions; kinetics of leaching and precipitation, pressure leaching and reduction; solvent extraction and ion exchange; principles of electrochemistry of aqueous solutions; conductance and transference; electrolytic cell types and potential; current and energy efficiency; principles of pyrometallurgy, including calculation of the values of thermodynamics functions, calcination, roasting, reduction and reduction at slag-metal interfaces; extraction of ferrous and nonferrous metals.

2109321   Quality Control and Quality   3(3-0-6)
            Management for Materials Engineering
Quality philosophy; quality management strategies in Materials Engineering, organizing for quality. quality concepts; quality control techniques in Materials Engineering.

2109333   Metallic Materials   3(3-0-6)
Microstructures, properties, and application of ferrous and non-ferrous alloys including plain carbon steels, alloy steels, cast irons, aluminium alloys, copper alloys, and white metals.

2109334   Polymeric Materials   3(3-0-6)
Monomer and polymerization; basic polymer molecular concepts; polymer additives; structures, properties, and application of polymers including thermoplastic, thermoset, elastomer, and composite polymers.

2109335 Ceramic Materials   3(3-0-6)
Structure of ceramic crystals; structure of glass; structural imperfection: structural defects, association of defects, non-stoichiometric solids; properties and application of ceramics in Engineering.

2109336 Materials in Daily Life   3(3-0-6)
Learn different aspects of materials as found in daily life, in various occupations and in suitable applications. Environmentally friendly materials. Full utilization of materials in both efficient sense and aesthetic sense. Topics include materials for design and architecture, fashion, arts and craft materials, biomedical materials and

biomaterials, automotive materials and household materials.

2109341 Materials Characterisation 3(3-0-6)
Principles and operation of scanning electron microscopy, transmission electron microscopy, x-ray fluorescence , x-ray diffraction, atomic absorption, emission spectrometer, image analyser; non-destructive testing.

2109377 Microstructure Laboratory 1(0-3-0)
Analysis of microstructure of metallic materials.

2109399 Industrial Visit 1(0-3-0)
Condition : 3rd year student
Visiting the factories related to metal and materials processings; analyzing the processes and presenting a report of the visit.

2109400 Communication and Presentation 3(3-0-6)
Skills for Metallurgical Engineers
Necessary skills needed for a winning presentation performance in various settings: academic presentations, project demonstrations, and job interviews; a systematic approach to a great stress-free presentation and a personal design to effectively interact with an audience, sell their ideas, and share their enthusiasm; workshop dealing with common mistakes, miscues, and unexpected surprises that may arise during any meeting encounter.

2109411 Mechanical behaviour of Materials 3(3-0-6)
Condition : PRER 2109212, 2103231
Elastic behaviour; theory of plasticity; dislocation theory; mechanical failure: fractures, fatigue, creep, embrittlement; materials testing: tension, hardness, torsion, impact, fatigue, creep; fracture mechanics; mechanical behaviour of composite materials.

2109428 Materials Processing 3(3-0-6)
Theory and modern development of foundry processes; pattern design; casting design; runner and riser design; finishing and inspection of casting products; causes and elimination of defects and design limitations; injection moulding; rapid solidification; theory and practice of rolling, forging, extrusion, wire and tube drawing, deep drawing; causes and elimination of defects.

2109430 Corrosion of Metals 3(3-0-6)
Principles of corrosion; anode and cathode processes; origin and characteristic of corrosion currents; standard electrochemical series; passivity and protective films; effects of environment on corrosion rate; forms of corrosion; corrosion testing; measures to minimize or protect the corrosion, cathodic protection, inhibitors, coating and non-metallic materials in combating corrosion; other materials degradation; materials selection.

2109445 Failure Analysis 3(3-0-6)

General practice in failure analysis: data collection, non-destructive testing, mechanical testing, macro and micro analysis, determination of failure mechanism; failure mechanisms and related environmental factors: fractures in ductile, brittle and fatigue modes; failure due to creep, corrosion and stress-corrosion, weld decay; defects due to heat treatment, case studies.

2109450 Materials Selection and Design 3(3-0-6)
Criteria and concept in design of component and products and economic consideration; materials selection process; material property charts; effects of composition, processing, and structure on materials properties; properties versus performance of materials; case studies of materials processing and design; case studies of materials selection.

2109478 Mechanical Testing Laboratory 1(0-3-0)
Mechanical properties testing: tension test, bending and torsion test, impact test and hardness test.

2109488 Metallurgical and Materials 3(0-6-3)
Engineering Project
Practical interesting projects or problems in various fields of metallurgical and materials engineering.

Course group in Advanced Processing

2109312 Chemical Metallurgy II 3(3-0-6)
Condition : PRER 2109310
Physical chemistry in iron and steel making; blast furnace; steel making processes; direct reduction processes; reaction of carbon, silicon and chromium; removal of sulphur and phosphorus; deoxidation; vacuum degassing of steel; hydro and pyrometallurgy of ores commonly found in Thailand.

2109419 Directional Solidification 3(3-0-6)
Solidification behaviour of ferrous and non-ferrous alloys; modulus of cooling and feeder head calculation; the use of internal and external chills; exothermic anti-piping powder and exothermic feeder head.

2109423 Electroplating 2(1-3-2)
Condition : PRER 2109310
Fundamentals of electrochemistry; technology and control of various electroplating processes including chromium plating, nickel plating, copper plating, tin and tin alloys plating, and zinc and zinc alloys plating.

2109424 Iron-making and Steel-making 2(2-0-4)
Condition : PRER 2109310
Fundamentals of iron-making and steel-making processes including blast furnace, direct reduction, direct smelting, basic oxygen process, electric arc furnace, secondary metallurgy and continuous casting processes; physical chemistry of iron-making and steel-making processes.

2109425   Materials Joining   3(3-0-6)

Introduction to materials joining: soldering, brazing and welding, wetting, solid-phase welding, adhesive joining, joining of ceramic, fusion welding processes, mass and heat flow in fusion welding, metallurgical effects of the weld thermal cycle, weld defect, hot and cold cracking, porosity in welds, residual stress in welds. destructive and non-destructive testing of the joints, safety in welding, welding labory demonstration.

**2109454   Computational Materials   3(2-3-4)
            Engineering**

Information technology (IT) in materials engineering. Introduction to some basic tools/computer software for programming and computation. Review of heat transfer in solid. Introduction to computational materials engineering with some applications.

2109463   Jewelry Metals and Processing   3(3-0-6)

Gold, Silver and Metals in PGMs, Metals for fashion jewelry. Effects of alloying elements, Metallurgy in jewelry metals. Physical property, Mechanical property, Anti-tarnish property, Jewelry process, Investment casting, Forming processes, Defects in jewelry production and solution methods.

2109480   Seminar   1(1-0-2)

Condition : Consent of Faculty

Presentation and discussion on topics of interest in metallurgical and materials engineering.

**2109496   Special Problems in Metallurgical   3(3-0-6)
            and Materials Engineering**

Interesting issues in metallurgical and materials engineering.

**2109508   Rate Phenomena and Modeling in   3(3-0-9)
            Process Metallurgy**

Rate of metallurgical processes with engineering application to process simulation and control; special attention to processes important to iron and steelmaking homogeneous and heterogeneous reaction kinetics; mass and energy transport; steady-state and nonsteady-state reaction systems; development of process models.

2109510   Instrumental Analysis   3(2-3-7)

Operation principles of transmission electron microscopy and scanning electron microscopy, Xray diffraction , X-ray fluorescence , atomic absorption and spectro analysis, ESCA and Auger electron spectrometer; interpretation of instrumental results in terms of mechanical properties,

**2109516   Advanced Topics in Physical   3(3-0-9)
            Metallurgy**

Advanced topics of current research interests in physical metallurgy.

2109518   Surface Technology   3(3-0-9)

Carburizing , nitriding, flame hardening, diffusion hardening; chemical vapor deposition and physical vapor deposition; electroplating; hot dip coating; metal spraying and ion implantation.

2109519   Solidification of Casting   3(3-0-9)

Study of solidification of metal in molds; characteristics of liquid-solid phase transformations; Sand and metal thermal behavior; macroscopic structures; mechanical properties, and casting defects.

2109525   Welding Engineering   3(3-0-9)

Types and processes of welding; mass and heat flow during welding; metallurgy effects of heat thermal cycle; solid-phase welding and joining of ceramics; welding of ferrous and non-ferrous metals; behavior of welds in service.

**2109526   Advanced Topics in Chemical   3(3-0-9)
            Metallurgy**

Advanced topics of current research interests in chemical metallurgy.

**2109536   Advanced Topics in Production   3(3-0-9)
            Metallurgy**

Advanced topics of current research interests in production metallurgy.

2109537 Tribology of Materials   3(3-0-9)

Solid lubrication and surface treatment; fundamentals of contacts between solids; abrasive, erosive, and cavitation wear; adhesion and adhesive wear, corrosive and oxidative wear; fatigue wear; fretting and minor wear mechanism; wear of non-metallic materials; case study.

Course group in Advance Materials

2109381   Superalloys   3(3-0-6)

Types of superalloys, production processes and its microstructures, superalloys applications. The relationship among heat treatments, forming processes, microstructures and mechanical properties at high temperatures of nickel, cobalt and iron based superalloys, HIP restoration, microstructure analysis by SEM and TEM.

**2109426   Engineering Ceramic   3(3-0-6)
            Manufacturing Process**

Ceramic manufacturing process; ceramic raw materials; ceramic powder synthesis; body preparation; rheology; organic additives; thermal process; sintering; slip casting; tape casting; extrusion; injection moulding; pressing; porous ceramic; sol-gel process; ceramic matrix composite; research and development of engineering ceramic manufacturing process.

2109432   Refractory Materials   3(3-0-6)

Classification of refractory materials; properties of important refractory materials; application of refractories

in materials processing units; failures of refractories in materials processing units.

2109433   Electronic Materials   3(3-0-6)
Elementary quantum physics; the band theory of solids semiconductors; semiconductor devices; dielectric materials and insulation; superconductivity.

2109434   Technology Development of   3(3-0-6)
**   Advanced Materials for Medical Application**
Properties and types of materials for medical uses; mechanical, structural, chemical and biological characterization; production technology and formation of materials for medical application; research and technology development for advanced materials; advanced material used as biosensor; future   trends in biomedical engineering.

2109435   Defects in Solids   3(3-0-6)
Point defects; thermodynamics of points defects; extended defects; structural aspects of composition variation; defects and diffusion; intrinsic defect and extrinsic defect in insulators, nonstoichiometry and intrinsic electronic conductivity, nonstoichiometry and extrinsic electronic conductivity; magnetic and optical defects.

2109491   Materials and Sustainable   3(3-0-6)
**   Development**
Principles of sustainability analysis; sustainability indexes; materials technology and nanotechnology enabling sustainable development sustainability in materials production; renewable energy; fuel cell; photovoltaic; bioenergy; green-house gas emissions; sustainable environment; materials life cycle analysis; materials recycling.

2109494   Selected Topics in Metallurgical   3(3-0-6)
**   and Materials Engineering**
Topics of current interest and new development in various fields of metallurgical and materials engineering.

2109504   Advanced Physical Metallurgy I   3(2-3-7)
Classification of phase transformations continuous and discontinuous precipitation from solid solution; eutectoidal transformation, massive and martensitic transformation,order-disorder changes; relation of properties to microstructure; techniques and methodology used to study microstructure.

2109509   Stainless Steel Technology   3(3-0-9)
Stainless steel development; stainless steel grades; phase equilibrium diagram; microstructure and metallography; passive film; martensitic, ferritic, austenitic, duplex and precipitation hardening stainless steels ; production technology; improvement of mechanical and corrosion properties and selection.

2109514   Advanced Corrosion   3(3-0-9)
Engineering aspects of corrosion and its control; forms by which corrosion manifests itself; simplified mechanisms of corrosion and methods of combating corrosion; electrode processes; activation, ohmic, and concentration polarization; passivation; potentiostatic studies and alloy design; applications to engineering systems.

2109517   Composite Materials I   3(3-0-9)
Properties of engineering composite materials; types of composite materials; fiber and their interfaces; geometrical properties; elasticity; case studies.

2109520   Physical Ceramics   3(3-0-9)
Physical and chemical process responsible for microstructure development; modern electronic ceramics; structual defects, sintering of ceramics and grain growth; mechanical, thermal, electrical, magnetic properties and dielectric property.

2109527   High Temperature Materials   3(3-0-9)
Theory of alloying and relationship among temperature, structure, and mechanical properties in nickel, cobalt, and iron base alloys; effect of thermomechanical processing; analysis of microstructures by transmission electron microscopy, scanning electron microscopy, X-ray diffraction, and X-ray microprobe.

2109530   Physical Metallurgy of Steels   3(3-0-9)
Condition : Consent of Faculty
Properties of high purity iron; interstitial and substitutional solutes; carbon steels; high strength low alloy steels; thermomechanical treatment of steels; alloy steels; steels for magnetic and electrical application.

2109533   Powder Metallurgy   3(3-0-9)
Preparation and fabrication of metal powder; engineering properties and industrial uses; theory of compaction and sintering.

2109535   Cellular Metal   3(3-0-9)
The structure, manufacturing methods, characterization techniques, mechanics. Physical and mechanical properties of cellular metals; energy absorption; sandwich structures and case studies.

2109555   Nano-structured Materials and   3(3-0-9)
**   Amorphous Materials**
Definition and classifications of nano-structured materials and amorphous materials; nanomaterials and amorphous materials in nature; processing pathways in relation to metastability and free energy; zero-dimensional, one-dimensional, two-dimensional and three-dimensional nanomaterials; nanomaterials characterizations; environmental and health impacts of nanomaterials.

COURSES DESCRIPTIONS IN METALLURGICAL ENGINEERING (M.ENG., D.ENG.)

2109501 Physical Metallurgy 3(3-0-9)
Structures of metals; physical properties of single crystals, and polycrystals; defects in crystals; diffusion in metals; recovery recrystallization and grain growth; binary and ternary phase equilibrium diagrams; principles of phase transformation.

2109502 Structures and Properties of Metals 3(3-0-9)
Structures and properties of metals and its alloy; relationship between microstructures and mechanical properties of metals.

2109503 Metallographic Examination 1(3-0-1)
Macro and microscopic examinations of important ferrous and non-ferrous metals.

2109504 Advanced Physical Metallurgy I 3(2-3-7)
Classification of phase transformations continuous and discontinuous precipitation from solid solution; eutectoidal transformation, massive and martensitic transformation, order-disorder changes; relation of properties to microstructure; techniques and methodology used to study microstructure.

2109507 Advance Mechanical Metallurgy 3(3-0-9)
Behavior of metals under simple and combined stress systems; elements of elastic theory , plastic deformation, dislocation theory, strength theories, and fracture; experiment in mechanical metallurgy.

2109508 Rate Phenomena and Modeling in 3(3-0-9) Process Metallurgy
Rate of metallurgical processes with engineering application to process simulation and control; special attention to processes important to iron and steelmaking homogeneous and heterogeneous reaction kinetics; mass and energy transport; steady-state and nonsteady-state reaction systems; development of process models.

2109509 Stainless Steel Technology 3(3-0-9)
Stainless steel development; stainless steel grades; phase equilibrium diagram; microstructure and metallography; passive film; martensitic, ferritic, austenitic, duplex and precipitation hardening stainless steels ; production technology; improvement of mechanical and corrosion properties and selection.

2109510 Instrumental Analysis 3(2-3-7)
Operation principles of transmission electron microscopy and scanning electron microscopy, Xray diffraction , X-ray fluorescence , atomic absorption and spectro analysis, ESCA and Auger electron spectrometer; interpretation of instrumental results in terms of mechanical properties.

2109511 Extractive Metallurgy 3(3-0-9)
Principles of extractive metallurgy; thermodynamics and kinetics of pyrometallurgy including roasting, smelting and refining; physical chemistry of iron and steel-making; principles of hydrometallurgy including thermodynamics of aqueous solutions, kinetics of leaching and precipitation.

2109514 Advanced Corrosion 3(3-0-9)
Engineering aspects of corrosion and its control; forms by which corrosion manifests itself; simplified mechanisms of corrosion and methods of combating corrosion; electrode processes; activation, ohmic, and concentration polarization; passivation; potentiostatic studies and alloy design; applications to engineering systems.

2109515 Quantitative Analysis of 3(3-0-9) Microstructure
Basic probability theory and statistical analysis relevant to the quantitative description of a microstructure stereological relationships and the mathematical foundation and the microstructural tools needed to quantify the structure; applications of quantitative metallography to problems in failure analysis; solidification, heat treatment, phase equilibria, and deformation behavior.

2109516 Advanced Topics in Physical 3(3-0-9) Metallurgy
Advanced topics of current research interests in physical metallurgy.

2109517 Composite Materials I 3(3-0-9)
Properties of engineering composite materials; types of composite materials; fiber and their interfaces; geometrical properties; elasticity; case studies.

2109518 Surface Technology 3(3-0-9)
Carburizing , nitriding, flame hardening, diffusion hardening; chemical vapor deposition and physical vapor deposition; electroplating; hot dip coating; metal spraying and ion implantation.

2109519 Solidification of Casting 3(3-0-9)
Study of solidification of metal in molds; characteristics of liquid-solid phase transformations; Sand and metal thermal behavior; macroscopic structures; mechanical properties, and casting defects.

2109520 Physical Ceramics 3(3-0-9)
Physical and chemical process responsible for microstructure development; modern electronic ceramics; structual defects, sintering of ceramics and grain growth; mechanical, thermal, electrical, magnetic properties and dielectric property.

2109525 Welding Engineering 3(3-0-9)
Type and process of welding ; mass and heat flow during welding; metallurgical effects of heat thermal cycle; solid-phase welding and joining of ceramic; welding of ferrous and non-ferrous metals; behavior of welds in service.

**2109526 Advanced Topics in Chemical 3(3-0-9)
Metallurgy**

Advanced topics of current research interests in chemical metallurgy.

2109527 High Temperature Materials 3(3-0-9)

Theory of alloying and relationship among temperature, structure, and mechanical properties in nickel, cobalt, and iron base alloys; effect of thermomechanical processing; analysis of microstructures by transmission electron microscopy, scanning electron microscopy, X-ray diffraction, and X-ray microprobe.

2109528 Properties of Solids 3(3-0-9)

Atomistic approach of metal physics, crystal structure, lattice vibration, energy band; electric, electronic, optical and thermal properties of metal; electron spins; introduction to basic quantum mechanics.

2109530 Physical Metallurgy of Steels 3(3-0-9)

Properties of high purity iron; interstitial and substitutional solutes; carbon steels ; HSLA steel; thermomechanical treatment of steel, alloy steels, steels for magnetic and electrical applications.

2109533 Powder Metallurgy 3(3-0-9)

Preparation and fabrication of metal powder; engineering properties and industrial uses; theory of compaction and sintering.

2109535 Cellular Metal 3(3-0-9)

The structure, manufacturing methods, characterization techniques, mechanics. Physical and mechanical properties of cellular metals; energy absorption; sandwich structures and case studies.

**2109536 Advanced Topics in Production 3(3-0-9)
Metallurgy**

Advanced topics of current research interests in production metallurgy.

2109537 Tribology of Materials 3(3-0-9)

Solid lubrication and surface treatment; fundamentals of contacts between solids; abrasive, erosive, and cavitation wear; adhesion and adhesive wear, corrosive and oxidative wear; fatigue wear; fretting and minor wear mechanism; wear of non-metallic materials; case study.

**2109541 Principles of Metallurgical 3(3-0-9)
Processing**

Introduction to the science of metallurgy; metallurgical furnaces; refractories; metallurgical fuels; temperature measurement and control; metallurgical calculation; energy and mass balances; analysis of steady and non-steady state processes, heat and mass transfer applied to metallurgical processes.

**2109555 Nano-structured and Amorphous 3(3-0-9)
Materials**

Definition and classification of nano-structured materials and amorphous materials; nanomaterials and amorphous materials in nature; processing pathways in relation to metastability and free energy; zero-dimension, one-dimensional, two-dimensional and three-dimensional nanomaterials; nanomaterials characterizations; environmental and health impacts of nanomaterials.

**2109601 Thermodynamics and Phase 3(3-0-9)
Equilibria in Multicomponent System**

Examination and study of thermodynamics of phase equilibria in multicomponent systems; measurements of thermodynamic activity, graphical presentation of phase equilibrium, solid and liquid solution models, development of equations of state using statistical models.

2109602 Transport Phenomena in Solids 3(3-0-9)

Fick's first and second law and their solutions; continuity equation; diffusion couples; interaction between diffusing atoms rate of diffusion; quantitative analysis of diffusion problems; energy and rate at which solid-state transformation occurs in pure metal and alloys; influences of defects on nucleation and grain growth.

**2109603 Concepts in Metallurgy and 3(3-0-9)
Materials Engineering**

Physical metallurgy aspect to metallurgy and materials engineering which includes crystallography, defects and dislocations; microstructure, phase, phase boundaries and related energies; solidification theories; phase transformations and phase equilibria; continuous and discontinuous precipitations.

**2109604 Applications of Metallurgical 3(3-0-9)
and Materials Theories in Industries**

Forming process, Annealing, Alloy theories, Practical refractory in industries, Lubricant roles, Welding phenomena, Metals and materials under extreme conditions, Heat transfer, Transport phenomena, Problems in industries, Apply theories to solve industrial problems.

2109605 Steel Manufacture 3(3-0-9)

Structure and properties of slags; ionic theory and reactions in slags gas reactions in the blast furnace, partitioning of solute elements between iron and slag in blast furnace; steelmaking processes; refining slags; oxidation and deoxidation reactions; distribution of sulphur between the slag and the metals; removal of phosphorus from the metal.

**2109610 Physical Chemistry of Chemical 3(3-0-9)
Metallurgy**

Kinetics and mechanisms of reaction in chemical metallurgical systems; high temperature oxidation and reduction; slag metal reactions and other related processes; direct reduction.

2109617   Composite Materials II   3(3-0- 9)
    Theory of laminate, unidirectional strength of laminate Fiber strength, Short fiberous composite, other topics and case study.

**2109620   Solution Concentration and   3(3-0- 9)
            Purification**
    Study of aqueous solution chemistry including estimation of activity coefficients and complex equilibria calculations; application of solution chemistry of reaction kinetics and mass transfer phenomena in cementation; solvent extraction; and precipitation reactions.

2109623   Fracture Analysis   3(3-0-9)
    Deformation and fracture mechanics of engineering materials; fracture, microstructural aspects of fracture toughness; environment-assisted cracking; fatigue crack propagation; analysis of engineering failures.

2109630   Forming Process Analysis   3(3-0-9)
    Plastic forming of metals bending, forging rollings forge rolling, drawing; sheet metal forming; forging of complicated shapes; geometry of plastic area; formability; asymmetry of plastic deformation; computer analysis of forming process.

2109659 Aluminium Technology   3(3-0-9)
    Physical metallurgy of aluminium and its alloys; productions of aluminium; deformation process such as rolling extrusion ; relationship between microstructure and materials properties of aluminium alloys; recrystallization – recovery ; structural developments from the as cast to the worked and quenched state; surface finishes and treatments.

**2109711 Seminar in Metallurgical and   1(1-0-3)
            Materials Engineering I**
    Seminar in selected research topics of interest in Metallurgical and Materials Engineering.

**2109712 Seminar in Metallurgical and   1(1-0-3)
            Materials Engineering II**
    Seminar in Metallurgical and Materials Engineering II

**2109713 Seminar in Metallurgical and   1(1-0-3)
            Materials Engineering III**
    Seminar in Metallurgical and Materials Engineering III

**2109714 Seminar in Metallurgical and   1(1-0-3)
            Materials Engineering IV**
    Selected research topics of interest in metallurgical and materials engineering.

**2109715 Seminar in Metallurgical and   1(1-0-3)
            Materials Engineering V**
    Selected research topics of interest in metallurgical and materials engineering.

**2109715 Seminar in Metallurgical and   1(1-0-3)
            Materials Engineering V**
    Selected research topics of interest in metallurgical and materials engineering.

**2109716 Seminar in Metallurgical and   1(1-0-3)
            Materials Engineering VI**
    Selected research topics of interest in metallurgical and materials engineering.

**2109717 Seminar in Metallurgical and   1(1-0-3)
            Materials Engineering VI**
    Selected research topics of interest in metallurgical and materials engineering.

2109811 Thesis   12 Credits

2109828 Dissertation   48 Credits

2109894 Doctoral Dissertation Seminar   0(0-0-0)

2109897 Qualifying Examination   0(0-0-0)

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DEPARTMENT OF COMPUTER ENGINEERING

Objectives

1. Graduates have knowledge of basic sciences and engineering sciences necessary to engage in further learning.

2. Graduates have knowledge and skills needed for the engineering profession.

3. Graduates are able to use engineering tools appropriately.

The undergraduate program in Computer Engineering is relatively broad-based. The program covers various aspects in computer science and engineering which include the design, analysis, organization, and applications of computer systems. The department offers courses which can be divided into three major areas.

1. Digital System Engineering : Courses cover the design and analysis of digital computer systems which include logic design, microprocessors, microcomputer systems, assembly language, VLSI design, computer architectures, data communications and computer networks.

2. Systems Software Engineering : Courses cover the principles of design and analysis of algorithms, systems software, programming languages, compilers, and operating systems. The students will, in addition, understand the interactions between software and hardware at various interface levels.

3. Information Processing : Courses cover the design and analysis of information processing systems, information technology, software engineering, artificial intelligence, data base management system, computer graphics, and their applications.

A bachelor degree in Computer Engineering will be awarded upon successful completion of the four year curriculum. Being highly competent in the design, analysis, and applications of systems software, digital systems, and information processing, the graduate will be able to work as a systems programmer, a systems analyst or a system engineer.

The department also offers four additional curriculums leading to the Master Degree in Computer Science, Master Degree in Software Engineering, Master Degree in Computer Engineering, and Doctor of Philosophy in Computer Engineering.

HEAD :

Natawut   Nupairoj,   Ph.D. (Michigan St.)

PROFESSORS :

Boonserm   Kijsirikul,   Ph.D. (Tokyo Institute
                                            of Technology)
Prabhas   Chongstitvatana,   Ph.D. (Edinburgh U.)

ASSOCIATE PROFESSORS :

Atiwong   Suchato,   Ph.D. (M.I.T.)
Kultida   Rojviboonchai   Ph.D (Tokyo)
Nongluk   Covavisaruch,   M.S. in E.E.
                                            (Missouri Columbia)
                                            M.A. (Languages &
                                            International Trade)
                                            (Eastern Michigan)
Pornsiri   Muenchaisri,   Ph.D. (Oregon State)
Sartid   Vongpradhip,   Ph.D. (U.of Tech.
                                            Sydney)
Setha   Pan-Ngum,   Ph.D. (U. of Warwick)
Somchai   Prasitjutrakul,   Ph.D. (U. of Illinois)
Wiwat   Vatanawood,   Ph.D. (Chula)
Taratip   Suwannasart,   Ph.D. (lllinois Institute
                                            of Technology)
Twittie   Senivongse,   Ph.D. (U. of Kent)
Yachai   Limpiyakorn,   Ph.D. (Illinois Institute of
Technology)

ASSISTANT PROFESSORS :

Arthit   Thongtak,   D.Eng. (Tokyo Institute of
                                            Technology)
Athasit   Surarerks,   Ph.D. (U.of Pierre et
                                            Marie Curie)
Attawith   Sudsang,   Ph.D. (U. of Illinois)
Boonchai   Sowanwanichakul, B.Eng. (Chula)
Chotirat   Ratanamahatana,   Ph.D. (U. of California)
Krerk   Piromsopa,   Ph.D. (Michigan St.)
Natawut   Nupairoj,   Ph.D. (Michigan St.)
Nakornthip   Prompoon,   M.S. (George Wash.U.)
Nattee   Niparnan   Ph.D. (Chula)
Suebskul   Phiphobmongkol,   Ph.D. (Auburn)
Sukree   Sinthupinyo   Ph.D. (Chula)
Proadpran   Punyabukkana Pitsatorn,
                                            Ph.D. (Claremont)
Pizzanu   Kanongchaiyos,   Ph.D. (U.of Tokyo)
Thanawan   Chantaratanapibul, M.Sc. (Chula)
Thanarat   Chalidabhongse   Ph.D. (Maryland)
Veera   Muangsin,   Ph.D. (U. of Manchester)
Vishnu   Kotrajaras,   Ph.D. (Imperial College)

LECTURERS :

Chairat   Phongphanphanee, Ph.D. (U. of Southampton)
Chate   Patanothai,   M.Sc. in EE. (U. of Miami)
Duangdao   Wichadakul   Ph.D. (U. of Illinois)
Nuttapong   Chentanez   Ph.D. (Berkeley)
Peerapon   Vateekul   Ph.D. (U. of Miami)
Pitchaya   Sitthi-Amorn   Ph.D. (U. of Virginia)
Thit   Siriboon,   Ph.D. (Oregon State)
Thongchai   Rojkangsadan,   M.Sc. (Chula)

COMPUTER ENGINEERING CURRICULUM
FIRST YEAR CURRICULUM
COMMON TO ALL ENGINEERING STUDENTS

COURSE NO.	SUBJECT	CREDITS
	THIRD SEMESTER	
2110200	DISCRETE STRUC	3
2110215	PROG METH I	3
2110221	COMP ENG ESSENTIALS	3
2110251	DIG COMP LOGIC	3
2110253	COMP ELEC INTF	3
2110263	DIG LOGIC LAB I	1
xxxxxxx	GENERAL EDUCATION	3
		19
	FORTH SEMESTER	
2110201	COMP ENG MATH	3
2110211	INTRO DATA STRUCT	3
2110254	DIG DESIGN VER	3
2110265	DIG DESIGN LAB I	1
2603284	STAT PHYS SCIENCE	3
5500208	COM PRES SKIL	3
xxxxxx	GENERAL EDUCATION	3
		19
	FIFTH SEMESTER	
2110313	OS AND SYS PROG	3
2110316	PROG LANG PRIN	3
2110327	ALGORITHM DESIGN	3
2110352	COMP SYS ARCH	3
2110363	HW SYN LAB I	1
xxxxxx	GENERAL EDUCATION	3
		16

COURSE NO.	SUBJECT	CREDITS
	SIXTH EMESTER	
2110318	DIS SYS ESSEN	1
2110332	SYS ANA DESIGN	3
2110422	DB MGT SYS DESIGN	3
2110471	COMP NETWORK I	3
2110xxx	APPROVED ELECTIVES	3
5500308	TECH WRIT ENG	3
xxxxxxx	GENERAL EDUCATION	3
		19
	SUMMER SEMESTER	
2100301	ENGINEERING PRACTICE	2
	SEVENTH SEMESTER	
2110423	SOFTWARE ENG	3
2110355	FORM LANG/AUTO	3
2110490	COMP ENG PRE-PROJ	1
2110xxx	APPROVED ELECTIVES	6
xxxxxxx	FREE ELECTIVE	3
		16
	EIGHTH SEMESTER	
2110499	COMP ENG PROJECT	3
2110xxx	APPROVED ELECTIVES	9
xxxxxxx	FREE ELECTIVE	3
		15

TOTAL CREDITS FOR GRADUATION = 142

MASTER DEGREE PROGRAMS
COMPUTER SCIENCE

NAME OF THE DEGREE

: Master of Science
: M.Sc.

ADMISSION

The applicant must have the following qualification:
1. Hold a Bachelor degree in Computer Science, Computer Engineering, Software Engineering, Information Technology, Mathematics, Physics, Statistics, or other Engineering fields.
2. Have other qualifications as announced each year by Graduate School of Chulalongkorn University (if any), or have other qualifications approved by the Computer Science Program Committee.

DEGREE REQUIREMENTS

The program requires the total of 36 credits comprising
1. Required Courses: 9 credits (including a non-credit Seminar course)
2. Track Elective Courses: 9 credits chosen from one of the following tracks:
    a. Intelligent Systems track
    b. Enterprise Information Systems track
3. General Elective Courses: 6 credits
4. Thesis: 12 credits

COURSE REQUIREMENTS

1) *Required Courses*

2110607	Research Methods in Computer Science	3(3-0-9)
2110636	Performance Analysis and Evaluation	3(3-0-9)
2110681	Computer Algorithm	3(3-0-9)
2110701	Seminar in Computer Engineering I	1(0-1-3)

Remark: 2110701 Seminar in Computer Engineering I is a non-credit course, with S/U evaluation.

2) *Track Elective Courses*

Each student must choose one of the tracks.

Intelligent Systems Track

Each student chooses 3 courses from the following list. (Remaining courses in the track can be chosen as General Elective Courses.)

2110654	Artificial Intelligence	3(3-0-9)
2110682	Embedded and Real-Time Systems	3(3-0-9)
2110714	Digital Systems	3(3-0-9)
2110743	Machine Learning	3(3-0-9)
2110773	Data Mining	3(3-0-9)

Enterprise Information Systems Track

Each student chooses 3 courses from the following list. (Remaining courses in the track can be chosen as General Elective Courses.)

2110523	Enterprise Application Architecture	3(3-0-9)
2110637	Large-Scale Information Systems	3(3-0-9)
2110640	Information Security	3(3-0-9)
2110663	Worldwide Network Infrastructure	3(3-0-9)
2110673	Information Storage and Retrieval	3(3-0-9)

3) *General Elective Courses*

Each student chooses 2 courses from the following list.

2110522	UNIX/LINUX for Enterprise Environment	3(3-0-9)
2110638	Object-Oriented Technology	3(3-0-9)
2110651	Digital Image Processing	3(3-0-9)
2110678	Mobile Computing	3(3-0-9)
2110694	Directed Studies in Computer Science	3(3-0-9)
2110697	Special Topics in Computer Science I	3(3-0-9)
2110698	Special Topics in Computer Science II	3(3-0-9)
2110713	Optimization Methods	3(3-0-9)
2110731	Distributed Systems	3(3-0-9)
2110732	Parallel Computing	3(3-0-9)
2110741	Robotics	3(3-0-9)
2110742	Evolutionary Computation	3(3-0-9)
2110746	Big Data Analytics	3(3-0-9)
2110747	Social Network Analysis	3(3-0-9)
2110781	Special Topics in Distributed Systems	3(3-0-9)
2110792	Advanced Topics in Artificial Intelligence	3(3-0-9)
2110795	Advanced Topics in Computer Network	3(3-0-9)

In addition to the list above, students can choose among the following as General Elective Courses:
1. Remaining elective courses of the chosen track which are not part of the 9-credit Track Elective Courses
2. Electives courses of the other track that is not chosen
3. Graduate courses of other programs of the Department (i.e. 21105xx, 21106xx, or 21107xx courses not listed as the General Elective Courses above)
4. Graduate courses of Chulalongkorn University (approval by the Computer Science Program Committee is required).

4) *Thesis*

| 2110811 | Thesis | 12 | credits |

STUDY PROGRAM

First Semester

2110606	Research Methods in Computer Science	3
2110636	Performance Analysis and Evaluation	3
2110681	Computer Algorithm	<u>3</u>
		9

Second Semester

2110xxx	Track Elective Courses	6
2110xxx	General Elective Courses	<u>3</u>
		9

Third Semester

2110711	Seminar in Computer Engineering I	-
2110xxx	Track Elective Courses	3
2110xxx	General Elective Courses	3
2110811	Thesis	<u>3</u>
		9

Fourth Semester

| 2110811 | Thesis | <u>9</u> |
| | | **9** |

COMPUTER ENGINEERING

: Master of Engineering
: M.Eng.

ADMISSION

The applicant must hold a Bachelor's Degree in Computer Engineering for plan A(1) or a Bachelor's Degree in any Engineering discipline for plan A(2), meet the Graduate School requirements, and also must pass the Interview by the Computer Engineering Department.

DEGREE REQUIREMENTS

Plan A(1) program consists of three non-credit required courses and 36 credits of thesis. Plan A(2) program consists of 3 non-credit required courses, 12 credits of elective courses, and 24 credits of thesis.

COURSE REQUIREMENTS

1) *Required Courses*   *non-credit*

2110606	Research Methods in Computer Engineering	3(3-0-9)
2110701	Seminar in Computer Engineering I	1(0-3-1)
2110702	Seminar in Computer Engineering II	1(0-3-1)

2) *Elective Courses*   *12*   *credits*

2110502	Formal Verification	3(3-0-9)
2110522	UNIX/LINUX for Enterprise Environment	3(3-0-9)
2110523	Enterprise Application Architecture	3(3-0-9)
2110541	Computer Systems Audit	3(3-0-9)
2110605	Computer Programs Structure	3(3-0-9)
2110611	Information Processing and Computer System	3(3-0-9)
2110612	System Programming	3(3-0-9)
2110614	Programming Languages and Compilation	3(3-0-9)
2110621	System Analysis and Design	3(3-0-9)
2110622	Data Management	3(3-0-9)
2110623	Software Requirements Engineering	3(3-0-9)
2110624	Software Engineering	3(3-0-9)
2110629	File Management	3(3-0-9)
2110631	Operating System	3(3-0-9)
2110632	Advanced Topics in Operating Systems	3(3-0-9)
2110634	Software Design and Development	3(3-0-9)
2110636	Performance Analysis and Evaluation	3(3-0-9)
2110637	Large-Scale Information Systems	3(3-0-9)
2110638	Object-Oriented Technology	3(3-0-9)
2110639	Computer System Security	3(3-0-9)
2110640	Information Security	3(3-0-9)
2110642	Object-Oriented Software Engineering	3(3-0-9)
2110644	Formal Software Specification	3(3-0-9)
2110645	Software Engineering Methodology	3(3-0-9)
2110646	User Interface Design	3(3-0-9)
2110651	Digital Image Processing	3(3-0-9)
2110654	Artificial Intelligence	3(3-0-9)
2110657	Computer Simulation	3(3-0-9)
2110661	Computer Network	3(3-0-9)

2110663	Worldwide Network Infrastructure	3(3-0-9)
2110664	Network Management	3(3-0-9)
2110665	Computer Communication System and Standards	3(3-0-9)
2110671	Database Management Systems	3(3-0-9)
2110672	Data Modeling Techniques	3(3-0-9)
2110673	Information Storage and Retrieval	3(3-0-9)
2110674	Information Technology Center Management	3(3-0-9)
2110678	Mobile Computing	3(3-0-9)
2110681	Computer Algorithm	3(3-0-9)
2110682	Embedded and Real-time Systems	3(3-0-9)
2110683	Concurrent Processing	3(3-0-9)
2110684	Information System Architecture	3(3-0-9)
2110685	Computer Application in Enterprises	3(3-0-9)
2110686	Enterprise Computing	3(3-0-9)
2110694	Directed Studies in Computer Science	3(3-0-9)
2110696	Advanced Topics in Computer Application	3(3-0-9)
2110697	Special Topics in Computer Science I	3(3-0-9)
2110698	Special Topics in Computer Science II	3(3-0-9)
2110711	Theory of Computation	3(3-0-9)
2110712	Analysis of Algorithms	3(3-0-9)
2110713	Optimization Methods	3(3-0-9)
2110714	Digital Systems	3(3-0-9)
2110721	Software Metrics	3(3-0-9)
2110722	Software Project Management	3(3-0-9)
2110723	Advanced Software Engineering Development	3(3-0-9)
2110724	Software Testing and Quality Assurance	3(3-0-9)
2110730	Software Quality Process and Management	3(3-0-9)
2110731	Distributed Systems	3(3-0-9)
2110732	Parallel Computing	3(3-0-9)
2110741	Robotics	3(3-0-9)
2110742	Evolutionary Computation	3(3-0-9)
2110743	Machine Learning	3(3-0-9)
2110744	Machine Vision	3(3-0-9)
2110745	Cryptography	3(3-0-9)
2110746	Big Data Analytics	3(3-0-9)
2110747	Social Network Analysis	3(3-0-9)
2110751	Computer Aided Design in Digital Systems	3(3-0-9)
2110752	Design for Testability	3(3-0-9)
2110753	Asynchronous Design	3(3-0-9)
2110771	Advanced Database Design	3(3-0-9)
2110772	Multi-Dimensional Database Systems	3(3-0-9)
2110773	Data Mining	3(3-0-9)
2110781	Special Topics in Distributed Systems	3(3-0-9)

2110791	Advanced Topics in Software Engineering	3(3-0-9)
2110792	Advanced Topics in Artificial Intelligence	3(3-0-9)
2110793	Advanced Topics in Digital Systems	3(3-0-9)
2110794	Advanced Topics in Database Systems	3(3-0-9)
2110795	Advanced Topics in Computer Network	3(3-0-9)

3) Thesis

2110814	Thesis (for plan A(2))	24	credits
2110816	Thesis (for plan A(1))	36	credits

STUDY PROGRAMS

Plan A (1)

First Semester

2110606	Researh Methods	-
2110816	Thesis	9
		9

Second Semester

2110701	Seminar Computer Eng. I	-
2110816	Thesis	9
		9

Third Semester

2110702	Seminar Computer Eng. II	-
2110816	Thesis	9
		9

Fourth Semester

2110816	Thesis	9
		9

Plan A (2)

First Semester

2110606	Researh Methods	-
2110 xxx	Electives	9
		9

Second Semester

2110701	Seminar Computer Eng. I	-
2110 xxx	Electives	3
2110814	Thesis	6
		9

Third Semester

2110702	Seminar Computer Eng. II	-
2110814	Thesis	9
		9

Fourth Semester

2110814	Thesis	9
		9

SOFTWARE ENGINEERING

NAME OF THE DEGREE

: Master of Science
: M.Sc.

ADMISSION

The program has 2 plans.

Plan A(2) is the plan **with thesis**. The applicant must
1. Hold a Bachelor's degree in Engineering, Statistics, Science, or equivalent.
2. Have other qualifications as announced each year by Graduate School of Chulalongkorn University (if any), or have other qualifications approved by the Software Engineering Program Committee.

Plan B is the plan with **no thesis**, but students **must do the master project and pass the comprehensive exam.** The applicant must
1. Hold a Bachelor's degree in one of these fields.
   - Engineering
   - Statistics
   - Science
   - Industrial Education with one of these sub-fields
       - Education Technology and Communication
       - Computer and Information Technology
       - Computer Technology or
       - Electronics and Computer
   - Business Administration with one of these sub-fields
       - Business Computer
       - Business Information Technology
       - Computer Information or
       - Computer Information Systems – Software Development
   - or hold other Bachelor's degree but have **at least 1 year** experience working in Information Technology or Computer.

2. Have other qualifications as announced each year by Graduate School of Chulalongkorn University (if any), or have other qualifications approved by the Software Engineering Program Committee.

DEGREE REQUIREMENTS

Both Plan A(2) and Plan B require the total of 36 credits.

Plan A(2)
1. Non-credit Courses (2 courses)
2. Required Courses 12 credits
3. Electives 12 credits
4. Thesis 12 credits

Plan B
1. Non-credit Courses (2 courses)
2. Required Courses 18 credits
3. Electives 12 credits
4. Master Project 6 credits
5. Comprehensive Exam

COURSE REQUIREMENTS

Plan A(2)

1) *Non-credit Courses*

2110606	Research Methods in Computer Engineering	3(3-0-9)
2110701	Seminar in Computer Engineering I	1(0-3-1)

Remark: Non-credit courses will be evaluated with S/U.

2) *Required Courses*

2110623	Software Requirements Engineering	3(3-0-9)
2110634	Software Design and Development	3(3-0-9)
2110721	Software Metrics	3(3-0-9)
2110724	Software Testing and Quality Assurance	3(3-0-9)

3) *Electives*

Choose 4 courses. Electives will be divided in 2 groups: Software Engineering Electives and General Electives. Student must study at least 2 courses (6 credits) of Software Engineering Electives.

---Software Engineering Electives

2110502	Formal Verification	3(3-0-9)
2110521	Software Architectures	3(3-0-9)
2110523	Enterprise Application Architecture	3(3-0-9)
2110644	Formal Software Specification	3(3-0-9)
2110645	Software Engineering Methodology	3(3-0-9)
2110646	User Interface Design	3(3-0-9)
2110722	Software Project Management	3(3-0-9)
2110723	Advanced Software Engineering Development	3(3-0-9)
2110725	Software Engineering Process and Improvement	3(3-0-9)
2110726	Software Configuration Management	3(3-0-9)
2110727	Software Evolution and Maintenance	3(3-0-9)

2110728	Special Topics in Software Engineering I	3(3-0-9)
2110729	Special Topics in Software Engineering II	3(3-0-9)
2110730	Software Quality Process and Management	3(3-0-9)
2110791	Advanced Topics in Software Engineering	3(3-0-9)

---General Electives

Student can enroll in any courses open for graduate students. Course must be instructed either by the Department of Computer Engineering or any department in Chulalongkorn University (approval by the Software Engineering Program Committee is required).

4) *Thesis*

2110811 Thesis   12 credits

Plan B

1) *Non-credit Courses*

| 2110606 | Research Methods in Computer Engineering | 3(3-0-9) |
| 2110701 | Seminar in Computer Engineering I | 1(0-3-1) |

Remark: Non-credit courses will be evaluated with S/U.

2) *Required Courses*

2110623	Software Requirements Engineering	3(3-0-9)
2110634	Software Design and Development	3(3-0-9)
2110721	Software Metrics	3(3-0-9)
2110722	Software Project Management	3(3-0-9)
2110724	Software Testing and Quality Assurance	3(3-0-9)
2110725	Software Engineering Process and Improvement	3(3-0-9)

3) *Electives*

Choose 4 courses. Electives will be divided in 2 groups: Software Engineering Electives and General Electives. Student must study at least 2 courses (6 credits) of Software Engineering Electives.

---Software Engineering Electives

2110502	Formal Verification	3(3-0-9)
2110521	Software Architectures	3(3-0-9)
2110523	Enterprise Application Architecture	3(3-0-9)
2110644	Formal Software Specification	3(3-0-9)
2110645	Software Engineering Methodology	3(3-0-9)
2110646	User Interface Design	3(3-0-9)
2110723	Advanced Software Engineering Development	3(3-0-9)
2110726	Software Configuration Management	3(3-0-9)

2110727	Software Evolution and Maintenance	3(3-0-9)
2110728	Special Topics in Software Engineering I	3(3-0-9)
2110729	Special Topics in Software Engineering II	3(3-0-9)
2110730	Software Quality Process and Management	3(3-0-9)
2110791	Advanced Topics in Software Engineering	3(3-0-9)

---General Electives

Student can enroll in any courses open for graduate students. Course must be instructed either by the Department of Computer Engineering or any department in Chulalongkorn University (approval by the Software Engineering Program Committee is required).

4) *Master Project*

| 2110797 | Pre-Master Project in Software Engineering | 3(0-0-12) |
| 2110798 | Master Project in Software Engineering | 3(0-0-12) |

5) *Comprehensive Exam*

2110896   Comprehensive Examination

Remark: Comprehensive examination will be evaluated with S/U. The student can enroll in this course since the semester that all courses in the program are registered.

STUDY PROGRAMS

Plan A(2)

First Semester

2110623	Software Requirement Eng.	3
2110701	Seminar in Computer Engineering I	-
2110724	Software Testing and Quality Assurance	3
2110xxx	Elective	3
		9

Second Semester

2110634	Software Design and Development	3
2110721	Software Metrics	3
2110xxx	Elective	3
		9

Third Semester

| 2110606 | Research Methods in Computer Engineering | - |

2110xxx	Electives	6
2110811	Thesis	<u>3</u>
		9

Fourth Semester

| 2110811 | Thesis | <u>9</u> |
| | | *9* |

Plan B

First Semester

2110623	Software Requirement Eng.	3
2110701	Seminar in Computer Engineering I	-
2110 722	Software Project Management	3
2110724	Software Testing and Quality Assurance	<u>3</u>
		9

Second Semester

2110634	Software Design and Development	3
2110721	Software Metrics	3
2110 725	Software Engineering Process And Improvement	<u>3</u>
		9

Third Semester

2110606	Research Methods in Computer Engineering	-
2110xxx	Electives	6
2110797	Pre-Master Project in Software Engineeing	<u>3</u>
		9

Fourth Semester

2110xxx	Electives	6
2110798	Master Project in Software Engineeing	3
2110896	Comprehensive Exam	<u>-</u>
		9

PH.D. DEGREE PROGRAM

NAME OF THE DEGREE

: Doctor of Philosophy
: Ph.D.

ADMISSION

The applicant must hold one of the following qualification :

A) Bachelor's Degree (Hons-2nd level or equivalent) or grade point not less than 3.25.

B) Master's Degree of Engineering or Science in Computer, Physics or Mathematics.

In addition he/she has to meet the Graduate School requirement.

DEGREE REQUIREMENTS

The program for Bachelor's Degree Holder, plan 2(1), consists of 12 credits of required courses including 4 non - credit seminars , 12 credits of elective courses ,and 48 credits of thesis , for a total of 72 credits.

The program for Master's Degree Holder, plan 2(2), consists of 4 non – credits seminars, 12 credits of elective courses, and 48 credits of Dissertation , for a total of 60 credits.

The student who has fulfilled the requirement of the program and of the Graduate School will be awarded the Degree of Doctor of Philosophy in Computer Engineering.

COURSE REQUIREMENTS

	1) Required Courses 12 credits	
2110711	Theory of Computation	3(3-0-9)
2110712	Analysis of Algorithms	3(3-0-9)
2110713	Optimization Methods	3(3-0-9)
2110714	Digital Systems	3(3-0-9)
2110716	Seminar I	1(1-0-3)
2110717	Seminar II	1(1-0-3)
2110718	Seminar III	1(1-0-3)
2110719	Seminar IV	1(1-0-3)
	2) Elective Courses 12 credits	
2110694	Directed Studies in Computer Science	3(3-0-9)
2110697	Special Topics in Computer Science I	3(3-0-9)
2110698	Special Topics in Computer Science II	3(3-0-9)
2110721	Software Metrics	3(3-0-9)
2110722	Software Project Management	3(3-0-9)
2110723	Advanced Software Engineering Development	3(3-0-9)
2110724	Software Testing and Quality Assurance	3(3-0-9)
2110730	Software Quality Process and Management	3(3-0-9)
2110731	Distributed Systems	3(3-0-9)
2110732	Parallel Computing	3(3-0-9)
2110741	Robotics	3(3-0-9)
2110742	Evolutionary Computation	3(3-0-9)
2110743	Machine Learning	3(3-0-9)
2110744	Machine Vision	3(3-0-9)
2110746	Big Data Analytics	3(3-0-9)
2110747	Social Network Analysis	3(3-0-9)
2110751	Computer Aided Design in Digital Systems	3(3-0-9)
2110752	Design for Testability	3(3-0-9)
2110753	Asynchronous Design	3(3-0-9)
2110771	Advanced Database Design	3(3-0-9)
2110772	Multi-Dimensional Database Systems	3(3-0-9)
2110773	Data Mining	3(3-0-9)
2110791	Advanced Topics in Software	3(3-0-9)

	Engineering	
2110792	Advanced Topics in Artificial Intelligence	3(3-0-9)
2110793	Advanced Topics in Digital Systems	3(3-0-9)
2110794	Advanced Topics in Database Systems	3(3-0-9)
2110795	Advanced Topics in Computer Network	3(3-0-9)

1) *Dissertation*

2110828	Dissertation	48 credits
2110894	Doctoral Dissertation Seminar	0(0-0-0)
2110897	Qualifying Examination	0(0-0-0)

STUDY PROGRAMS

Plan 2 (1)

First Semester

2110716	Seminar I	-
2110 xxx	Required coures	12
		12

Second Semester

2110717	Seminar II	-
2110 xxx	Electives	9
2110828	Thesis	3
		12

Third Semester

2110718	Seminar III	-
2110 xxx	Electives	3
2110828	Thesis	9
		12

Fourth Semester

2110719	Seminar IV	-
2110828	Thesis	12
		12

Fifth Semester

2110828	Thesis	12
		12

Sixth Semester

2110828	Thesis	12
		12

Plan 2 (2)
First Semester

2110716	Seminar I	-
2110 xxx	Electives	9
		9

Second Semester

2110717	Seminar II	-
2110 xxx	Electives	3
2110828	Thesis	6
		9

Third Semester

2110718	Seminar III	-
2110828	Thesis	9
		9

Fourth Semester

2110719	Seminar IV	-
2110828	Thesis	9
		9

Fifth Semester

2110828	Thesis	12
		12

Sixth Semester

2110828	Thesis	12
		12

COURSE DESCRIPTIONS IN COMPUTER ENGINEERING (B.ENG.)

2110101   Computer Programming   3(3-0-6)
Computer concepts, computer system components, hardware and software interaction, electronic information and data processing concepts; programming: data types, operators, statements, control structures; programming tools; programming styles and conventions; debugging; program design and development with applications to engineering problems using a high level language.

2110191   Innovative Thinking   3(3-0-6)
Condition : Free Elective
Definition of innovative thinking ; Types of innovation ; Innovator Role Model; Innovative thinking process; Creative mistakes; Innovation development.

2110200   Discrete Structures   3(3-0-6)
Sets, relations, functions, theorem and proof; combinatorics; counting, principle of inclusion exclusion, recurrent relations, generating functions; graphs and trees; introduction to number theory.

2110201   Computer Engineering Mathematics 3(3-0-6)
Linear algebra, vector, matrix, inverse matrix, solution to system of linear equations, factorization, vector space, subspace, rank, dimension, basis, orthogonality, projection, determinant, determinant computation, eigenvalue, eigenvector, singular value decomposition, computer programming for linear algebra.

2110211   Introduction to Data Structures   3(3-0-6)
Condition : Prerequisite 2110101

Linear allocation: array, stack, queue, dequeues; linked allocation: singly linked lists, and doubly linked lists; string processing and pattern matching; trees: binary tree, traversal, representation, B-tree and AVL-tree; internal searching and sorting: binary, radixes, shell, quicksort and merge sort; heap storage, hash coding and table handling.

2110213   Information Systems Organization 3(3-0-6)

Hardware systems: personal computer, network, Internet, internet protocol, domain name, cable, hub, switch, router, modem, Internet server, corporate server, real-time server, embedded system; application systems: multi-tier system, web server, markup language, application server, database server, query language, multi-vendor database access interface; transaction systems: process abstraction, inter-process communication, synchronization, deadlock, transaction atomicity, checkpoint and rollback, concurrency control.

2110215 Programming Methodology I   3(2-3-4)
Condition : Prerequisite 2110101

Programming methodology: object-oriented programming, event-driven programming, concurrent programming; error and exception handling; application programming interface (API); programming tools; programming styles and practice.

2110221   Computer Engineering Essentials   3(3-0-6)

Overview of computer engineering, information system and information technology; hardware and software; logic circuit and processor; algorithm and program; database; computer network and internet, artificial intelligence and robot; embedded system; data center; security; computer ethics; intellectual property; computer industry.

2110250   Computer Organization   3(3-0-6)

Computer systems organization, hardware components in a computer system, basic computer principles, instruction unit, instruction execution cycle, instruction set architecture, assembly language principles.

2110251   Digital Computer Logic   3(3-0-6)

Number systems; logic gates and logic expressions; Boolean algebra: Karnaugh map and tabulation method; combination logic circuit and applications: adder, subtractor, multiple outputs circuit, decoder, encoder, multiplexer and demultiplexer; gate implementation: tristate; speed and delay in logic circuits; sequential circuits and design; flip-flop, and counter; register.

2110253   Computer Electronics and   3(3-0-6)
Interfacing

Principles of design; design of DC and AC circuits using

diodes, bipolar junction transistors, field-effect transistors and use of transistors in digital circuits, physical design of simple gates, flip-flops, and memory circuits, interfacing logic families and standard buses.

2110254   Digital Design and Verification   3(3-0-6)
Condition : Prerequisite 2110251 or 2110254

Processor design at instruction set level and register transfer level; hardware description language (HDL); functional verification of HDL models; microprocessors; control unit; memory unit; adders; I/O device interfaces.

2110263   Digital Computer Logic Laboratory I   1(0-2-1)

Hands-on experience in using digital electronics by way of logic gates and integrated circuits; practical construction, testing, and implementation of combinational and sequential logic circuits.

2110265   Digital Design and Verification   1(0-2-1)
Laboratory I
Condition : Prerequisite 2110251

Writing hardware description language (HDL) to implement digital designs, adder, arithmetic logic unit, control unit, memory modules, system integration, writing test benches to verify the design.

2110271   Programming Tools   3(2-2-5)

Source-code tools; executable-code tools; user-interface tools; code management tools; deployment tools; documentation tools; testing tools; integrated development environments.

2110291   Individual Study in Computer   1(0-0-3)
Engineering I

Independent study and investigation, theoretically and practically, in computer engineering topics according to each student's interest under the supervision and guidance of the instructor.

2110292   Individual Study in Computer   1(0-0-3)
Engineering II

Independent study and investigation, theoretically and practically, in computer engineering topics according to each student's interest under the supervision and guidance of the instructor.

2110313   Operating Systems and System   3(3-0-6)
Programming
Condition : Prerequisite 2110211, 2110213
or 2110221

OS services: functions, organisation, process, concurrent programming, synchronisation, critical section, semaphore, monitor, deadlock, processor management, memory management, device management, file management, resource protection, and networking; service interfaces: system call, application programming interface (API); service development; tools and utilities: system management tools, development tools, and operation tools.

2110316 Programming Languages 3(3-0-6)
Principles
Condition : Prerequisite 2110211

Language definition: grammar, syntax, and semantics; conventional paradigm: data type, control structure, block structure, and recursion; interpretive languages; runtime environment and virtual computer; unconventional paradigm: functional, logic, and markup languages; object-orientation and software components: class, instance, method, message passing, inheritance, method binding, polymorphism, framework, and component-based programming; basic compiling techniques: scanner, parser, code generation, and tools.

2110317 Fundamental of Distributed 3(3-0-6)
Systems
Condition : Prerequisite 2110313

Interprocess communication and remote procedure call; Logical clock and ordering; centralised transaction and concurrency control; distributed transaction; two-phase commit protocol; distributed concurrency control; deadlock and distributed deadlock; load distribution; fault tolerance: fault model, recovery; replication: view and vector clock; distributed transaction under failure conditions; security; distributed services.

2110318 Distributed Systems Essentials 1(1-0-2)
Condition : Prerequisite 2110313 or
Consent of faculty

Characteristics and system models: client/server, proxy, peer-to-peer; message passing: marshaling, request-reply protocol; distributed objects and remote invocation; time, clock, and ordering; group communication: basic, reliable, and ordered multicast; transaction and concurrency control; distributed transaction: two-phase commit, recovery; advanced topics: consensus, replication, Web services.

2110327 Algorithm Design 3(3-0-6)
Condition : Prerequisite 2110200, 2110211

Algorithm design techniques: divide and conquer, dynamic programming, greedy algorithms, state-space search; asymptotic analysis of algorithms; introduction to computational complexity; algorithm designs for NP-hard problems; backtracking, branch and bound, approximation algorithms.

2110332 System Analysis and Design 3(3-0-6)
Condition : Prerequisite 2110211

Data processing systems and systems life cycle; analysis methodology: tools, cost analysis, problem definition, proposal and feasibility study; design methodology: tools, database approach, systems design, file and form design, program design, documentation; implementation methodology: coding, testing and software maintenance.

2110333 Event-Driven Programming 3(2-2-5)
Condition : Prerequisite 2110101 or Consent of
Faculty

Events, event queues, event focus, event handlers, event loop, callbacks, delegation; GUI and distributed environments; event-driven I/Os; windowing system; GUI programming; event-driven program interactions.

2110334 Network Programming 3(2-2-5)
Condition : Prerequisite 2110210 and
2110213 Consent of Faculty

Networking concepts; internet standards; sockets programming; web programming; client-server programming.

2110352 Computer System Architectures 3(3-0-6)
Condition : Prerequisite 2110250 or
2110253

Performance metrics; central processing unit; hardwired and microprogram of control units; instruction level parallelism : pipeline, superscalar; memory system: cache memory, virtual memory, disk array; development and future of architecture.

2110355 Formal Languages and Automata 3(3-0-6)
Theory

Studies concepts of grammars, automata, languages, computability and complexity; the relationship between automata and various classes of languages; Turing machine and equivalent models of computation, the Chomsky hierarchy, context-free grammar, push-down automata, etc.; pumping lemmas and variants, closure properties and decision properties; parsing algorithms.

2110361 Hardware Synthesis Laboratory 2(0-4-2)
Condition : Prerequisite 2110264

Synthesis of digital systems on FPGA technology, use of hardware description language to model digital systems and implement the design on a programmable device, design decomposition, testing and debugging the design.

2110363 Hardware Synthesis LaboratoryI 1(0-2-1)
Condition : Prerequisite 2110265

Synthesis of digital systems on FPGA technology, use of hardware description language to model digital systems, testing and debugging the design.

2110388 Database Programming 4(2-4-6)
Condition : Prerequisite 2110210 and
2110213, Consent of Faculty

Structured query language (SQL), database connectivities; database programming tools and components; concurrency control; transactions processing; programming for database-backed site.

2110391 Individual Study in Computer 1(0-0-3)
Engineering III

Independent study and investigation, theoretically and practically, in computer engineering topics according to each student's interest under the supervision and guidance of the instructor.

2110392 Individual Study in Computer 1(0-0-3)
Engineering IV

Independent study and investigation, theoretically and practically, in computer engineering topics according to

each student's interest under the supervision and guidance of the instructor.

2110398   Software Development   1(0-2-1)
**   Pre – Project**
Study and specifying topic, scope, methodologies of problem solving and expected benefit of various areas of software development project under project advisor's supervision. Project proposal is examined by a department committee. Written progress reports must be submitted and presented periodically.

2110399   Software Development Project   3(0-6-3)
Continuing of the approved project from Software Development Pre-Project course must be carried out under project advisor's supervision. Written progress report must be submitted periodically. A written final report is required and an oral examination must be taken with a department project committee at the end of the project.

2110401   Computer Engineering Professional 3(3-0-6)
**   Ethics**
Ethical theory; privacy; intellectual properties: patents, copyrights; computer crimes; professional codes of ethics; social issues; case studies.

2110412   Parallel Computer Architecture   3(3-0-6)
*   Condition : Prerequisite 2110211*
Parallel architectures; parallel computation models; parallel algorithms; parallel programming and languages.

2110413   Computer Security   3(3-0-6)
Computer security principle; symmetric key cryptography; public key cryptography; message digest; authentication: access control; enterprise security; network security.

2110414   Large Scale Computing Systems   3(3-0-6)
High-performance and large-scale computing infrastructure: cluster, peer-to-peer, Grid, Cloud; virtualization; software architecture and middleware; HPC applications and algorthms; HPC software development.

2110420   Compiler Construction   3(3-0-6)
Grammar, syntax, and semantics; lexical analysis; parsing methods; symbol table construction; intermediate representation; code generation; basic and advanced code optimization techniques.

2110421   Theory of Programming   3(3-0-6)
**   Languages**
Data and control abstractions; binding; type checking; advanced control constructs, backtracking and nondeterminism; formal methods for program description, formal syntax and formal semantics; methods for proving programs correctness.

2110422   Database Management Systems   3(3-0-6)
**   Design**
*   Condition : Prerequisite 2110200, 2110211*

Database concepts: goals, data independence, relationships, logical and physical organizations, schema and subschema; data models: hierarchical, network, and relational models; data normalization: first, second, and third normal forms of data relations; canonical schema, data independence; data description languages; query facilities: relational algebra, relational calculus, data structures for establishing relations, query functions, design and translation strategies; file organization, file security; data integrity and reliability.

2110423   Software Engineering   3(3-0-6)
Design tools and techniques; top-down design, modular design, software tools, debugging and test data; software reliability, theory and concepts, errors, faults and estimation, reliability models, availability models; management techniques, cost estimation, software maintenance.

2110424   Software Process Improvement   3(3-0-6)
*   Condition : Consent of Faculty*
Software process improvement premise; software process modeling; foundation and infrastructure of software process improvement; approach for transitioning to process improvement program; quality assurance components in software project life cycle; software engineering process group; software process and product measurement.

2110428   Introduction to Data Mining   3(3-0-6)
Fundamental concepts of data mining; data mining methodologies, decision trees, classification, association, clustering; data mining algorithms.

2110429   Information Retrieval Systems   3(3-0-6)
*   Condition : Prerequisite 2110211*
Information structures; dictionary systems; statistical systems; vector matching and searching strategies; input specifications and systems organization; output systems; evaluation; automatic question answering.

2110430   Time Series Mining and   3(3-0-6)
**   Knowledge Discovery**
Time series mining: classification, clustering (shape-based/model-based) ,associationrules ,summarization visualization,anomaly detection, motif discovery; similarity measurement: dynamic time warping; distance measure; data preprocessing; time series indexing; time series representation and dimensionality reduction.

2110431   Introduction to Digital Imaging 3(3-0-6)
Overview of theory of digital image processing and analysis: definition of terms, basic principles of human visual perception, image representation, preprocessing, image enhancement, image segmentation, feature extraction and analysis, image compression; survey of applications.

2110432   Automatic Speech Recognition   3(3-0-6)

Overview of speech and language technology; human speech production models; spectrogram; speech sounds in languages and spectrogram reading; speech representation; template matching using dynamic time warping; acoustic modeling; frame-based speech recognition using Hidden Markov models; language modeling; examples of other approaches to automatic speech recognition.

2110433   Computer Vision   3(3-0-6)

Image formation; feature detection; color; texture; region segmentation and representation; object recognition; dynamic vision; 3D vision; vision applications.

2110435   Introduction to Robotics   3(3-0-6)

An overview of robotics technology; introduction to the configulation space concept, rigid transformation and manipulator kinematics; sensing and control; robot programming; robot motion planning and application; robot manipulation.

2110441   Software Design and Development 3(3-0-6)

Design techniques : models of structured programming, code reading and correctness, stepwise refinement and reorganization, top-down design and development, structured design, strength, and coupling measures; organization and management: milestones and estimation, chief programmer teams, program libraries, walk through, and documentation; team project: organization, management and development of large scale software.

2110442   Object-Oriented Analysis and   3(3-0-6)
            Programming

Object-oriented design and object-oriented software construction; design and construct : classes, methods, messages, instances, inheritance, static and dynamic blinding, replacement and refinement and polymorphism analyze : frameworks and design patterns, and object-oriented software engineering.

2110443   Human-Computer Interaction   3(3-0-6)
Condition : Prerequisite 2110101

HCI design, implementation and evaluation; graphical user interface programming; prototyping tools and toolkits; window-based systems; usability engineering.

2110444   Introduction to Formal   3(3-0-6)
            Verification
Condition : Prerequisite 2110200

Fundamental concepts of mathematical logic; formal specification language definition : syntax, semantics; formal specification language: Z, Object Z, CafeOBJ; mathematical models of software and hardware; formal verification methods.

2110445   Enterprise information Systems 3(3-0-6)
Condition : Consent of Faculty

Enterprise information systems; information technology infrastructure and integration; impact of information systems on organizations; information technology and business strategies; e-business and e-commerce; ethical and social issues related to technology; technology decisions; business value of information systems.

2110451   Digital Computer Hardware Design 3(3-0-6)

The principles of design of modern digital computers; especially in the simple and advanced microprogrammed control unit; ALU design, carry look-ahead and multiplication and division algorithms.

2110455   Testing Digital Circuits   3(3-0-6)

Testing techniques for digital logic circuits; fault modelling; test generation; test evaluation; testabillity analysis; design for greater testabillity; automatic test equipment; IDDQ testing; writing simulation programs, current research issues on testing.

2110471   Computer Networks I   3(2-3-4)
Condition : Prerequisite 2110221

History and Overview of Computer Networks, Network Architecture and Protocol, LAN and WAN, Client-Server and Peer-to-Peer Computing, Data Security and Integrity, Wireless and Mobile Computing.

2110473   Fault Tolerant Computing   3(3-0-6)

Fault model; test generation of combinational and sequential circuits: Boolean difference, path sensitization and algorithm; digital simulation technique; design of self checking circuit; error detection and correction codes redundancy techniques; diagnosis of digital system and design of simplified testing.

2110475   VLSI Design   3(3-0-6)

Integrated circuit technology; design and implementation of very large scale integrated circuits including design methodology: design using stick diagram; the use of CAD tools including layout generators, simulators, and plot utilities; I/O pads; study of some digital subsystem, digital architecture and design styles; Fabrication processes; criterion for foundries; case study of some custom design integrated circuits.

2110476   Artificial Intelligence I   3(3-0-6)

Philosophy of mind, knowledge and reasoning, agent-based systems, planning perception, robotics: sensing, navigation & control, introduction to evolutionary computation.

2110477   Artificial Intelligence II   3(3-0-6)

Definition of Artificial Intelligence problem solving by search, knowledge representation, natural language processing, Prolog programming, machine learning, neural networks.

2110478   Computer and Communication   3(3-0-6)

Introduction: computer and communication technology; Communication and network model: Shannon and Weaver model, ISO-OSI model, LAN, and Inter/Intranet; System component: modem, multiplexer, interface, and repeater/bridge/router/switch; Resource management and error control; Data security: natural disaster and vandalism.

2110479 Computer Graphics 3(3-0-6)

The fundamentals of computer imagery; modeling ; curve, surface, geometric primitves 2D and 3D geometric transformations, rendering: clipping and windowing, scene, algorithms for visible surface determination, introduction to local and global shading models, color, and real-time rendering methods; presentation of projects in computer graphics engineering.

2110481 Wireless Computer Networks 3(3-0-6)
Condition : Prerequisite 2110478

Digital transmission; queueing theory, mobile IP internetworking, IPv6, DHCP, proxy service.

2110482 High Technology Entrepreneurchip 3(3-0-6)

This is a course focused on the student participating in the building business plan for new venture that create or use a new technology to create significant new value.

2110490 Computer Engineering Pre-Project 1(0-2-1)

Determination of topics or problems; scope, methodologies of problem solving and expected benefit from various areas of computer engineering projects under the supervision of a project advisor; examination of project proposal; periodical writing of progress reports and report presentation.

2110491 Topics in Systems and Languages 3(3-0-6)
Condition : Prerequisite 2110421

Current interest and new developments in the areas of software systems, theory of programming languages and translations.

2110492 Topics in Operations Systems 3(3-0-6)
Condition : Prerequisite 2110411

Topics of current interest and new developments in the areas of operating systems, modeling, performance analysis, utility systems.

2110493 Topic in Database Management 3(3-0-6)
Systems
Condition : Prerequisite 2110422

Topics of current interest and new developments in the areas of database management systems, information systems and data dictionary.

2110495 Advanced Topics in Computer 3(3-0-6)
Engineering I
Condition : Senior Standing or Consent of instructor

Topics of current interest and new developments in various fields of computer engineering.

2110496 Advanced Topics in Computer 3(3-0-6)
Engineering II
Condition : Senior Standing or Consent of instructor

Topics of current interest and new developments in various fields of computer engineering.

2110497 Special Problems in Computer 3(2-3-4)
Engineering I
Condition : Senior Standing or Consent of instructor

A study of investigation of special problems assigned by the instructor with the consent of the head of department. The work must be completed within one semester. A written report, a copy of which is to be kept by the department, is required and an oral examination must be taken.

2110498 Special Problems in Computer
Engineering II 3(2-3-4)
Condition : Senior Standing or Consent of instructor

A study of investigation of special problems assigned by the instructor with the consent of the head of department. The work must be completed within one semester. A written report, a copy of which is to be kept by the department, is required and an oral examination must be taken.

2110499 Computer Engineering Project 3(0-6-3)
Condition : Prerequisite 2110490

Continuing of approved project from course 2110490 must be carried out under project advisor's supervision. Written progress reports must be submitted periodically. A written final report is required and an oral examination must be taken with a department project committee at the end of project.

COURSE DESCRIPTIONS IN COMPUTER ENGINEERING
(M.ENG., M.SC., PH.D.)

2110501 Automata Computability and Formal
Languages 3(3-0-9)

Finite states concepts: regular expressions, closure properties,sequencial machines and finite state transdicers. state minimization; formal grammars: chomsky hierarchy grammars, pushdown acceptors and linear bounded automata, closure properties and algorithms on grammars; computability and Turing machines as acceptor and transducer, universal machine, computable and noncomputable functions, and halting problem.

2110502 Formal Verification 3(3-0-9)

Mathematical logic and temporal logic; formal models: identifying problem domain and building the formal models of concurrent system and/or asynchronous system; verification of the formal models: model checking;

verification modeling language and tools: Petri Nets, signal transition graph, Promela and SPIN.

2110505 Distributed Systems 3(3-0-9)

Definition; interprocess communication; logical clock; concurrency control: two-phase locking, optimistic, timestamp ordering; distributed transaction, atomic commit protocol; deadlock: detection, prevention, avoidance, distributed detection; scheduling; reliability; fault tolerance, replication, recovery; security; distributed services: name, file, distributed management; standards and cases.

2110511 Game Programming 3(3-0-9)
Condition : Consent of Faculty

Theory of game design; graphics programming; computer graphics model; data structure for game programming; online game.

2110512 Computer Animation 3(3-0-9)
Condition : Consent of Faculty

Techniques and algorithms in computer-generated animation; vector algebra; numerical techniques; 2D and 3D animation programming; motion specification : shape interpolation algorithms and models for rule-and constraint-based motion generations.

2110513 Assistive Technology 3(3-0-9)

Background, issues, and research in assistive technology, application of IT in desigeing and developing software application; tools, or programs to the need of disabled or the eldeily to increase their independence and improve their quality of life.

2110521 Software Architectures 3(3-0-9)
Condition : Consent of Faculty

Principles of software architectures; practical methods in software architectures using scenario-based analysis, heuristic, and formal approaches; architectural styles; architectural description language; software architectural analysis and design; software architectures specification tools; software architecture-based testing; use of software architectures in the software development process.

**2110522 UNIX/Linux for Enterprise 3(3-0-9)
Environment**

Historical perspectives; branches and distributions; main characteristitics and components; subsystems and supports; advancements; server: performance considerations, monitoring, and tuning; desktop: distros, usability, and compatibility; administration and installation practices.

2110523 Enterprise Application Architecture 3(3-0-9)

Foundation concepts of enterprise architecture; analysis and design of enterprise application; UML profile speciflcation, design quality metrics; patterns of enterprise application architecture: structure, constraints and limitation of the patterns; enterprise applications integration techniques and implementaion: presentation,

data, application level integration approach and their implementations; best practices and enterprise architecture modelling standards and tools.

2110541 Computer Systems Audit 3(3-0-9)

Design of information system; internal control and auditing of data; validity; reliability; security and protection.

2110579 Computer Graphics Systems 3(3-0-9)

Architectural aspects of modern GPUs, programming on GPU: high level languages for GPU programming, GPU applications for graphics and general purposes : geometry modelling, jphysical simulation scientific computing and games.

2110605 Computer Programs Structure 3(3-0-9)

High-level structured programming languages; data types and operations; control structures; subprograms; records, sets, pointers and dynamic memory allocations; recursive programming; non-numerical problem solving techniques; problem analysis and program design; introduction to software engineering.

**2110606 Research Methods in Computer 3(3-0-9)
Engineering**

Research methods in Computer Engineering; Research techniques and tools; Project and time management; Technical paper writing; Oral presentation; Current research topics.

**2110607 Research Methods in Computer 3(3-0-9)
Science**

Research methods in Computer Science; research techniques and tools in Computer Science; project and time management; academic writing; oral presentation; code of conduct for researchers; current Computer Science research topics.

**2110611 Information Processing and 3(3-0-9)
Computer System**

Introduction to information processing concepts, processing methods, computer development and applications; classification and architecture; data communications and computer networks; computer center management.

2110612 System Programming 3(3-0-9)

Components of a programming system; evolution of operating systems; design of assembler, macro language, macro processor, loader schemes; types of loaders; design of loaders.

**2110614 Programming Languages and 3(3-0-9)
Compilation**

Language structures data, operation, control structures; software-simulated computer; language translation lexical analysis, and parsing, and code generation; other language methodologies list processing, logic programming, object-oriented programming.

2110621 System Analysis and Design 3(3-0-9)
Basic analysis steps, determining system alternatives, determining system economics, defining logical system requirements, basic design tools and objectives; hardware and software: selection and evaluation; design and engineering of software; database development, program development, system implementation, post implementation analysis.

2110622 Data Management 3(3-0-9)
List structures: lists, stacks, queues; table and hash in tree structures: binary search trees, AVL trees, B- trees, heaps; searching and sorting; fundamental of file structures

**2110623 Software Requirements 3(3-0-9)
Engineering**
Methods, tools, notations, and validation techniques for the elicitation, analysis and specification of software requirements; investigating the project or applying approaches to software requirements engineering.

2110624 Software Engineering 3(3-0-9)
Fundamental areas of software engineering: life cycle, paradigms, metrics, and tools; management techniques; cost estimation; software maintenance methodologies; incremental programming; very high level languages.

2110629 File Management 3(3-0-9)
Introduction to data management, files, and applications; an overview of input/output system architecture; logical file organizations; mapping logical organization onto physical storage; operating systems; file system interface; higher level languages; data management facilities.

2110631 Operating System 3(3-0-9)
Evolution, types, goals, functions and organization: concepts of process; process synchronization; process management; memory management; device management; file management;

**2110632 Advanced Topics in Operating 3(3-0-9)
Systems**
Condition: Consent of Faculty
Advanced and current topics in Operating Systems.

**2110634 Software Design and 3(3-0-9)
Development**
Techniques of software design and development: project management, structured programming, verification and validation, security and privacy, and project documentation; students are required to apply these techniques to large software projects.

**2110636 Performance Analysis and 3(3-0-9)
Evaluation**
Performance metrics; performance measurements; benchmarking; workload characterization; summarizing measured data; introduction to queuing theory; single queue analysis; introduction to simulation; analysis of simulation results.

2110637 Large-Scale Information Systems 3(3-0-9)
System framework; middleware; service-oriented architecture; large-scale services; scalable data services; cloud computing; cluster architecture and system; management distributed algorithms; map-reduce architecture; volunteer computing.

2110638 Object-Oriented Technology 3(3-0-9)
Object orientation concepts and software development; object-oriented programming language implementation; software development frameworks; design patterns; design heuristics; design flaws; aspect-oriented programming; case studies; current topics in object-oriented technology.

2110639 Computer System Security 3(3-0-9)
Security system planning and administration; access control; data encryption; computer crime protection; disaster recovery planning; security models; including Orange book, and RACF

2110640 Information Security 3(3-0-9)
Information security models: confidentiality; integrity; authentication software security; network security; privacy; security management security; related laws and regulations.

**2110642 Object-Oriented Software 3(3-0-9)
Engineering**
An overview of object-oriented technology concepts on objects, classes, inheritance, polymorphism, and relationship between classes; software development process, software configuration management, software quality assurance, object-oriented project planning and management, object-oriented analysis and design methodologies, object-oriented programming and object-oriented software testing and maintenance, use of CASE tools.

2110644 Formal Software Specification 3(3-0-9)
Mathematical Logic: Set, Relation, Function, Predicate Calculus, Algebraic system; Formal software specification language: Z, CafeOBJ; Identifying problem domain; Design and software modeling; Formal software specification method; Consistency verification of formal specification and its proof; Utilization of formal software specification in software process.

**2110645 Software Engineering 3(3-0-9)
Methodology**
Software engineering process concepts; context for personal software process; planning and measurement concepts; software size measurement; general size estimating methods; resource and schedule estimation; process measurement; design and code reviews; software quality management.

2110646　User Interface Design　3(3-0-9)
Foundations of user-interface; human-centered software evaluation; software development; graphic user-interface design; graphic user-interface programming; multimedia systems.

2110651　Digital Image Processing　3(3-0-9)
Visual perception, digitization and coding of images, converting pictures to discrete(digital) forms; image enhancement; image restoration including improving degraded low-contrast, blurred, or noisy pictures; image compression : data compression used in image processing; image segmentation referred to as first step in image analysis.

2110654　Artificial Intelligence　3(3-0-9)
Definitions and application of artificial intelligence; knowledge representation; Prolog programming; natural language processing; machine learning techniques.

2110657　Computer Simulation　3(3-0-9)
Monte Carlo simulation; discrete event simulation and implementation techniques, queueing theory; equilibrium and steady state; input/output analysis; random numbers; output measurement; simulation accuracy; trace and execution-driven simulation; computer system simulation; continuous system simulation; combining continuous and discrete-event simulation

2110661　Computer Network　3(3-0-9)
Introduction to network and network components; transmission links and protocols; design and analysis of networks; WAN; IMP; topology; network protocols; flow control and routing techniques.

2110662　Communication and Computer　3(3-0-9)
**　　　　　Network**
Network components; transmission links and protocols; design and analysis of networks; WAN; IMP; topology; network protocols; flow control and routing techniques.

2110663　Worldwide Network Infrastructure　3(3-0-9)
Background and history of networks and the internet; principles of network applications, protocols, services, socket programming; client/server and peer-to-peer paradigms; reliable data transfer; congestion control; the Internet Protocol (IP); routing in the internet; multimedia networking; wireless and mobile networks; large-scale and global networks; next generation networks.

2110664　Network Management　3(3-0-9)
Condition: Consent of Faculty
Information systems environment, business, and networks; network management data integrity, data security, network availability, network service, network adaptability.

2110665　Computer Communication　3(3-0-9)
**　　　　　System and Standards**

Introduction to computer and communication systems: on-line system, computer networks, distributed processing; communication model: OSI Standard; networks and standards: ISDN, X.25.

2110671　Database Management　3(3-0-9)
**　　　　　Systems**
Definition, objectives, and basic concepts information storage and retrieval system; data management system; data management functions and components of database management system: database interrogation, update; data model; security policy; major trade-offs in database management; introduction to object oriented database.

2110672　Data Modeling Techniques　3(3-0-9)
Data modelling concepts; conceptual objects used on simple and complex abstraction level: entity and entity set, entity attributes, relationship and relationship sets, relationship attributes, domain; normalization of relation: INF, 2NF,3NF,4NF and 5NF; conceptual data modeling: entity-relationship,data folw,logical and physical model, transformation of theological modle into a physical model,and functional design; object-oriented design concept.

2110673　Information Storage and　3(3-0-9)
**　　　　　Retrieval**
Models and methods for storage and retrieval of information; Topics include information retrieval techniques, text analysis and automatic indexing, document clustering, search techniques, retrieval performance measurement, and search mechanisms for retrieval from the World Wide Web.

2110674　Information Technology Center　3(3-0-9)
**　　　　　Management**
Organization of the Information-Technology Center, computer personnel; nature of the users; software development tools; computer site operation; personnel management; systems software tuning; hardware evaluation; problems facing the director of the center.

2110678　Mobile Computing　3(3-0-9)
Principles, technologies and applications of mobile computing and wireless networks; mobile and wireless environment; protocols and architecture of mobile computing; mobile device technology; mobile computing security; application of distributed system in mobile computing; mobile middleware; mobile information and database access; mobile computing platforms; Web-based mobile application development.

2110681　Computer Algorithm　3(3-0-9)
Analysis and design of efficient algorithms; divide and conquer, recursion, dynamic programming and greedy algorithm; selection of appropriate data abstraction; analysis and correctness of algorithms; algebraic algorithms; combination problems; proving techniques for complexity analysis.

**2110682　Embedded and Real-time　3(3-0-9)
　　　　　Systems**

Microcontroller architecture (RAM, ROM, CPU), I/O, and peripheral devices, I/O interfacing, real-time operating systems, real-time constraints, scheduling theory, real-time system design methodology, case studies.

2110683　Concurrent Processing　3(3-0-9)

Principles of distributed, parallel and concurrent systems, parallel architecture and concurrent computing models; concepts of networks protocols for concurrent processing, operating systems and hardware support for distribution of codes, concurrent processing, parallel processing and networking.

2110684　Information System Architecture　3(3-0-9)

Hardware systems: personal computers, network equipment, servers, clusters and super servers, embedded system; application systems: multi-tier systems, markup language, query language; transaction systems: process abstraction, inter-process communication, synchronization, deadlock, transactions, concurrency control; Web-based applications; global systems.

2110685　Computer Application in Enterprises　3(3-0-9)

Business transaction; processes and organisation; information and business decision; human resources and knowledge management; data warehousing.

2110686　Enterprise Computing　3(3-0-9)

IT infrastructure; management; stabillity, efficiency and responsiveness; theoretical and practical aspects of systems management; discipline in data centres; development, integration, and management of IT processes; business-support functions; enterprise services; information systems services.

**2110694　Directed　Studies in Computer　3(3-0-9)
　　　　　Science**

Study of current interest and new developments in various fields of computer science.

**2110696　Advanced Topics in Computer　3(3-0-9)
　　　　　Application**

Current advanced topics and technologies in computer applications.

**2110697　Special Topics in Computer　3(3-0-9)
　　　　　Science I**

Current special topics and new technologies in computer science.

**2110698　Special Topics in Computer　3(3-0-9)
　　　　　Science II**

Current special topics and new technologies in computer science.

**2110701　Seminar in Computer　1(0-3-1)
　　　　　Engineering I**

Seminar in Computer Engineering about the thesis and assignments.

**2110702　Seminar in Computer　1(0-3-1)
　　　　　Engineering II**

Seminar in Computer Engineering about the thesis and assignments.

2110711　Theory of Computation　3(3-0-9)

Computable functions decidable predicates and solvable problems; computational complexity; NP-complete problems; automata theory; formal language; lambda calculus.

2110712　Analysis of Algorithms　3(3-0-9)

Algorithm complexity and problem complexity; discrete mathematics real analysis, and combinatorics; algorithms and data structures; average-case worst-case and amortized analysis.

2110713　Optimization Methods　3(3-0-9)

Dynamic optimization; mathematical programming; least square methods; gradient methods; Newton's method; linear programming; nonlinear programming; discrete optimizations.

2110714　Digital Systems　3(3-0-9)

Digital system architecture; logic elements, processor, compilers, operating systems; digital abstraction, synthesis of digital systems; performance measures; interpretation; micro architecture; memory architecture; processes; multiplexing; synchronization; interrupts; real time systems.

2110716　Seminar I　1(1-0-3)

Seminar in the assigned topics on current experiment and / or research on computer engineering.

2110717　Seminar II　1(1-0-3)

Seminar on current experiment and / or research on computer engineering concerning theses.

2110718　Seminar III　1(1-0-3)

Seminar on current experiment and / or research on computer engineering concerning theses.

2110719　Seminar IV　1(1-0-3)

Seminar on current experiment and / or research on computer engineering concerning theses.

2110721　Software Metrics　3(3-0-9)

Theoretical foundations of software metrics; data collection; experimental design and analysis; software metric validation; measuring the software development and maintenance process; measuring software systems; support for metrics; statistical tools; applications of software measurement.

2110722　Software Project Management　3(3-0-9)

Concepts of software product and process quality; roles of Total Quality Management (TQM); use of metrics, feasibility studies; cost and effort estimates; discussion of project planning and scheduling; the Capability Maturity Model; basis tenets and application of process validation.

**2110723   Advanced Software Engineering   3(3-0-9)
Development**

Software development process improvement; a series of individual programming and process projects; project planning measurement size estimation task scheduling and defect clarification.

**2110724   Software Testing and Quality   3(3-0-9)
Assurance**

Technical and management views of software testing and SQA; quality concepts; black and white box testing techniques; test coverage; levels of testing; the formation of a testing organization; testing-in-the-large; documentation for testing; inspections and walkthroughs.

**2110725   Software Engineering Process and   3(3-0-9)
Improvement**
Condition : Consent of Faculty

Process definition; software engineering process model; process implementation and change; process quality assessment; process and product measurement; software engineering process standards such as IEEE and ISO Standards.

**2110726   Software Configuration   3(3-0-9)
Management**
Condition : Consent of Faculty

Software configuration management (SCM) process; SCM planning; configuration management plan; SCM measures; software configuration identification; software change request process; software configuration status reporting; software configuration auditing; software release management and delivery.

**2110727   Software Evolution and   3(3-0-9)
Maintenance**
Condition : Consent of Faculty

Basic knowledge on software evolution; software comprehension and software maintenance; definition of software evolution and maintenance; laws of software evolution; maintenance categories; maintenance process and process models; maintenance metrics and testing; impact analysis; software rejuvenation; software maintainability.

**2110728   Special Topics in Software   3(3-0-9)
Engineering I**
Condition : Consent of Faculty

Current advanced topics and new technologies in software engineering.

**2110729   Special Topics in Software   3(3-0-9)
Engineering II**
Condition : Consent of Faculty

Current advanced topics and new technologies in software engineering.

**2110730   Software Quality and Process   3(3-0-9)
Management**

Software quality basics; quality tools; software life cycle processes and process assets entablishment; process management premise; process improvement models; improvement paradigms; quality management in process im provement context; conflguration management; measurement information model.

2110731   Distributed Systems   3(3-0-9)

Characterization and models of distributed systems; remote communication between system components; distributed applications; transactional applications; concurrency control of transactions; coordination between system components: global system state, time synchronization, access to shared resources, ordering of exchanged messages, agreement; fault tolerance; data replication; system recovery;current distributed systems and related issues;current research topics.

2110732   Parallel Computing   3(3-0-9)

Architectures in parallel computing : shared/distributed memory, SIMD/MIMD architecture, interconnection networks, granularity of the machines, dataflow and systolic arrays computers; parallel processing : pipelining and parallelism, software for parallel computers.

2110741   Robotics   3(3-0-9)

A broad view of robotics : robot control, sensors and interfacing, robot intelligence and programming; a broad spectrum of disciplines : mechanical, electrical, industrial, and computer engineering; current topics : planning, subsumption architecture, reactive systems.

2110742   Evolutionary Computation   3(3-0-9)

Computer algorithms gleaned from the model of biology; algorithms inspired by organic evolution : genetic algorithms, classifier systems, genetic programming and evolution strategies; theoretical basis of these algorithms.

2110743   Machine Learning   3(3-0-9)

Computing with logic; using logic set theory, number theory, algebras graph theory, automata; language of first order logic, model theory and logic programming; problems of inductive inference in the framework of first-order predicate calculus and the probability calculus; introduction of computational learning theory.

2110744   Machine Vision   3(3-0-9)

Low-level vision and higher-level techniques : binary machine vision, morphology, neighborhood operators, labeling, texture, region segmentation, feature extraction, motion, image matching, model matching and knowledge-based vision systems.

2110745   Cryptography   3(3-0-9)

Introduction; symmetric encryption; block ciphers; pseudorandom permutations and pseudorandom

functions; one-way functions; pseudorandom generators; hash functions; message authentication; authenticated encryption; asymmetric encryption; digital signatures; authenticated key exchange; interactive proofs and zero knowledge.

2110746   Big Data Analytics   3(3-0-9)

Introduction to Big Data Analytics, Hadoop, MapReduce, Spark, Programming Languages for Big Data Analytics, Search and Indexing, Recommendation System, Regression, Classification, Clustering and Feature Selection.

2110747   Social Network Analysis   3(3-0-9)

Social networks definition; types of social networks; Social Network Represintation by Computational Models; Random Network Models; Network Centrality; Clusters in Social Networks; Small World Models; Data Retrieval from Social Networks Data Analysis and Classification from Social Networks; Application examples, such as an analysis for enterprises.

**2110751   Computer Aided Design in Digital   3(3-0-9)
            Systems**

Layout editing; schematic datacapture; simulation; design rule checking; automatic placement and routing; logic synthesis for combination and sequential circuits; logic synthesis for architectural design; formal method for specifications.

2110752   Design for Testability   3(3-0-9)

Methods of design for testability; digital chip design for automatic testing equipment; ad hoc rules and structured method called scan design; fault analysis; controllability; observability; Scan-In Scan-Out (SISO) principle; Level Sensitive Scan Design (LSSD); built-in testing and other current techniques.

2110753   Asynchronous Design   3(3-0-9)

Design of digital systems not using global clock; limitation to synchronous processor; hazard analysis; Fundamental of asynchronous logic design; delay assumption; signaling protocol; asynchronous communication; Petri net; signal transition graph; completion detection; data and control paths implementations.

2110771   Advanced Database Design   3(3-0-9)

Fundamental of database design : data modeling, relational theory, query language, dependency theory; query optimization, computing with logic and universal relation.

2110772   Multi-Dimensional Database Systems 3(3-0-9)

Modern multi-dimensional database systems : spatial databases, temporal databases, multimedia databases; algorithms and data structures : R-tree, R+ tree, R* tree, quad-tree, spatial and temporal reasoning, disk clustering and declustering.

2110773   Data Mining   3(3-0-9)

Overview of data mining; process of knowledge discovery in large databases; applications of data mining to real-world problems; data preprocessing; data warehousing and OLAP; data mining methods: association, classification, clustering.

**2110779   Advanced Topics in Computer   3(3-0-9)
            Graphics**

In-depth study of selected current and interesting topics in computer graphics; hardware architecture, graphics systems, picture/image generation, graphics utilities, computational geometry and object modeling, methodoiogy and techniques, three-dimensional graphics and realism and current applications.

**2110781   Special Topics in Distributed 3(3-0-9)
            Systems**

Current topics, related researches, and technology trends in distributed systems.

**2110791   Advanced Topics in Software   3(3-0-9)
            Engineering**

State of the art and current interest in software engineering.

**2110792   Advanced Topics in Artificial 3(3-0-9)
            Intelligence**

In-depth study of the current and interesting topics in artificial intelligence : problem solving, search, heuristic methods, machine learning, knowledge representation, natural language processing, computer vision, expert systems, theorem proving and current applications.

**2110793   Advanced Topics in Digital   3(3-0-9)
            Systems**

State of the art and current interest in digital systems.

**2110794   Advanced Topics in Database   3(3-0-9)
            Systems**

State of the art and current interest in database systems.

**2110795   Advanced Topics in Computer   3(3-0-9)
            Network**

State of the art and current interest in computer network.

**2110797   Per-Master Project in Software 3(0-0-12)
            Engineering**

Condition : Consent of Faculty

Integration of software engineering principles to prepare for software engineering project to get the output which in the project proposal.

**2110798   Per-Master Project in Software 3(0-0-12)
            Engineering**

Condition : Prerequisite 2110797

Integration of software engineering principles for software engineering project.

2110799	Master Project	6(0-0-24)
2110811	Thesis	12 Credits
2110814	Thesis	24 Credits
2110816	Thesis	36 Credits
2110828	Dissertation	48 Credits
2110894	Doctoral Dissertation Seminar	0(0-0-0)
2110896	Comprehensive Exarnination	0(0-0-0)
2110897	Qualifying Examination	0(0-0-0)

COURSES OFFERED TO STUDENTS OUTSIDE FACULTY OF ENGINEERING ONLY :

2110172 Information Technology 3(2-2-5)
Application software packages: word processing, spreadsheet, presentation and database software; utility software; basic computer system management: backup and restore, software installation and uninstallation.

2110182 Introduction to computer and data 2(2-0-4) Processing
An overview of computer components, hardware and software interaction: basic data processing concepts, data transformation, method of data processing, data communication and programming concepts.

2110183 Introduction to Computer and 3(3-0-6) Programming
An overview of computer components, hardware and software interaction, EDP concepts: programming concepts and introduction to FORTRAN programming.

2110206 Assembly Language 3(2-2-4) Programming
This course will emphasized hand-on experience with Assembly language programming, loader, assembler and I/O devices.

2110281 Basic Programming 2(1-2-3)
Overview of elements of Basic Language, including BASIC statements: arithmetic, input and output, flow of control, subprogram; file processing; sequential access, and random access; application programs in various fields.

DEPARTMENT OF NUCLEAR ENGINEERING

The Department of Nuclear Engineering (formerly Department of Nuclear Technology) was established in 1972 with the main purpose of training the students with the career in nuclear energy. The department offers programs leading to degrees in Doctor of Engineering (D.Eng.) in Nuclear Engineering, Master of Engineering (M.Eng.), Master of Science (M.Sc.) in Nuclear Technology and Bachelor of Engineering in Nuclear and Radiological Engineering. The curricula are multidisciplinary and are structured to cover the diversified principles of nuclear technology and nuclear engineering, ranging from the fundamental science and mathematics to the specialized engineering applications. The areas of specialization include the nuclear power engineering, the environmental and the industrial applications of radiation and nuclear technology, the nuclear instrumentation, the radioisotope production, the radiation processing, the radiation protection and the nuclear materials. The graduates from the programs find work in the government institutions such as the Office of Atoms for Peace (OAP) and Thailand Institute of Nuclear Technology (TINT), in the public and private universities, in other state or public organizations such as the Electricity Generating Authority of Thailand (EGAT), the Department of Medical Science and in various industrial and medical sectors.

At present, the use of nuclear energy in industry is increasing. Thus, there is a need for the personnel in this specialized field involving the safety control and the research & development leading to the proper, efficient and safely use of the radioisotopes. This includes the development of the techniques and the instruments for in-house usage. Furthermore, the preparation of the personnel with the solid background in nuclear engineering is also crucial to the future decision regarding the implementation of the nuclear energy in generating the electricity, if this option is considered necessary.

HEAD :

Phongphaeth Pengvanich, Ph.D.(Michigan)

ASSOCIATE PROFESSORS :

Somyot Srisatit, M.Eng.(Chula)
Sunchai Nilsuwankosit, Ph.D.(Wisconsin)
Doonyapong Wongsawaeng, Ph.D.(Berkeley)

ASSISTANT PROFESSORS :

Phongphaeth Pengvanich, Ph.D.(Michigan)
Somboon Rassame, Ph.D.(Purdue)

LECTURERS :

Decho Thong-Aram, M.Eng.(Chula)
Chadet Yenchai, M.Sc.(Chula)
Phannee Saengkaew Ph.D.(Magdeburg)
Rawiwan Kritsananuwat Ph.D.(Tokyo Metropolitan)

NAME OF THE DEGREE

: Doctor of Philosophy
: Ph.D.

ADMISSION

The applicant must submit an application under one of the following Admission Types.

Type 1.1: Ph.D. with Nuclear Background

The applicant must have a Master Degree in Nuclear Engineering or Nuclear Technology; meet the requirements of the Graduate School; have a minimum grade point average of 3.50 (out of 4); and have at least one good-quality international publication (conference or journal).

Type 1.2: Master continuing to Ph.D. with Nuclear Background

The applicant must have a Bachelor Degree in Nuclear Engineering from Chulalongkorn University; meet the requirements of the Graduate School; obtain at least an honor-level grade; and have at least one international publication (conference or journal).

Type 2.1: Ph.D. with Non-Nuclear Background

The applicant must have a Master Degree in Science or Engineering (non-nuclear); meet the requirements of the Graduate School; and have a minimum grade point average of 3.50.

Type 2.2: Master continuing to Ph.D. with Non-Nuclear Background

The applicant must have a Master Degree in Engineering (non-nuclear) from Chulalongkorn University; meet the requirements of the Graduate School; and obtain at least an honor-level grade.

FIELDS OF STUDY

The student must concentrate on one of the following fields of study:
● Nuclear Engineering
● Nuclear Security and Safeguards

DEGREE REQUIREMENTS

The student entering under
● Admission Type 1.1 must pass 49 credits of dissertation course;
● Admission Type 1.2 must pass 74 credits of dissertation course;
● Admission Type 2.1 must pass 13 credits of the specific required courses (see COURSE REQUIREMENTS) and pass 36 credits of dissertation course;
● Admission Type 2.2 must pass 13 credits of the specific required courses (see COURSE REQUIREMENTS), pass 9 credits of the specific elective courses, pass 3 credits of the general elective courses, and pass 49 credits of dissertation course.

Every student must also
● pass total of 6 credits of the general required courses (see COURSE REQUIREMENTS);
● pass a qualification examination;
● present an acceptable dissertation and pass an oral examination; publish at least 1 research paper related to the dissertation work in an international research journal;
● present the dissertation work in a national or international symposium; and meet publication requirements of the Graduate School.

COURSE REQUIREMENTS

Courses are divided into prerequisite, general required, specific required, general elective, specific elective, and thesis courses. Course requirements may vary depending on the field of study and the study plan.

0) Prerequisite Courses

Student with insufficient background knowledge of mathematics and/or nuclear engineering must take

2111600	Nuclear Engineering I *	3(3-0-9)
2111631	Applied Mathematics in Nuclear Technology *	3(3-0-9)

*Non-credit course, the student is given S/U (Satisfactory/Unsatisfactory) instead of the letter grade.

Student with Admission Type 1.1 or 1.2 with insufficient practical knowledge of nuclear/radiation experiments must take one of the following courses

2111603	Radiation Detection and Measurements Laboratory *	1(0-3-7)
2111604	Radiation Detectors and Nuclear Instruments Laboratory *	1(0-3-7)
2111659	Methods and Instrumentation for Nuclear Security and Safeguards Laboratory *	1(0-3-7)

*Non-credit course, the student is given S/U (Satisfactory/Unsatisfactory) instead of the letter grade. Student may be exempted from taking the course upon receiving the approval from the Programme Board. A proof of priori knowledge on the subject is required.

1) General Required Courses:

All of the following courses are required for all Admission Types (1.1, 1.2, 2.1, and 2.2) for the total of 6 credits.

2111801	Seminar in Nuclear Engineering I *	2(2-0-6)
2111802	Seminar in Nuclear Engineering II *	2(2-0-6)
2111803	Seminar in Nuclear Engineering III*	2(2-0-6)

*Non-credit course, the student is given S/U (Satisfactory/Unsatisfactory) instead of the letter grade.

2) Specific Required Courses:

The following courses are required for Admission Types 2.1 and 2.2 for the total of 13 credits.

2.1) *Nuclear Engineering Field of Study: All of the following courses are required for the total of 13 credits.*

2111604	Radiation Detectors and Nuclear Instruments Laboratory	1(0-3-7)
2111613	Radiation Safety and Shielding	3(3-0-9)
2111642	Nuclear Reactor Engineering	3(3-0-9)
2111643	Nuclear Power Engineering	3(3-0-9)
2111663	Radiation Detectors and Nuclear Instruments	3(3-0-9)

2.2) *Nuclear Security and Safeguards Field of Study: All of the following courses are required for the total of 13 credits.*

2111610	Nuclear Security	3(3-0-9)
2111651	Weapon Mass Destruction Nonproliferation	3(3-0-9)
2111658	Methods and Instrumentation for Nuclear Security and Safeguards	3(3-0-9)

2111659	Methods and Instrumentation for Nuclear Security and Safeguards Laboratory	1(0-3-7)

One of the following courses must also be selected.

2111642	Nuclear Reactor Engineering	3(3-0-9)
2111643	Nuclear Power Engineering	3(3-0-9)

3) Specific Elective Courses minimum 12 credits

3.1) *Nuclear Engineering Field of Study: Choose from the following courses; minimum of 9 credits are required.*

2111603	Radiation Detection and Measurements Laboratory	1(0-3-7)
2111607	Environmental Radiation Measurements	3(3-0-9)
2111608	Practical Radiation Detection and Measurements	3(3-0-9)
2111609	Radiation Dosimetry	3(3-0-9)
2111616	Environmental Impact of Nuclear Power Plant	3(3-0-9)
2111621	Radiation Chemistry and Processing	3(3-0-9)
2111626	Industrial Radiation and Radioisotope Applications	3(2-3-7)
2111627	Material Analysis by Nuclear Techniques	3(3-0-9)
2111628	Radioisotope Production and Utilization	3(3-0-9)
2111629	Nuclear Chemical Engineering	3(3-0-9)
2111632	Numerical Calculation for Nuclear Engineering	3(3-0-9)
2111640	Nuclear Reactor Control	3(3-0-9)
2111646	Radioactive Waste Management	3(3-0-9)
2111647	Nuclear Fuels and Nuclear Fuel Cycles	3(3-0-9)
2111648	Nuclear Power Plant Systems and Operation	3(2-3-7)
2111650	Introduction to Plasma Physics and Nuclear Fusion	3(3-0-9)
2111655	Computer Application in Nuclear Technology	3(3-0-9)
2111660	Industrial Radiation Imaging	3(3-0-9)
2111661	Experimental Nuclear Engineering	3(2-3-7)
2111662	Nuclear Electronics	3(3-0-9)
2111664	Digital Computer Interfacing for Nuclear Instrument	3(3-0-9)
2111666	Radiation Machines	3(3-0-9)
2111678	Nuclear Materials Engineering	3(3-0-9)
2111683	Current Topics in Nuclear Engineering	3(3-0-9)
2111687	Special Topics in Nuclear Engineering	3(3-0-9)

3.2) *Nuclear Security and Safeguards Field of Study: Choose from the following courses; minimum of 9 credits are required.*

2111652	Strategic Trade Control	3(3-0-9)
2111653	Nuclear Safeguards	3(3-0-9)
2111654	Nuclear Fuel Cycle and	3(3-0-9)

Environmental Impacts

| 2111656 | Physical Protection of Nuclear Materials and Facilities I | 3(3-0-9) |
| 2111657 | Advanced Detection Technologies for Radioactive and Nuclear Materials | 3(3-0-9) |

4) General Elective Course

Both fields of study: Student must take 3 credits of the courses available in the Master of Engineering in Nuclear Engineering Program.

5) Dissertation

Number of required credits depends on student's admission type.

For Admission Types 1. 1 and 2.2 : 49 credits of the following courses

2111829 Dissertation

> (Student may register for this course multiple times. The number of credits for each registration depends upon the agreement between the student and his/her thesis advisor.)

For Admission Type 2.1 : 36 credits of the following course

2111826 Dissertation

> (Student may register for this course multiple times. The number of credits for each registration depends upon the agreement between the student and his/her thesis advisor.)

For Admission Type 1.2: 74 credits of the following courses

2111830 Dissertation

> (Student may register for this course multiple times. The number of credits for each registration depends upon the agreement between the student and his/her thesis advisor.)

NAME OF THE DEGREE

: Master of Engineering
: M.Eng.

ADMISSION

The applicant must have a Bachelor Degree in engineering or a Bachelor Degree in an equivalent/related field, must meet the requirements of the Graduate School and also must pass the entrance examination administered by the department.

DEGREE REQUIREMENTS

A student must pass a minimum of 15 credits of the required courses and another 12 credits from elective courses, a total of 27 credits.

A student must present an acceptable thesis and pass an oral examination in the field of Nuclear Technology for a quantity of 12 credits.

A student who has fulfilled the requirements of the program with a passing grade not less than 3.00 within a period of study of no less than 4 regular semesters and no more than 8 regular semesters will be awarded the Degree of Master of Engineering in Nuclear Technology.

FIELDS OF STUDY

The student must concentrate on one of the following fields of study:
● Nuclear Engineering
● Nuclear Security and Safeguards

STUDY PLAN
In each field of study, two study plans are possible:
A-1 Full thesis plan
A-2 Coursework and thesis plan

DEGREE REQUIREMENTS

For A-1 plan, the student must

● pass 2 credits of the required courses (see COURSE REQUIREMENTS);
● pass a minimum of 37 credits of the thesis course;
● present an acceptable thesis and pass an oral examination;
● meet the publication requirements of the Graduate School; and
● obtain "Satisfactory (S)" grade in all courses within the allowed period of study (no less than 4 and no more than 8 regular semesters).

For A-2 plan, the student must

● pass a minimum of 27 credits of the required and the elective courses (see COURSE REQUIREMENTS);
● pass the total of 12 credits of the thesis course;
● present an acceptable thesis and pass an oral examination;
● meet the publication requirements of the Graduate School; and
● obtain a passing grade point average (GPA) of no less than 3.00 within the allowed period of study (no less than 4 and no more than 8 regular semesters).

COURSE REQUIREMENTS

Courses are divided into prerequisite, general required, specific required, general elective, specific elective, and thesis courses. Course requirements may vary depending on the field of study and the study plan.

A-1 Plan

0) Prerequisite Courses

Student with insufficient background knowledge of nuclear engineering must take

2111600   Nuclear Engineering I *   3(3-0-9)

*Non-credit course, the student is given S/U (Satisfactory/Unsatisfactory) instead of the letter grade.

Student may be exempted from taking the course upon receiving the approval from the Programme Board. A proof of priori knowledge on the subject is required.

1) General Required Courses

Both fields of study: The following courses are required for the total of 2 credits.

2111701   Seminar in Nuclear Technology I *   1(1-0-3)
2111702   Seminar in Nuclear Technology II *   1(1-0-3)

2) Thesis Course

Both fields of study: 37 credits of the following course are required.

2111812 Thesis
(Student may register for this course multiple times. The number of credits for each registration depends upon the agreement between the student and his/her thesis advisor. S(atisfactory)/U(nsatisfactory) is given instead of letter grades.)

A-2 Plan

0) Prerequisite Courses

Student with insufficient background knowledge of nuclear engineering must take

2111600   Nuclear Engineering I *   3(3-0-9)
*Non-credit course, the student is given S/U (Satisfactory/Unsatisfactory) instead of the letter grade.

Student may be exempted from taking the course upon receiving the approval from the Programme Board. A proof of priori knowledge on the subject is required.

1) General Required Courses

Both fields of study: The following courses are required for the total of 2 credits.

| 2111701 | Seminar in Nuclear Technology I | 1(1-0-3) |
| 2111702 | Seminar in Nuclear Technology II | 1(1-0-3) |

2) Specific Required Courses

2.1) *Nuclear Engineering Field of Study: All of the following courses are required for the total of 13 credits.*

2111604	Radiation Detectors and Nuclear Instruments Laboratory	1(0-3-7)
2111613	Radiation Safety and Shielding	3(3-0-9)
2111642	Nuclear Reactor Engineering	3(3-0-9)
2111643	Nuclear Power Engineering	3(3-0-9)
2111663	Radiation Detectors and Nuclear Instruments	3(3-0-9)

2.2) *Nuclear Security and Safeguards Field of Study: All of the following courses are required for the total of 13 credits.*

2111610	Nuclear Security	3(3-0-9)
2111651	Weapon Mass Destruction Nonproliferation	3(3-0-9)
2111658	Methods and Instrumentation for Nuclear Security and Safeguards	3(3-0-9)
2111659	Methods and Instrumentation for Nuclear Security and Safeguards Laboratory	1(0-3-7)

ONE of the following courses must also be selected

| 2111642 | Nuclear Reactor Engineering | 3(3-0-9) |
| 2111643 | Nuclear Power Engineering | 3(3-0-9) |

3) Specific Elective Courses minimum 12 credits

3.1) *Nuclear Engineering Field of Study : Choose from the following courses; minimum of 9 credits are required.*

| 2111603 | Radiation Detection and | 1(0-3-7) |

	Measurements Laboratory	
2111607	Environmental Radiation Measurements	3(3-0-9)
2111608	Practical Radiation Detection and Measurements	3(3-0-9)
2111609	Radiation Dosimetry	3(3-0-9)
2111616	Environmental Impact of Nuclear Power Plant	3(3-0-9)
2111621	Radiation Chemistry and Processing	3(3-0-9)
2111626	Industrial Radiation and Radioisotope Applications	3(2-3-7)
2111627	Material Analysis by Nuclear Techniques	3(3-0-9)
2111628	Radioisotope Production and Utilization	3(3-0-9)
2111629	Nuclear Chemical Engineering	3(3-0-9)
2111632	Numerical calculation for Nuclear Engineering	3(3-0-9)
2111640	Nuclear Reactor Control	3(3-0-9)
2111646	Radioactive Waste Management	3(3-0-9)
2111647	Nuclear Fuels and Nuclear Fuel Cycles	3(3-0-9)
2111648	Nuclear Power Plant Systems and Operation	3(2-3-7)
2111650	Introduction to Plasma Physics and Nuclear Fusion	3(3-0-9)
2111655	Computer Application in Nuclear Technology	3(3-0-9)
2111660	Industrial Radiation Imaging	3(3-0-9)
2111661	Experimental Nuclear Engineering	3(2-3-7)
2111662	Nuclear Electronics	3(3-0-9)
2111664	Digital Computer Interfacing for Nuclear Instrument	3(3-0-9)
2111666	Radiation Machines	3(3-0-9)
2111678	Nuclear Materials Engineering	3(3-0-9)
2111683	Current Topics in Nuclear Engineering	3(3-0-9)
2111687	Special Topics in Nuclear Engineering	3(3-0-9)

3.2) *Nuclear Security and Safeguards Field of Study: Choose from the following courses; minimum of 9 credits are required.*

2111652	Strategic Trade Control	3(3-0-9)
2111653	Nuclear Safeguards	3(3-0-9)
2111654	Nuclear Fuel Cycle and Environmental Impacts	3(3-0-9)
2111656	Physical Protection of Nuclear Materials and Facilities I	3(3-0-9)
2111657	Advanced Detection Technologies for Radioactive and Nuclear Materials	3(3-0-9)

4) General Elective Course

Both fields of study: Student must take 3 credits of the courses available in the Master of Engineering in Nuclear Engineering Program.

5) Thesis

For A1 plan
2111811 Thesis   12 credits
For A2 plan
2111817 Thesis   37 credits

NAME OF DEGREE

2111601* Introduction to Nuclear science and   3(3-0-9)
          Technology
2111631* Applied Mathematics in Nuclear   3(3-0-9)
          Technology

*Non-credit course, the student is given S/U
(Satisfactory/Unsatisfactory) instead of the letter grade.

Student may be exempted from taking the course upon
receiving the approval from the Programme Board. A proof
of priori knowledge on the subject is required.

1) General Required Courses

Both fields of study: The following courses are required for
the total of 2 credits.

 2111701 Seminar in Nuclear Technology I   1(1-0-3)
 2111702 Seminar in Nuclear Technology II   1(1-0-3)

2) Specific Required Courses

2.1) *Nuclear Technology Field of Study: All of the following
     courses are required for the total of 10 credits*

2111603 Radiation Detection and   1(0-3-7)
          Measurement Laboratory
2111608 Practical Radiation Detection and   3(3-0-9)
          Measurement
2111612 Radiation Protection   3(3-0-9)
2111684 Current Topics in Nuclear   3(3-0-9)
          Technology

2.2) *Nuclear Security and Safeguards Field of Study : All of
     the following courses are required for the total of 10
     credits.*

2111610 Nuclear Security   3(3-0-9)
2111651 Weapon Mass Destruction   3(3-0-9)
          Nonproliferation
2111658 Methods and Instrumentation for   3(3-0-9)
          Nuclear Security and Safeguards
2111659 Methods and Instrumentation for   1(0-3-7)
          Nuclear Security and Safeguards
          Laboratory

3) Specific Elective Courses minimum 9 credits

3.1) *Nuclear Technology Field of Study: Choose from the
     following courses; minimum of 9 credits are required.*

2111604 Radiation Detectors and Nuclear   1(0-3-7)
          Instruments Laboratory
2111607 Environmental Radiation   3(3-0-9)
          Measurements
2111609 Radiation Dosimetry   3(3-0-9)
    : Master of Science
    : M.Sc.

ADMISSION

The degree of Master of Science in Nuclear
Technology is offered under the general regulations of the
Graduate School. The program is intended to those
students who plan a career of research related to nuclear
technology. The courses cover basic nuclear science &
technology, radiation protection, radiation measurement,
application of radiation and radioisotope, nuclear
materials and radiation chemistry & processing. From
November 2013, the program also includes courses related
to nuclear security and safeguards.

To be eligible for admission to the program an
applicant must hold a Bachelor degree in science, applied
science, technology or engineering. Applicants are
required to take the entrance examination administered by
the department.

DEGREE REQUIREMENTS

The program consists of 27 credits of courses, 12
credits of required courses and 15 credits of electives. To
graduate a, student must present an acceptable thesis and
pass an oral examination for a quantity of 12 credits.

A student who has fulfilled the requirements of the
program with the cumulative GPA of not less than 3.00
with a period of study not less than 4 regular semesters
and not more than 8 regular semesters will be awarded a
Degree of Master of Science in Nuclear Technology with
concentration in Nuclear Technology or in Nuclear
Security and Safeguards.

FIELDS OF STUDY

The student must concentrate on one of the
following fields of study:
    ● Nuclear Technology
    ● Nuclear Security and Safeguards

COURSE REQUIREMENTS

Courses are divided into prerequisite, general required,
specific required, general elective, specific elective, and
thesis courses. Course requirements may vary depending
on the field of study and the study plan.

0) Prerequisite Courses

Student with insufficient background knowledge of
nuclear engineering must take

2111613	Radiation Safety and Shielding	3(3-0-9)
2111616	Environmental Impact of Nuclear Power Plant	3(3-0-9)
2111621	Radiation Chemistry and Processing	3(3-0-9)
2111626	Industrial Radiation and Radioisotope Applications	3(2-3-7)
2111627	Material Analysis by Nuclear Techniques	3(3-0-9)
2111628	Radioisotope Production and Utilization	3(3-0-9)
2111629	Nuclear Chemical Engineering	3(3-0-9)
2111632	Numerical calculation for Nuclear Engineering	3(3-0-9)
2111640	Nuclear Reactor Control	3(3-0-9)
2111646	Radioactive Waste Management	3(3-0-9)
2111647	Nuclear Fuels and Nuclear Fuel Cycles	3(3-0-9)
2111648	Nuclear Power Plant Systems and Operation	3(2-3-7)
2111650	Introduction to Plasma Physics and Nuclear Fusion	3(3-0-9)
2111655	Computer Application in Nuclear Technology	3(3-0-9)
2111660	Industrial Radiation Imaging	3(3-0-9)
2111662	Nuclear Electronics	3(3-0-9)
2111663	Radiation Detectors and Nuclear Instruments	3(3-0-9)
2111664	Digital Computer Interfacing for Nuclear Instrument	3(3-0-9)
2111666	Radiation Machines	3(3-0-9)
2111678	Nuclear Materials Engineering	3(3-0-9)
2111683	Current Topics in Nuclear Engineering	3(3-0-9)
2111686	Special Topics in Nuclear Technology	3(3-0-9)

3.2) *Nuclear Security and Safeguards Field of Study: Choose from the following courses; minimum of 9 credits are required.*

2111652	Strategic Trade Control	3(3-0-9)
2111653	Nuclear Safeguards	3(3-0-9)
2111654	Nuclear Fuel Cycle and Environmental Impacts	3(3-0-9)
2111656	Physical Protection of Nuclear Materials and Facilities I	3(3-0-9)
2111657	Advanced Detection Technologies for Radioactive and Nuclear Materials	3(3-0-9)

4) General Elective Course
Both fields of study: Student must take 6 credits of the courses available in the Master of Science in Nuclear Technology Program.

5) Thesis

| 2111811 | Thesis | 12 credits |

NAME OF DEGREE

: Bachalor of Engineering
: B.Eng.

ADMISSION

Since 2016, the Bachelor Degree program in Nuclear and Radiological Engineering has been established and offered for the students with the background in science and mathematics. The program is intended to those students who plan their careers in the industry, research and services involving the nuclear and radiological engineering. The courses cover the basic nuclear science & technology, radiation protection, radiation measurement, application of radiation and radioisotope, nuclear materials and radiation chemistry & processing. The program also includes courses related to nuclear security and safeguards.

To be eligible for admission to the program, an applicant must hold a secondary school certificate or an equivalent document. The applicant must also pass the selection process administered by Chulalongkorn University and the authority.

DEGREE REQUIREMENTS

The graduate from the program, a student must collect at least 145 course credits as described in the following section.
A student who has fulfilled the requirements of the program with the cumulative GPA of no less than 2.00 with a period of study not more than 8 education years will be awarded a Bachelor Degree in Nuclear and Radiological Engineering.

FIELD OF STUDY

The program is concentrated on the following field of study:
● Nuclear and Radiological Engineering

COURSE REQUIREMENTS

Courses are divided into that of the general education (no less than 30 course credits), the program specific courses (no less than 72 course credits) and the free elective courses (no less than 6 course credits) .

NUCLEAR AND RADIOLOGICAL ENGINEERING CURRICULUM
FIRST YEAR CURRICULUM
COMMON TO ALL ENGINEERING STUDENTS

COURSE NO.	SUBJECT	CREDITS

THIRD SEMESTER

2103213	ENG MECHANICS I	3
2103241	THERMODYNAMICS I	3
2111200	ESS NUC ENG	3
2111202	BAS NUC DET	3
2111203	NUC RAD LAB	1
2111204	HEA PHY RAD	3
2111205	INT NUC MAT	3
		19

FORTH SEMESTER

2104223	ENG STAT I	3
2111206	NUC PLA TEC	3
2102391	ELEC ENG I	3
2102392	ELEC ENG LAB I	1
2103351	FLUID MECHANICS I	3
2111208	NUC REAC ANALYSIS	3
5500208	COM PRES SKIL	3
		19

FIFTH SEMESTER

2100311	ENG ESSENTIALS	3
2111301	ENV ASP NUC	3
2111308	ELE CIR NUC	3
2111306	IND RAD MAT	3
2111307	IND RAD LAB	1
2111312	NUC3S	3
5500308	TECH WRIT ENG	3
		19

COURSE NO.	SUBJECT	CREDITS

SIXTH EMESTER

2111311	RAD MAC I	3
2111303	ENV ASP NUC	3
2111304	PRI NUC INS	3
2111305	NUC INS LAB	1
2111310	NUC REA SAF	3
2111309	NUC REA LAB	1
2111401	SEM NUC ENG	1
xxxxxxx	APPROVED ELECTIVES	3
		18

SUMMER SEMESTER

2100301	ENGINEERING PRACTICE	2

SEVENTH SEMESTER

2104203	ENG MANAGEMENT	3
2111402	PRO NUC ENG I	1
2111444	SOC SCI NUE	3
xxxxxxx	APPROVED ELECTIVES	3
xxxxxxx	GENERAL EDUCATION	6
xxxxxxx	FREE ELECTIVE	3
		19

EIGHTH SEMESTER

2111403	PRO NUC ENG II	1
xxxxxxx	APPROVED ELECTIVES	3
xxxxxxx	GENERAL EDUCATION	6
xxxxxxx	FREE ELECTIVE	3
		13

TOTAL CREDITS FOR GRADUATION = 145

2111200   Essence of Nuclear Engineering   3(3-0-6)

Atomic physics and nuclear physics; interaction between radiation and matters; neutron calculations; types of nuclear reactors; generation of nuclear reactors; applications of nuclear technology and radioisotopes; research reactor; Thailand nuclear power program; other topics of interest in nuclear engineering.

2111202   Basic Principle of Nuclear   3(3-0-6)
**   Radiation Detection and Measurement**

Radiation sources; nuclear radiation properties; interaction of radiation with matter, statistics of radiation counting; characteristics of various nuclear radiation detectors; relative and absolute measurements.

2111203   Nuclear Radiation Detection and   3(3-0-6)
**   Measurement Laboratory**

Laboratory works on nuclear radiation properties; interaction of radiation with matter; characterization of various nuclear radiation detectors; statistical errors of radiation counting; relative and absolute measurements; nuclear radiation spectroscopy.

2111204   Health Physics and Radiation   3(3-0-6)
**   Protection**

Basic concepts of radiation; interactions with tissue; biological effects of radiation; radiation detection and dosimetry; dose limits & regulatory issues; protection from external radiation; internal radiation hazard; surface contamination and decontamination; calculation of internal and external body radiation exposure dose; calculation of gamma and x-ray shielding; clinical applications.

2111205   Introduction to Nuclear Materials   3(3-0-6)

Nuclear fuel cycle; uranium resources in Thailand; uranium extraction from seawater; materials used in nuclear power plants; crystal structures of metals; point defect in metals; diffusion in solids; non-permanent and permanent deformation; dislocation theory; creep; grain and grain growth; generation of fission gas and release; effect of radiation on structure and properties of materials.

2111206   Nuclear Power Plant Technology   3(3-0-6)

Introduction to nuclear power plant technologies, pressurized water reactor, boiling water reactor, otheradvanced reactor types, Thermodynamics of nuclear power plants, rankine cycle, thermal design of nuclear reactors, reactor heat generation, single phase heat transfer, two phase heat transferin nuclear reactor.

2111208   Nuclear Reactor Analyis   3(3-0-6)

Production and characteristics of neutrons; the fission process; neutron diffusion theory; slowing-down theory; Fermi theory of the bare thermal reactor; one- and multi-group diffusion methods; basic principles of nuclear reactor kinetics.

2111301   Environmental Aspects of Nuclear 3(3-0-6)
**   Engineering**

Environmental Aspects of Nuclear Engineering al impact of nuclear power plants; Impact of nuclear fuel cycle; radionuclides released from nuclear power plants; atmospheric diffusion; marine diffusion; dispersion simulation using computer codes; types of radioactive waste; radioactive waste transport; radioactive waste management; spent fuel transport; spent fuel management.

2111303   Industrial Control Electronics   3(3-0-6)

Principle of industrial control systems; transducer devices e.g. temperature, pressure, humidity, strain/stress; signal conditioning; industrial equipment; analog and digital control system; data transmission/receiving with computer.

2111304   Principle of Nuclear Instrument   3(3-0-6)

Properties of radiation; interaction of radiation with matter; radiation detectors; standard NIM and CAMAC instrumentation system; principle of nuclear instruments e.g. low voltage power supply, high voltage power supply, pre-amplifier, main-amplifier, rate meter, single channel analyzer, counter and timer, multi-channel analyzer radiation detection system setting.

2111305   Nuclear Instrument Laboratory   1(0-3-0)

Operation of nuclear instrumentation laboratory e.g. low voltage power supply, high voltage power supply, pre-amplifier, main-amplifier, rate meter, single channel analyzer, counter and timer, radiation detection system setting.

2111306   Industrial Uses of Radiation and   3(3-0-6)
**   Radioactive Material**

Basic principle of nuclear techniques used for industrial application; radiation sources and equipment used for industrial application; industrial radiography and computed tomography; nuclear techniques used for industrial gauging; nuclear analytical techniques for on-line elemental analysis in industry; radioisotope tracers used in industrial processes; basic principle of radiation processing for industrial application.

2111307   Industrial Uses of Radiation and   3(3-0-6)
**   Radioactive Material Laboratory**

Laboratory works on nuclear techniques used for industrial application; industrial radiography and computed tomography; nuclear techniques used for industrial gauging; nuclear analytical techniques for on-line elemental analysis in industry; radioisotope tracers used in industrial processes.

2111308   Electronic Circuits for Nuclear   3(3-0-6)
**   Instruments**

Study the principles, behavior and characteristic of the passive/active electronic devices; electrical signal and waveform; designing and calculation of electronic circuits, including the power supply circuit, feedback, amplifier, Oscillator, Filters, logic. application of radiation measurement devices and in other areas; electronic circuits simulation on computer.

2111309 Nuclear Reactor Laboratory 3(3-0-6)
Condition: Prerequisite 2111208

Approaching of critically, control rod calibration, measurement of thermal neutron flux, measurement of fast neutron flux, profiling of axial flux, calibration of thermal power.

2111310 Nuclear Reactor Safety 3(3-0-6)
Condition: Prerequisite 2111206

Safety systems and functions of current and advanced reactor technologies, design basis accidents, severe accidents, safety analysis report, probabilistic safety analysis, technology of accident analysis, computer simulation of accidents, role of safety culture, current regulatory issues, significant nuclear accidents.

2111311 Radiation Machines I 3(3-0-6)

Particle Sources; Charge Particle Motion in Static Fields; Linear Transverse Motion; Acceleration and Longitudinal Motion; Beam Distribution; Guiding and Focusing; Accelerator; Laser; Cyclotron; Synchrotron; Other Auxiliary Components.

2111312 Nuclear Safety, Security, and 3(3-0-6)
Safeguards
Condition: Prerequisite 2111201

Nuclear Safety; Nuclear Security; Nuclear Safeguards; Objectives; Interrelationship between Safety, Security, and Safeguards; National and International Policies; Related Law & Regulations; Related Regimes; Important Elements; Case Studies.

2111401 Seminar in Basic Nuclear 3(3-0-6)
Engineering
Condition: Senior Standing or Consent of Faculty

Instructors provide research topics in nuclear technology to students; each student requires selecting a tentative project with a written report and making an oral presentation and discussion of relevance items of selected topic.

2111402 Project in Nuclear Engineering I 3(3-0-6)
Condition: Senior Standing or
Consent of Faculty

Perform a preliminary nuclear engineering project in a team manner such that the processes comply with prescribed design processes including report documenting and presenting the project in a professional way.

2111403 Project in Nuclear Engineering II 3(3-0-6)
Condition: Prerequisite 2111402

Perform and complete a nuclear engineering project in a team manner such that the processes comply with prescribed design processes including report documenting and presenting the project in a professional way.

2111404 Microcontroller Programming and 3(3-0-6)
Interfacing

Architecture and principle of microprocessor, microcontrollers, and peripheral devices;programming for control applications; interfacing methods and techniques with real world.

2111405 Vacuum Technology for Scientific 3(3-0-6)
Instrument

Gas properties; relevant physical concept of vacuum system; vacuum gauge; vacuum pump; control valve; vacuum system design; cleaning techniques; applications of vacuum technology for scientific instruments and devices; leak detection techniques and maintenance.

2111406 Principle of Scientific Instrument 3(3-0-6)

Theory and principle of scientific instrument e.g. spectrophotometer, x-ray spectroscopy and radiography, electron microscopy; maintenance method for scientific instrument.

2111407 Basic scientific instrument 3(3-0-6)
maintenance
Condition: Prerequisite 2111308

Using fault finding tools for investigation fault of device and electronic signal; scientific instrument structure and components study; fault diagnosis of Scientific Instruments; circuit analysis; replacement parts and accessories correctly; test the validity of the operation after maintenance.

2111408 Ionizing Radiation Calibration and 3(3-0-6)
Dosimetry

Radiation terminology and units; basic principle of radiation dosimetry for various kinds of ionizing radiation; low and high level radiation dosimetry; various types of radiation dosimeter; radiation calibration systems; radiation calibration techniques.

2111410 Plasma Physics and Applications 3(3-0-6)

Basic characteristics of plasma; motions of charge particles under electric and magnetic fields; Maxwell's equations; plasma as fluid; plasma oscillation; different types of waves in plasma; diffusion process in plasma; methods of plasma generation; plasma measurements; nuclear fusion and current technology; plasma applications in industry.

2111411 Nuclear Techniques for Material 3(3-0-6)
Analysis

Theoretical principle; methodology; instrumentation and characteristics of nuclear analytical techniques e.g. thermal and fast neutron activation techniques, prompt gamma radiation measurement techniques, measurement of gamma radiation from inelastic neutron collision,

charged particles induced x-ray and gamma-ray analytical techniques, x-ray fluorescence techniques, electron and X-ray microanalysis, x-ray diffraction, track-etch techniques.

2111412 Nuclear Technology in Medicine 3(3-0-6)
Condition : Prerequisite 2111201

Radiopharmaceuticals as radioactive tracers in medical imaging, functional studies, andtherapy for many diseases e.g. cardiovascular disease, digestive system, lung, skeleton, blood and nervous system etc., Positron emission tomography (PET), Radiotherapy; teletherapy and brachytherapy, Radioimmunoassay for measuring concentrations of antigens, Medical Radiography; computed tomography (CT); Magnetic resonance imaging (MRI)or magnetic resonance tomography (MRT),PET, Single-photon emission computed tomography (SPECT), mammography; dental radiology, Neutron therapy, Heavy-ion therapy.

2111416 Nuclear Techniques for 3(3-0-6)
Measurement and Inspection in
Industrial Process
Condition : Prerequisite 2111304

Radiation gauging for measurement of thickness, level, moisture and density; detection of corrosion and blockage; distillation column and packed column scan; industrial radiography and tomography; elemental analysis techniques; radiotracer techniques.

2111417 Nuclear Techniques for elemental 3(3-0-6)
Analysis
Condition : Prerequisite 2111304

Principles of nuclear analytical techniques; advantages and limitations; x-ray fluorescence analysis technique; nuclear activation analysis techniques; prompt gamma-ray neutron activation analysis techniques; charged particle activation analysis techniques.

2111421 Thermal Hydraulics 3(3-0-6)
Condition : Prerequisite 2111206

Two-phase flow, conservation equations, flow patterns, void fraction modeling, pressure drop modeling, steam separation, flow instabilities, critical flow, bubble nucleation, pool boiling, subcooled and saturated flow boiling, boiling crises, transient analysis (single channel), loop analysis, condensation.

2111422 Nuclear Power Plant Simulation 3(3-0-6)
Condition : Prerequisite 2111206

Operational characteristics of nuclear power plants with the simulation computer programs, reactivity control systems, safety systems, and response to transients and accident situations.

2111423 Heat Transfer Process in Nuclear 3(3-0-6)
Power Plant
Condition: Prerequisite 2111206

Heat production from a nuclear reactor, nuclear reactor cooling system, boiling and condensation, two-phase fluid, thermal energy-mechanical energy conversion, thermal cycle, efficiency improvement for heat transfer process, accident involving thermal system in a nuclear power plant and the emergency cooling system.

2111424 Radiation Transport 3(3-0-6)

Definitions and Assumptions regarding the radiation, interaction with the radiation, radiation transport theory, Pn approximation, Sn approximation, numerical calculation for radiation transport, monte-carlo technique.

2111425 Basic Nuclear Reactor Engineering 3(3-0-6)

Applying the nuclear reactor theory for the design and the operation of the nuclear theory, evaluation of the nuclear reactor's importance, safety by design for the nuclear reactor and the thermal system, the management on the operation of a nuclear reactor and the economics of the nuclear reactor's operation.

2111431 Nuclear Weapons and Nuclear 3(3-0-6)
Accidents

History of nuclear weapon development; how nuclear weapons work; materials for construction of nuclear weapons; impact of nuclear weapons; current topics on nuclear weapons; Three Mile Island accident, Chernobyl accident and Fukushima accident; impacts on human and the environment; roles of International Atomic Energy Agency; potential of utilizing nuclear explosion for peaceful purposes.

2111432 Corrosion in Nuclear Power 3(3-0-6)
Systems
Condition : Prerequisite 2111205

Structural metals in nuclear power plants; properties and fabrication of Zircaloy; aqueous corrosion of reactor components; structural integrity of reactor components under combined mechanical loading, neutron irradiation, and chemical environment.

2111434 Radiation processing and its 3(3-0-6)
applications
Condition : Prerequisite 2111201

Radiation sources; chemical and physical effects of radiation; radiation effects to water, gases, monomers and polymers; polymer modification by radiation; radiation sterilization; development of material structures by radiation; radiation degradation of materials; food irradiation; radiation application in Agro-industry.

2111435 Radiation Detection Materials 3(3-0-6)
Development

Reviews of radiation measurement and detection, types of radiation detectors and their characterizations, development of radiation detection materials; crystal synthesis by chemical processes; the methods of bulk-crystal growths e.g. Bridgman-Stockbarger technique and

Czochralski technique; thin-film growth by chemical and physical deposition e.g. epitaxial technique and sputter technique.

2111443   Nuclear Waste Disposal   3(3-0-6)

Radioactivity; radiation effects on living things;dose limit; various characteristics of radioactive wastemanagement; disposal technology of nuclear waste.

2111444   Social Sciences for Nuclear   3(3-0-6)
           Engineering

Economics, Project Management, Law and International obligations, Psychology, Communication with Public, Public Acceptance, education in Nuclear Engineering.

COURSE DESCRIPTIONS IN NUCLEAR ENGINEERING AND NUCLEAR TECHNOLOGY ENGINEERING (PH.D, M.ENG, AND M.SC)

2111600* Nuclear Engineering I   3(3-0-9)

Atomic physics and nuclear physics; interaction between radiation and matters; neutron diffusion; types of nuclear reactors; generation of nuclear reactors; nuclear fuel cycle; applications of nuclear technology and radioisotopes; nuclear weapons; Thailand nuclear power program.

2111603* Radiation Detection and   1(0-3-7)
           Measurements Laboratory

Laboratory work on radiation measurements; statistical errors of radiation counting; characterization of radiation detectors; relative and absolute measurements; energy loss and penetration of charged particle through matter; interactions of photons with matter; interactions of neutrons with matter.

2111604   *Radiation Detectors and Nuclear   1(0-3-7)
           instruments laboratory

Laboratory works on electronics circuit of radiation detectors, nuclear pulse shaper and discriminator circuits; inspection and calibration of Nuclear Instrument Module, pulse amplifier, single channel analyzer, multichannel analyzer, time to amplitude converter and some special nuclear instruments; experiment on parameters that affect energy resolution of the spectroscopy system and pulse pile-up rejection.

2111607   Environmental Radiation   3(3-0-9)
           Measurements

Natural sources of radiation and man-made sources of radionuclides; instrumentation for radiation detection and measurement; measurement techniques and procedures for environmental samples; sampling and sample preparation for analyses in laboratory; statistical treatment of radioactivity measurements; laboratory and field radiation measurements.

2111608* Practical Radiation Detection   3(3-0-9)
           and Measurements

Nuclear radiation basics; sources of nuclear radiation; types of radioactive decay; statistical errors of radiation counting; interactions of nuclear radiation with matter; characteristics and utilization of various nuclear radiation detectors; relative and absolute measurements; gamma and X-ray spectroscopy; charged-particle spectroscopy; neutron detection and spectroscopy.

2111609   Radiation Dosimetry   3(3-0-9)

Basic principle of radiation dosimetry for various kinds of radiation: charged particle radiation, gamma radiation and neutron; low and high level radiation dosimetry; various types of radiation dosimeter.

2111610* Nuclear Security   3(3-0-9)

Nuclear security; overview of related legal framework; interrelationships between nuclear safety, security and safeguards; nuclear and radiation threat by non-State actors; counterterrorism; chemical biological,radiological and nuclear security of nuclear and nuclear (CBRN) Weapons; basic elements of nuclear security; planning nuclear materials and other radioactive materials outside regulatory control; information security; security culture.

2111612   Radiation Protection   3(3-0-9)

Basic concepts of radiation; biological effects of radiation on human body; dose limits; protection from external radiation; Internal radiation hazard; surface contamination and decontamination; radiation dosimetry; calculation of internal and external radiation exposure dose; calculation of gamma and x-ray shielding.

2111613   Radiation Safety and Shielding 3(3-0-9)

Definitions and basic concepts of radiation safety; biological effects of radiation: protection, dose limits; regulation concerning radioactive materials; transportation of radioactive materials; accidents and emergency procedure; gamma radiation and x-ray shielding; radiation shielding from nuclear reactor.

2111616   Environmental Impact of Nuclear 3(3-0-9)
           Power Plant

Radionuclides released from nuclear power plant, dispersion in the atmosphere; dispersion in aquatic environment; radiation dose calculation; food chain; reactor siting; accident risk analysis; emergency management.

2111621   Radiation Chemistry and   3(3-0-9)
           Processing

Radiation sources; chemical and physical effects of radiation; radiation effects to water, gases, monomers and polymers; polymer modification by radiation; radiation sterilization; food irradiation; radiation degradation of materials.

2111627   Material Analysis with Nuclear   3(3-0-9)
           Techniques

Condition: Prere 2111608 or 2111663

Theoretical principle; methodology; instrumentation and characteristics of nuclear analytical techniques e.gl thermal and fast neutron activation techniques, prompt gamma radiation measurement techniques, measurement of gamma radiation from inelastic neutron collision, charged particles induced x-ray and gamma-ray analytical techniques, x-ray fluorescence techniques, electron and X-ray microanalysis, x-ray diffraction, track-etch techniques.

2111628 Radioisotope Production and 3(3-0-9) Utilization

Radioisotope production; nuclear reactor-produced radioisotopes; special techniques to produce radioisotope; radioisotopes derived from generators; accelerator produced isotopes, labelled compounds; dispensing and quality control; radioisotope utilization.

2111629 Nuclear Chemical Engineering 3(3-0-9)

Production of fissiles and nuclear reactor materials; isotope separation; property of spent nuclear fuel; separation of remaining and newly producing fissiles from spent nuclear fuel.

2111631 Applied Mathematics in Nuclear 3(3-0-9) Technolog

Ordinary differential equations; linear differential equations with constant coefficients; Laplace transform, vector analysis; finite differences; gamma and beta functions; Fourier series and integral.

2111632 Numerical Calculation For 3(3-0-9) Nuclear Engineering

Numerical technique for differential,integration and finding; matric manipulation; data interpolaion; finite difference; simulation with Monte Carlo technique.

2111640 Nuclear Reactor Control 3(3-0-9)
Condition: Prere 2111642

Phylosophy of nuclear reactor and plant control; elementary physics of reactor control; nuclear reactor kinetics; nuclear reactor control radiation instruments; nuclear reactor control mechnisms; nuclear reactor control problems; computer simulation of nuclear reactor power.

2111642 Nuclear Reactor Engineering 3(3-0-9)

Production and characteristics of neutrons; the fission process; neutron diffusion theory; slowing-down theory; Fermi theory of the bare thermal reactor; one- and multi-group diffusion methods; basic principles of nuclear reactor kinetics and nuclear reactor control.

2111643 Nuclear Power Engineering 3(3-0-9)
Condition: Prerequisite consent of faculty

Power reactor systems; vapor power cycle; reactor heat generation; reactor heat transport, single phase flow, two- phase flow; reactor core thermal analysis; practices using PC-based simulators of nuclear power plants for operations under normal and abnormal conditions.

2111646 Radioactive Waste 3(3-0-9) Management

Nature of radioactive wastes; origin of low-high radioactive wastes; characteristics, forms and quantity of radioactive wastes; storage and transportation; waste management technologies; radioactive waste management plans in various countries.

2111647 Nuclear Fuels and Nuclear Fuel 3(3-0-9) Cycles
Condition: Prerequisite 2111642

Characteristics of fuel-element materials; design of fuel-elements; fuel-element fabrication; fuel cycles in nuclear reactors; properties of irradiated fuel; spent fuel reprocessing; economics of nuclear power.

2111648 Nuclear Power Plant Systems 3(2-3-7) and Operation
Condition: Prerequisite consent of faculty

Functions, equipment and operation of the main systems of a nuclear power plant; how each system is controlled, principles of overall unit operation and control, reactor safety and protection for the public; experiments used PC-based simulators of nuclear power plants for operations under normal and abnormal conditions.

2111650 Introduction to Plasma Physics 3(3-0-9) and Nuclear Fusion

Basic characteristics of plasma, methods of plasma generation; nuclear fusion process, problems and current status of fusion technology; single-particle motions, effects of electric and magnetic field on plasma motion; maxwell·s equations, fluid equation of motion; plasma oscillation, different types of waves in plasma; diffusion process in plasma, plasma resistivity; hydrodynamic equilibrium, various types of instability in plasma.

2111651* Weapon Mass Destruction 3(3-0-9) Nonproliferation

Issues concerning the proliferation of nuclear, chemical, and biological weapons; introduction to nuclear and radiological terrorism; international nuclear nonproliferation framework; weapon technologies of mass destruction; nuclear proliferation issues in South Asia.

2111652* Strategic Trade Controls 3(3-0-9)

National and international contexts of export control; threats of nuclear prokiferation to the state and business sectors, international export control framework; instruments for export control; catch-all concepts; intangible technology transfers, dual-use controls; end-use method.

2111653* Nuclear Safeguards 3(3-0-9)

Safeguarding nuclear material and facilities; monitoring principles and technologies; sefeguards issues; international framework of nuclear material safeguard; nuclear proliferation threat; radiological threat;

detectinlg nuclear and other radioactive materials; roles of intelligence; A. Q. Khan's network; counter proliferation of nuclear weapons; nuclear material safeguard in various countries.

**2111654* Nuclear Fuel Cycle and   3(3-0-9)
            Environmental Impacts**

Technology of nuclear fuel cycle; technologies used in manufacturing, safety handling, and disposing of nuclear materials and by-products; social environmental, and health impacts of materials used in each major step in the fuel cycle; potential of nuclear proliferation.

**2111655   Computer Application in Nuclear   3(3-0-9)
            Technology**

Calculation of gamma-ray shielding calculation of primary and secondary x-ray shielding; radioactivity calculation; radiation imaging; application of data acquisition for computed tomography reconstruction.

**2111656* Physical protection of Nuclear   3(3-0-9)
            Materials and Facilities I**

Principles of physical protection of nuclear materials and facilities: detection, delay, response; threat identification and analysis; vital area analysis; international physical safeguard framework; internal threats.

**2111657* Advanced Detection Technologies 3(3-0-9)
            for Radioactive and Nuclear Materials**
Condition: PRER. 2111608 or 2111658 or 2111663

Detection and identification of the types of nuclear materials; chemical and radiological characteristics of nuclear materials from raw materials to various finished products; detection technologies; nuclear forensics.

**2111658* Method and Instrumentation for   3(3-0-9)
            Nuclear Security and Safeguards**

Counting statistics; radiation detection; gamma detection; neutron detection; detection of charged particles; gamma spectroscopy; activation analysis; destructive analysis; non-destructive analysis; quantitative nuclear material material measurements; survey devices; use of detectors at port.

**2111659* Method and Instrumentation for   1(0-3-7)
            Nuclear Security and Safeguards Laboratory**

Use of gamma, neutron, and charged particle detection systems; gamma spectroscopy method; activation analysis; quantitative nuclear material measurements; uses of various survey and detection devices at port.

2111660   Industrial Radiation Imaging   3(3-0-9)
Condition: Prerequisite consent of faculty

Principles of industrial radiography and tomography; advantages and disadvantages; x-ray and gamma-ray radiography; neutron radiography; x-ray and gamma-ray computed tomography; neutron computed tomography; radiation imaging equipment.

2111661   Experimental Nuclear Engineering   3(2-3-7)
Condition: PRER. 2111663 or 2111642

Nondestructive testing methods; industrial radiography using x-rays and gamma-rays and neutrons; equipment for x-ray and gamma-ray radiography; x-ray and neutron computed tomography.

2111662   Nuclear Electronics Engineering   3(3-0-9)
Condition: Prerequisite consent of faculty

Outline of nuclear electronics; nuclear measuring systems; shaping of signals for spectroscopy; radiation detection circuit; high voltage bias power supply; pulse amplifier; pulse height and shape discriminators; timing circuit; single channel and multichannel analyzer; digital counter and ratemeter; energy resolution in spectroscopy systems.

**2111663* Radiation Detectors and Nuclear   3(3-0-9)
            Instruments**

Principle of radiation detection process; modes of detector operation; NIM and CAMAC standards for modular nuclear instrumentation; configurations of nuclear measurement systems; properties of radiation detectors; operation characteristics of various radiation detector; operation characteristics of various radiation detectors; nuclear pulse signal processing; radiation spectroscopy; nuclear instrumentation; application of counting statistics and error prediction in nuclear radiation measurement.

**2111664   Digital Computer Interfacing for   3(3-0-9)
            Nuclear Instruments**
Condition: Prerequisite: 2111608 or 2111663 or consent of faculty

Standard of nuclear instrument modules; nuclear instrumental system; electronic signal conditioning and interfacing for nuclear instrument; standard data bus of parallel and serials type; analog and digintal data conversion; uses of microcomputer and microcontroller interfacing for manipulation of nuclear instrument system.

2111666   Radiation Machines   3(3-0-9)

Principle and structure of radiation machine; mechanism of charge particles acceleration; electron and ion beams generation; electromagnetic and electrostatic lens; high vacuum technology; hight voltage power supply; basic refrigeration; operation of various types of accelerator and radiation machine; industrial and research applications of radiation machines.

2111678   Nuclear Materials Engineering   3(3-0-9)
Condition: Prerequisite consent of faculty

Nuclear fuel cycle; materials and thermal aspects of nuclear reactors; crystal structures of solids; point defects; diffusion in solids; elastic behavior of solids; dislocations in solid and creep deformation; grain and grain boundaries; cavities in solids; fission product behavior in nuclear fuel; radiation damage and fast-neutron irradiation effects in metals; introduction to the High-Temperature Gas-Cooled Reactor Technology.

2111683   Current Topics in Nuclear   3(3-0-9)
           Engineering
Current topics in nuclear engineering field are selected, summarized and discussed by the students with faculty participation.

2111684   Current Topics in Nuclear   3(3-0-9)
           Technology
Current topics in nuclear technology field are selected, summarized and discussed by the students with faculty participation.

2111686*   Special Topics in Nuclear   3(3-0-9)
           Technology
Special topics in nuclear technology; presentations and discussions led by instructors, concluding.

2111687*   Special Topics in Nuclear   3(3-0-9)
           Technology
Students' selection, summaries and discussion of special topics in nuclear engineering, with faculty participation.

2111701   Seminar in Nuclear Technology I   S/U
Instructors provide research topics in nuclear technology to students and each student is required to summarize with written report and oral presentation.

2111702   Seminar in Nuclear Technology II S/U
           Condition: Prerequisite: 2111701
Instructors provide research topics in nuclear technology to students each student required to conduct experimental research with written report and oral presentation; discussion of topics related to research works.

2111811   Thesis   12(0-0-0)
           THESIS

2111817*   Thesis   37(0-0-0)
           THESIS

2111829*   Dissertation   49(0-0-0)
           DISSER

2111826*   Dissertation   36(0-0-0)
           DISSER

2111830*   Dissertation   74(0-0-0)
           DISSER

DEPARTMENT OF WATER RESOURCES ENGINEERING

The Department of Water Resources Engineering was formerly one of the five divisions in the Department of Civil Engineering which had offered some basic courses in hydraulic, hydrology and water resources engineering to the undergraduate students in civil, environmental and survey engineering. The division had also offered a graduate program specialized in water resources engineering leading to the Master of Engineering Degree since 1971 and to the Doctor of Engineering Degree since 1984. At the end of 1991, the Department of Water Resources Engineering was established to reflect growing concern of Chulalongkorn University in the field of water resources development and management which nowaday, has become one of the nation 's most critical problems.

The Department offers programs leading to the Master and Doctor of Engineering degrees in Water Resources Engineering. Works are directed toward research and professional development in areas such as hydrology and hydrologic engineering; hydraulic engineering; irrigation engineering; groundwater; coastal engineering; and water resources planning and management. Students who wish to continue their study in water resources engineering should have completed the equivalent of the undergraduate majoring in civil engineering or water resources engineering, or other related fields with adequate background in civil engineering.

HEAD :

Anurak	Sriariyawat,	Ph.D. (Nottingham)

ASSOCIATE PROFESSORS :

Sucharit	Koontanakulvong,	D.Agr. (Kyoto)
Saree	Chanyotha	Ph.D. (Arizona)
Tuantan	Kitpaisalsakul,	D.Eng. (AIT)

ASSISTANT PROFESSORS :

Aksara	Putthividhya,	Ph.D. (U. of Michigan)
Anurak	Sriariyawat,	Ph.D. (Nottingham)

LECTURERS :

Busawan	Bidorn,	Ph.D. (FSU)
Piyatida	Ruangrassamee	Ph.D. (MIT)
Pongsak	Suttinon	D.Eng (Kochi UT)
Supattra	Visessri	Ph.D. (ICL)

NAME OF THE DEGREE

: Master of Engineering
: M.Eng.

ADMISSION

An applicant must hold a Bachelor's Degree in Civil Engineering, Irrigation Engineering, Water Resources Engineering or equivalent and also meet the requirements of the Graduate School.

DEGREE REQUIREMENTS

The candidate is required to complete at least a total of 36 credits, of which 24 credits shall be graduate course work. These 24 credits course work shall consist of 12 credits of required courses and 12 credits of approved elective credits. The grade point (GPA) must not be less than 3.00, Plus 12 credits of thesis and satisfactorily pass an oral examination.

COURSE REQUIREMENTS

1) Required Courses 12 credits

2112602	Hydroinformatics I	1(0-3-1)
2112605	Hydrology and Hydraulic Laboratory	1(0-3-1)
2112611	Engineering Fluid Mechanics	3(3-0-9)
2112614	Hydraulics of Open Channels	3(3-0-9)
2112631	Hydrological Processes	3(3-0-9)
2112698	Seminar in Water Resources Engineering	1(0-3-1)

2) Elective Courses

At least 12 credits must be chosen from the following courses with the approval of the advisor and in accordance with the approved student's plan.

2112501	Computer Application in Water Resources Engineering	3(3-0-9)
2112503	Irrigation Engineering	3(3-0-9)
2112504	Water Resources Systems Design	3(3-0-9)
2112505	Water Resources Planning and Management	3(3-0-9)
2112541	Introduction to Groundwater Contamination	3(3-0-9)
2112542	Probability and Time Series Analysis for Infrastructure Data	3(3-0-9)
2112543	Water Resources and Environmental Project management	3(3-0-9)
2112601	Digital Methods in Water Resources Engineering	3(3-0-9)
2112603	Hydroinformatics II	3(3-0-9)
2112604	Advanced Topics in Hydroinformatics for Water Resources Engineering	3(3-0-9)
2112615	Erosion and Sedimentation	3(3-0-9)
2112617	Hydraulic Design	3(3-0-9)
2112622	River Engineering	3(3-0-9)
2112633	Advanced Hydrology	3(3-0-9)
2112634	Statistical Hydrology	3(3-0-9)
2112635	Stochastic Processes in Hydrology and Hydraulics	3(3-0-9)
2112636	Urban Hydrology	3(3-0-9)
2112637	Flood Plain Hydrology	3(3-0-9)
2112641	Groundwater Hydrology	3(3-0-9)

2112642	Flow Through Porous Media	3(3-0-9)
2112643	Modelling of Subsurface Flow	3(3-0-9)
2112644	Groundwater Exploration and Development	3(3-0-9)
2112661	Coastal Engineering	3(3-0-9)
2112662	Port and Harbour Engineering	3(3-0-9)
2112663	Coastal Process and Protection	3(3-0-9)
2112664	Estuaries Hydraulics	3(3-0-9)
2112671	Systems Analysis for Large-Scale Systems	3(3-0-9)
2112672	Water Resources Systems Engineering	3(3-0-9)
2112673	Economics of Water Resources Systems	3(3-0-9)
2112674	Water Management	3(3-0-9)
2112681	Engineering for Water Disaster Mitigation	3(3-0-9)
2112691	Special Studies in Water Resources Engineering	3(3-0-9)
2112692	Advanced Topics in Water Resources Engineering	3(3-0-9)

3) *Thesis*

2112811	Thesis	12	credits
2112816	Thesis	36	credits

NAME OF THE DEGREE

: Doctor of Engineering
: D.Eng.

ADMISSION

An applicant must hold a Master Degree in Civil/Water Resources Engineering or equivalent with GPA above 3.25, passes an English examination and also meet the requirements of the Graduate School.

DEGREE REQUIREMENTS

An acceptable dissertation of not less than 48 credits, together with 12 credits in the primary area plus 2 credits in seminar (S/U), is required for the Doctoral Degree.

A student who has fulfilled the requirements of the program with a period of study no more than 10 regular semesters and satisfactorily pass an oral examination, will be awarded the Degree of Doctor of Engineering.

COURSE REQUIREMENTS

1) Required Courses (S/U) 2 credits

2112798	Seminar in Water Resources Engineering II	1(0-3-1)
2112799	Seminar in Water Resources Engineering III	1(0-3-1)
2112894	Doctoral Dissertation Seminar	S/U
2112897	Qualifying Examination	S/U

2) Elective Courses 12 credits

2112601	Digital Methods in Water Resources Engineering	3(3-0-9)
2112602	Hydroinformatics I	1(0-3-1)

2112603	Hydroinformatics II	3(3-0-9)
2112604	Advanced Topics in Hydroinformatics For Water Resources Engineering	3(3-0-9)
2112605	Hydrology and Hydraulic Laboratory	1(0-3-1)
2112611	Engineering Fluid Mechanics	3(3-0-9)
2112614	Hydraulics of Open Channels	3(3-0-9)
2112615	Erosion and Sedimentation	3(3-0-9)
2112617	Hydraulic Design	3(3-0-9)
2112622	River Engineering	3(3-0-9)
2112631	Hydrological Processes	3(3-0-9)
2112633	Advanced Hydrology	3(3-0-9)
2112634	Statistical Hydrology	3(3-0-9)
2112635	Stochastic Processes in Hydrology and Hydraulics	3(3-0-9)
2112636	Urban Hydrology	3(3-0-9)
2112637	Flood Plain Hydrology	3(3-0-9)
2112641	Groundwater Hydrology	3(3-0-9)
2112642	Flow Through Porous Media	3(3-0-9)
2112643	Modelling of Subsurface Flow	3(3-0-9)
2112644	Groundwater Exploration and Development	3(3-0-9)
2112661	Coastal Engineering	3(3-0-9)
2112662	Port and Harbour Engineering	3(3-0-9)
2112663	Coastal Process and Protection	3(3-0-9)
2112664	Estuaries Hydraulics	3(3-0-9)
2112671	Systems Analysis for Large-Scale Systems	3(3-0-9)
2112672	Water Resources Systems Engineering	3(3-0-9)
2112673	Economics of Water Resources Systems	3(3-0-9)
2112674	Water Management	3(3-0-9)
2112681	Engineering for Water Disaster Mitigation	3(3-0-9)
2112691	Special Studies in Water Resources Engineering	3(3-0-9)
2112692	Advanced Topics in Water Resources Engineering	3(3-0-9)

3) Dissertation

2112828	Dissertation	48	credits
2112829	Dissertation	60	credits
2112830	Dissertation	72	credits

COURSE DESCRIPTIONS IN WATER RESOURCES ENGINEERING

2112210 Water/Soc   3(3-0-6)

Importance of Water Resources; Context and roles of water resources in society, environment, and community; water cycle, surface water, precipitation, surface runoff, stream flow, erosion surface, water quality, salftwater/intrusion, groundwater, groundwater storage, groundwater abstraction, land subsidence groundwater quality groundwater contamination, remediation for contaminated groundwater, water supply water supply production proun, water distribution system, village water supply system, wastewater, paramenters, treatment technologies, water resources situation in the society, flood drought climate change and impacts, transboundary water resources problems, flood and drought mitigation measures, structural measures, dam/reservoir, rainfall harvesting water drainage system, water reuse program, non-structural measures, forecasting and warning system, conjunctive use of surface and groundwater; laws and regulations

2112341 Hydrology   2(2-0-4)
Condition: Prerequisite 2112346

Hydrologic cycles; precipitation; infiltration; rainfall – runoff and river gauging; hydrographs; reservoirs; evaporation; evapotranspiration; flood forecasting; flood routing; groundwater; measurement of hydrologic and meteorological parameters.

2112342 Principles of Hydrology   3(3-0-6)
Condition: Prerequisite 2112346

Hydrologic cycles; precipitation; infiltration; runoff rainfall and river gaging; hydrographs; reservoirs; evaporation; evapotranspiration; flood forecasting; flood routing; groundwater; measurement of hydrologic and meteorological parameters, ; application in water resources projects; demonstration of infiltration, runoff hydrographs; and groundwater flow.

**2112343 Hydrology for Surveying   3(3-0-6)
         Engineering**

Hydrologic cycle and processes; precipitation; streamflow and hydrograph analyses; infiltration soil water and groundwater movement; measurement of hydrogic and hydro-meteorological parameters; rainfall-runoff relationship; statistical and probabilitistic analyses of hydrogic data; introduction to water management; hydrological applications of GIS/Hydro-informatics..

2112344 Hydraulic Laboratory I   1(0-3-0)
Condition : Prerequisite 2112346

Experimental measurement of fluid pressure; principles of fluid flow through orifices and weirs ; momentum forces; measurement of flow in pipe, flow in open channel and unsteady flow.

2112346 Hydraulics I   3(3-0-6)
Condition : Prerequisite 2103213

Properties of fluid statics; dynamics and kinematics of fluid flow; energy equations in steady flow; momentum and dynamic forces in fluid flow; similitude and dimensional analysis; flow of fluid in pipes; open channel flow; fluid flow measurement; unsteady flow.

2112440 Hydraulic Engineering   3(3-0-6)
*Condition : Prerequisite 2112341 or
            2112342*

Open channel flow; flow in pressure conduits; water hammer; reservoirs; sediment transport in streams; reservoir sedimentation; dams; spillways; gates; tunnels; penstocks; turbines; hydraulic models; design of channels; groundwater and hydraulics of well; surface drainage.

**2112501 Computer Application in   3(3-0-9)
         Water Resources Engineering**

Application of computer in solving water resources problems; program development or application of available packages to solve assigned water   resources problems.

2112503 Irrigation Engineering   3(3-0-9)

Land grading and field layout; irrigation water requirements; water application techniques; water conveyance, control and acquisition.

**2112504 Water Resources Systems   3(3-0-9)
         Design**
Condition : Prerequisite 2112346

Introduction to water resources engineering; application of hydraulic and hydrology to related water system projects; reservoirs; pipe system and pump; design of water distributed system and urban drainage design.

**2112505 Water Resources Planning and 3(3-0-9)
         Management**
*Condition : Prerequisite 2112341 or
            2112342 OR 2112343*

Water resources and rainfall characteristics in Thailand; principles of water resources planning and management; water resources system modeling; role in planning and management; problem-based water resources management; concepts in probability and statistic modeling in hydrological waters; river basin models for water resources planning and management; climate change and hydrological uncertain issues.

**2112541 Introduction to Groundwater 3(3-0-9)
         Contamination**

Fundamentals of subsurface flow and transport; Relation of groundwater flow to geologic structure; mam-made contamination and their impacts of subsurface environment; Behavior of chemicals in subsurface environment; Management of contaminated groundwater; Movement of contaminants through groundwater and their eventual fate; Fate of Contaminants in saturated and unsaturated groundwater aquifers.

**2112542 Probability and Time Series   3(3-0-9)
         Analysisfor Infrastructure Data**

Probabilistic concepts and quantitative methods that are useful for water resources and infrastructure data analysis; random variables and their properties;

hypothesis testing; analysis of trends; Fourier transformation; characterization of data in the time domain; characterization of data in the frequency domain; correlation among variables; simulation of random variables; linear regression and time series models; Theory and use of MATLAB programming language to import raw data construct simulation models analyze data and present the results.

2112543 Water resources and environmental project management 3(3-0-9)
Condition : Consent of Faculty

The importance of water resources and environment in infrastructural development, water quantity and water quality aspects in infrastructural development, the projects principles of infrastructure planning in developing countries, appropriate and sustainable technologies for water and sanitation projects, technical, socio-cultural, public health, and economic factors important to planning and design of water and sanitation systems that unique in the city critical factors that are often unique to a major water resources and environmental project : the uncertainty lappen in water resources and environmental cleanup projects and process of environmental laws.

2112601 Digital Methods in Water Resources Engineering 3(3-0-9)
Condition : Prerequisite 2112501 or Consent of Faculty

Digital computer methods in solving problems in water resources engineering; selected problems in the areas of hydrology, groundwater, hydraulics, coastal engineering and water resources systems simulation and management.

2112602 Hydroinformatics I 3(3-0-9)
Introduction to information and communication technologies (ICTs) in water resources; integration of hydraulics, hydrology and environmental engineering; assimilation of measured data; concept of the geographic information system; GIS applications in water resources engineering; social dimension of the problems of water management; decision support tools.

2112603 Hydroinformatics II 3(3-0-9)
Drainage basin form and process; geomorphologic approach; physically-based catchment modeling; development of numerical schemes; modeling and forecasting of hydrological systems; database management system; risk analysis and mitigation; decision making process; applications of information and communication technologies (ICTs) to water and related resources management.

2112604 Advanced Topic in 3(3-0-9)
Hydroinformatics for Water Resources Engineering
Condition : Prerequisite 2112603 or Consent of Faculty

Analysis, design, installation and operation of combined measuring and numerical-modeling schemes; dynamic and mobile river systems; introduction to flood-

and other early warning systems; introduction to real-time water management systems; contemporary issues in hydroinformatics.

2112605 Hydrology and Hydraulic 1(0-3-1)
Labolatory
Experimental verification of advanced principles of hydrology and hydraulics; usage of various hydrological and hydraulic measurement devices; preparation for field laboratory/field measurement.

2112611 Engineering Fluid Mechanics 3(3-0-9)
Advanced topics in theoretical fluid mechanics and hydrodynamics including mechanics of ideal fluids and viscous fluids; incompressible and compressible flow; one-two-and three-dimenssional flows.

2112614 Hydraulics of Open Channels 3(3-0-9)
Continuity, energy and momentum principles applied to steady and unsteady flow in open channels, channel controls, transitions, flood routing, and models.

2112615 Erosion and Sedimentation 3(3-0-9)
Condition : Prerequisite 2112614

Form of erosion and methods of control; sediment properties and their measurement; initiation of sediment movement; transportation and deposition of sediment by flowing water; bed load and suspended load movement; sediment discharge formulas; river behavior and control.

2112617 Hydraulic Design 3(3-0-9)
Condition : Prerequisite 2112614

Analysis of flow behavior through various types of hydraulic structures such as spillway, stilling basin, energy dissipator, gates, outlet works, open channel, pressure conduit, transitions and flow measurement structure. Consideration and procedures for hydraulic design.

2112622 River Engineering 3(3-0-9)
River geomorphology; sediment transport and river behavior; stabilization and rectification of rivers; inland navigation and canalization; impacts of river engineering works; physical hydraulic models of rivers.

2112631 Hydrological Processes 3(3-0-9)
The hydrologic cycle; atmospheric moisture; precipitation; streamflow; infiltration; evaporation and evapotranspiration; groundwater and well hydraulics; hydrograph analysis; analysis and synthesis of hydrological processes; water quality; mathematical models and simulation in hydrology.

2112633 Advanced Hydrology 3(3-0-9)
Condition : Prerequisite 2112631 or Consent of Faculty

Transport phenomena in hydrology and meteorology; flood routing and overlandflow theory; linear and nonlinear analysis of rainfall-runoff system; conceptual and digital models for hydrologic processes.

2112634 Statistical Hydrology 3(3-0-9)

Condition : Prerequisite 2112631 or
Consent of Faculty

Basic statistical characteristics of hydrological data; probability and distributions; parameters estimation techniques; linear and non-linear equations and coefficients estimation; maximum probable values.

2112635   Stochastic Processes in   3(3-0-9)
Hydrology and Hydraulics
Condition : Prerequisite 2112631 or
Consent of Faculty

Basic characteristics of time series; time series analysis and synthesis; prediction and forecasting.

2112636   Urban Hydrology   3(3-0-9)
Condition : Prerequisite   2112631 or
Consent of Faculty

Effects of urban on hydrological processes; urban drainage system and flood protection design; mathematical modelling and simulation for design and management.

2112637   Flood Plain Hydrology   3(3-0-9)
Condition : Prerequisite 2112631 or
Consent of Faculty

Nature and origin of flood; rainfall-runoff analysis; flood routing; flood surface profile analysis; flood plain modelling and simulation; flood forecasting and flood protection measures.

2112641   Groundwater Hydrology   3(3-0-9)
Condition : Prerequisite 2112631 or
Consent of Faculty

Occurrence of groundwater; basic principles of flow through porous media; hydrology of aquifers; well hydraulics; numerical and analog models for aquifer analysis; discussion on special topics such as salt-water intrusion, water quality, artificial recharge, land subsidence and groundwater basin management.

2112642   Flow Through Porous Media   3(3-0-9)
Condition : Prerequisite 2112641 or
Consent of Faculty

Kinematics and dynamics of fluids in saturated porous and fractured media; introduction to free surface, unsaturated, and multiphase flows.

2112643   Modelling of Subsurface Flow   3(3-0-9)
Condition : Prerequisite 2112641 or
Consent of Faculty

Finite difference and finite element methods for subsurface fluid flow and mass   or energy transport simulation; applications to aquifers, unsaturated soils, seepage through earth dams.

2112644   Groundwater Exploration and   3(3-0-9)
Development
Condition : Prerequisite 2112641 or
Consent of Faculty

Review of geologic and hydrologic formation of groundwater; techniques and interpretation of field survey; data collection and analysis; water quality; groundwater exploration and construction of well; large-scale development of groundwater; simulation model of wellfields; determination of groundwater yield; analysis and management of groundwater basin; case studies.

2112661   Coastal Engineering   3(3-0-9)
Condition : Prerequisite 2112611 or
Consent of Faculty

An introductory course to coastal engineering; basic wave theories; wave mechanics-refraction, diffraction, reflection and breaking; wave generation and forecasting; wave forces on structures; longshore current and sediment transport;   field survey; coastal process and protection; design of coastal structure; hydraulic model.

2112662   Port and Harbour Engineering   3(3-0-9)
Condition : Prerequisite 2112661 or
Consent of Faculty

Review of wave mechanics and wave forecasting; functions of ports and harbors; various types of coastal structures for ports and harbours; analysis and design of structures; planning of ports and harbours; economics and environmental consideration, case studies.

2112663   Coastal Process and Protection   3(3-0-9)
Condition : Prerequisite 2112661 or
Consent of Faculty

Review of wave mechanics and generation process; wave forecasting; coastal process; mechanics of sediment transport; coastal protection works; beach and   land reclamation; economics and environmental consideration; case studies.

2112664   Estuaries Hydraulics   3(3-0-9)
Condition : Prerequisite 2112661 or
Consent of Faculty

Estuary phenomena and its problems in hydraulic aspect; tidal phenomena; tidal dynamics; tidal computation; density current; water pollution; mixing and dispersion process; and withdrawal of water from estuaries zone.

2112671   Systems Analysis for Large-Scale   3(3-0-9)
Systems

An introduction to system concept and methodologies; nature of large-scale   public projects; socio-economic evaluation; identification of objectives and alternatives; systems modelling; optimization techniques; simulation; applications to the design and management of large-scale projects.

2112672   Water Resources Systems   3(3-0-9)
Engineering
Condition : Prerequisite 2112671 or Consent of Faculty

Application of system analysis in water resources planning, design and operation; simulation modelling; deterministic and stochastic approaches; reservoir design and operation; optimization for multipurpose water resources system; design and management of urban water resources; river basins and groundwater aquifers. Determination of optimal operating rules and planning strategies. Current and proposed methods for feasibility studies of water resources development projects.

2112673 Economics of Water Resources 3(3-0-9)
Systems
Condition : Prerequisite 2112671 or
Consent of Faculty

Discounting techniques for public works planning; socio-economic evaluation in water resources development and pollution control; benefit-cost analysis; allocation of joint-costs in multipurpose development; design and risk analysis; applications to planning and management of flood control, drainage, water supply, hydropower, irrigation, water quality control, recreation and navigation.

2112674 Water Management 3(3-0-9)
Condition : Prerequisite 2112671 or
Consent of Faculty

Water requirements for agriculture, industries, communities and environmental; economic, social and political criteria in water resources allocations; water resources allocation techniques and optional allocations.

2112681 Engineering for Water Disaster 3(3-0-9)
Mittiagtion
Condition : Consent of Faculty (S/U)

Introduction to water disaster resilience, causes and mitigation of flood disaster, basic concept of designing flood mitigation and beach erosion protection, risk in hydrologic, hydraulic and coastal engineering, field trip to water disaster prone areas.

2112691 Special Studies in Water 3(3-0-9)
Resources Engineering

Special problems in water resources engineering with emphasis on research   work and independent study.

2112692 Advanced Topics in Water 3(3-0-9)
Resources Engineering

A special course offering the advanced topics on the current research and development in water resources engineering. (offered under special circumstance)

2112698 Seminar in Water Resources 1(0-3-1)
Engineering

Discussion of special topics related to advanced water resources engineering; analysis of data and conclusion; presentation of reports.

2112798 Seminar in Water Resources 1(0-3-1)
Engineering   II

Discussion of special topics related to advanced research works in water   resources engineering; analysis of data and conclusions; presentation of reports.

2112799 Seminar in Water Resources 1(0-3-1)
Engineering   III
Condition : Prerequisite   2112798 or Consent of Faculty

Discussion of special topics related to advanced research works in water   resources engineering; analysis of data and conclusions presentation of reports.

2112811 Thesis 12(0-0-0)

2112816 Thesis 36(0-0-0)

2112828 Dissertation 48(0-0-0)

2112829 Dissertation 60(0-0-0)

2112830 Dissertation 72(0-0-0)

2101894 Doctoral Dissertation Seminar 0(0-0-0) *(S/U)*

2112897 Qualifying Examination 0(0-0-0) *(S/U)*

International School of Engineering (ISE)

VISION

ISE aims for Internationalization of Engineering under the determination of Chulalongkorn University in educating students with Knowledge and Morality and the promotion of Thai culture

MISSION
- Teaching Engineering in English for both undergraduate and postgraduate students
- Promote and support research for academic excellence
- Support academic **services** for both domestic and international organizations
- Promote moral and Thai culture
- Support services after graduation for both career and higher education

ISE VALUES
- A unit under the Faculty of Engineering which has an excellence in academic, research and services in Engineering
- Readiness in human resources and forefront in teaching and learning
- Domestic and international collaboration with universities and Industries

ISE Executive Board (2018)

Chairman
Dean
Supot   Teachavorasinskun,Assoc.Prof.Dr.

Member
Associate Dean
Kasem   Choocharukul,Assoc.Prof.Dr.
Tawatchai   Charinpanitkul,Assoc.Prof.Dr.
Jirawat   Chewaroungroaj,Asst.Prof.Dr.
Anongnat   Somwangthanaroj,Assoc.Prof.Dr.
Manop   Wongsaisuwan,Asst.Prof.Dr.
Sanphet   Chunithipaisan,Asst.Prof.Dr.
Atiwong   Suchato,Assoc.Prof.Dr.
Pisut   Painmanakul,Assoc.Prof.Dr.

Assistant Dean
Thanyarat   Singhanart,Assoc.Prof.Dr.
Charnchai   Pluempittiwiriyawej,Asst.Prof.Dr.
Chaiyachet   Saivichit,Asst.Prof.Dr.
Niphon   Wansophark,Asst.Prof.Dr.
Sukree   Sinthupinyo,Asst.Prof.Dr.
Falan   Srisuriyachai,Dr.
Sirikanya   Singcuna
Phannee   Saengkaew,Dr.
Sawekchai   Tangaramvon,Dr.
Pimporn   Ponpesh,Dr.
Chotirat   Ratanamahatana,Assoc.Prof.Dr.

Other Administrative Position
On-anong   Larpparisudthi,Asst.Prof.Dr.
Duangporn   Pisanusan
Sanguan   Purahong
Wipapan   Pinkaew

Head of Department
Head of the Department of Mechanical Engineering
Pairod   Singhatanadgid,Assoc.Prof.Dr.
Head of the Department of Electrical Engineering
Komson   Petcharaks,Asst.Prof.Dr.
Head of the Department of Computer Engineering
Natawut   Nupairoj,Asst.Prof.Dr.
Head of the Department of Industrial Engineering
Paveena   Chaovalitwongse,Assoc.Prof.Dr.
Head of the Department of Chemical Engineering
Varong   Pavarajarn,Assoc.Prof.Dr.

Director
Witaya   Wannasuphoprasit,Asst.Prof.Dr.

Associate Director
Tawan   Paphapote,Asst.Prof.Dr.
Artiwan   Shotipruk,Prof.Dr.
David   Banjerdpongchai,Prof.Dr.

Undergraduate curricula

International School of Engineering (ISE) was formed to serve as a channel for the Faculty of Engineering, Chulalongkorn University to keep abreast with the world's challenges. Four diverse but complementary fields of study are offered at undergraduate level:
- Nano Engineering   (NANO)
- Automotive Design and
  Manufacturing Engineering   (ADME)
- Aerospace Engineering   (AERO)
- Information and Communication   (ICE)
  Engineering

Academic calendar for Undergraduate curricula

International semester system follows the international program time table set by Chulalongkorn University:
First semester: Fall (August – December)
Second semester: Spring (January – May)
Optional: Summer (June – July)

Graduate curricula

Furthermore, ISE offers post-graduate programs to produce graduates with the knowledge in multidisciplinary and advanced engineering fields. Our graduates will be equipped with skills in engineering and management and be able to interact with the international academic society:
- Master program in Infrastructure in Civil Engineering

Academic calendar for Graduate curricula

International graduate school of faculty of engineering uses the usual semester thai - programs in Chulalongkorn University:
First semester: June – September
Second semester: November – February
Optional: April – May

Contact:
International School of Engineering (ISE)
Building no.2, Room 107
Faculty of Engineering
Chulalongkorn University
Phayathai Road, Pathumwan
Bangkok 10330
Tel. 02-218 6422-3
Fax. 02-218 6424
http://www.ise.eng.chula.ac.th
Email: ise@eng.chula.ac.th

NANO ENGINEERING CURRICULUM
(INTERNATIONAL PROGRAM)

Nano Engineering program is a multi-disciplinary scheme in which students learn how to understand and engineer various functional systems at the atomic scale. Sub – microsco - pically the physical, chemical, and biological properties of materials are different those   of bulk forms in the macroscopic level from Uncovering these unique characteristics propels the groundbreaking research and development of novel applications, making nano - technology the next industrial revolution.

Nano Engineering program aims to develop produce undergraduate students with strong backgrounds in biomedical chemical, electrical, and materials engineering. Medicine, plastic, materials research, and high performance electronics are just some of the many areas in which development on the nano scale are becoming a major force for technological improvement. Upon completion of their degree, our students form a unique and important human resource pool, capable of driving manufacturing and services industries towards future success.

Nano Engineering curriculum has offered two majors in Nano-Engineering and Bio-Nano Engineering. By which, all students have to make a decision on their field in the third semester.

Each student is required to accumulate a minimum of 146 credits to graduate for Bachelor of Engineering Program in Nano-Engineering (International Program) which also includes 2 credits of industrial training and 4 credits of senior project.

Curriculum board

Phulporn Saengbangpla	M.Sc (Machester, UK)
Pramote Dechaumphai	Ph.D. (Virginia)
Ekachai Leelarasmee	Ph.D. (California)
Asi Bunyajitradulya	Ph.D. (California)
Siriporn Damrongsakkul	Ph.D. (London)
Atiwong Suchato	Ph.D. (Massachusetts)
Patama Visuttipitukul	Ph.D. (Tokyo)
Sunhapos Chatranuwathana	Ph.D. (Michigan)
Chaodit Aswakul	Ph.D. (London)
Yan Zhao	Ph.D. (London)
Surapong Sirikulvadhana	M.S (Michigan)
Varong Pavarajarn	Ph.D. (Oregon)

Professors

Electrial Engineering
David   Banjerdpongchai,   Ph.D.(Stanford)

Chemical Engineering
Artiwan   Shotipruk,   Ph.D.(Michigan, Ann Arbor)

Associate Professors

Electrical Engineering
Songphol   Kanjanachuchai,   Ph.D.(Cambridge)
Nisachon   Tangsangiumvisai,   Ph.D.(London)

Mechanical Engineering
Asi   Bunyajitradulya,   Ph.D.(UC, Irvine)

Chemical Engineering
Deacha   Chatsiriwech,   Ph.D.(Imperial College)
Tharathon   Mongkhonsi,   Ph.D.(London)
Sarawut   Rimdusit   Ph.D.(U.S.A.)
Anongnat   Somwangthanaroj,   Ph.D.(Michigan)

Metallurgical and materials Engineering

Seksak   Asavavisitchai,   Ph.D.(Nottingham)

Assistant Professors

Electrical Engineering
Arporn   Teeramongkonrasmee, Ph.D.(Chula)
Widhyakorn Asdornwised,   D.Eng.(Chula)
Manop   Wongsaisuwan,   D.Eng.(T.I.T.)
Chanchana   Tangwongsan,   Ph.D.(Wisconsin)
Chanchai   Pluempitiwiriyawej, Ph.D. (Carregie Mellan)
Thavatchai Tayjasanant,   Ph.D.(Canada)

Mechanical Engineering
Nopdanai   Ajavakom   Ph.D.(UC,Berkeley)
Niphon   Wonsophark   D.Eng.(Chula)
Thanyarat   Singhanart,   Ph.D.(Tokyo)
Alongkorn   Pimpin,   Ph.D. (Tokyo)

Chemical Engineering

Varong	Pavarajarn,	Ph.D.(Oregon State)
Sorada	Kanokpanont,	Ph.D.(Drexel)
Kasidit	Nootong,	Ph.D.(Pennsyvania)
Soorathep	Kheawhom,	Ph.D.(Tokyo)

Metallurgical and materials Engineering
| Ittipon | Diewwanit, | Sc.D.(MIT) |
| Patama | Visuttipitukul, | Ph.D.(Tokyo/Japan) |

Industrial Engineering
| Daricha | Sutivong | Ph.D.(Stanford) |

Lecturer

Electrical Engineering
Chanin	Wissawinthanon	Ph.D.(USA.)
Boonchuay	Supmonchai	B.Eng.(Chula)
Supatana	Auethavekiat	Ph.D. (Tokyo)

Mechanical Engineering
| Tawan | Paphapote | M.S.(Lllinolis) |
| Werayut | Srituravanich | Ph.D.(UCLA) |

Chemical Engineering
| Akawat | Sirisuk, | Ph.D.(Wisconsin) |
| Varun | Taepaisitphongse, | Ph.D.(UCLA) |

Environmental Engineering
| Achariya | Suriyawong, | Ph.D.(St.Louis) |

Computer Engineering
| Chate | Patanothai, | M.Sc.in EE.(Miami) |

ISE Staffs
Yan	Zhao,	Ph.D.(London)
Porpin	Pungetmongkol	Ph.D.(Tokyo)
Rehan	Hussain	Ph.D.(Cambridge)

Visiting Professor
| Pensri | Thongnopneua | Ph.D. |
| Suthiluk | Patumraj | Ph.D.(New Jersey) |

Assistant Professors
| Wuthichai | Wongthatsanekorn | Ph.D.(U.S.A.) |

Lecturer
Niti	Yongvanich	Ph.D. (Pennsylvania)
Nuwong	Chollacoop	Ph.D.(U.S.A.)
Pahnit	Seriburi	Ph.D.
Pimporn	Uttayarat	Ph.D. (Pennsylvania)
Yupawadee	Sathirakul	Ph.D.
Wibool	Piyawattanametha	Ph.D. (Los Angeles)
Viriya	Udomphol	Ph.D.
Akarin	Phaibulpanich	Ph.D.(Michigan)
Adisorn	Tuantranont	Ph.D(Colorado)
Anurat	Wisitsoraat	Ph.D.(U.S.A.)
Oratai	Jongprateep	Ph.D.(U.S.A.)
Wuthichai	Wongthatsanekorn	Ph.D.

| Benjaratg | Pupacdi | Ph.D. |

Curriculum
| Total number of credits requirement | 147 | credits |

| General Education | 30 | credits |

Core Courses	111	credits
Basic Sciences	22	credits
Basic Engineering	20	credits
Compulsory Nano Engineering	33	credits

Compulsory for Major		
A. Biomedical Nanotechnology	18	credits
B. Nano Materials Science	21	credits

Approved Electives		
A. Biomedical Nanotechnology	18	credits
B. Nano Materials Science	15	credits

| Free Electives | 6 | credits |

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1. General Education — 30 credits
Social Science	3	credits
Humanity	3	credits
Interdisciplinary	3	credits
Science and Mathematics	3	credits

General Education (Special) — 6 credits
| 2140111 | Exploring Engineering World | 3(3-0-6) |
| 2141100 | Introduction to Nanotechnology | 3(3-0-6) |

Foreign Language — 12 credits
5501112	Communicative English I	3(3-0-6)
5501123	Communicative English II	3(3-0-6)
5501214	Communication and Presentation Skills	3(3-0-6)
5501225	Technical Writing	3(3-0-6)

2. Core Course — 111 credits

Basic Mathematics and Sciences — 22 credits
2301107	Calculus I	3(3-0-6)
2301108	Calculus II	3(3-0-6)
2302103	General Chemistry Laboratory	1(0-3-0)
2302105	Chemistry for Engineers	3(3-0-6)
2303111	Biology for Engineers	3(3-0-6)
2303112	Biology Laboratory for Engineers	1(0-3-0)
2304153	Physics for Engineers	3(3-0-6)
2304154	Physics and Electronics for Engineers	3(3-0-6)
2304193	Physics Laboratory for Engineers	1(0-3-0)
2304194	Physics and Electronics Laboratory for Engineers	1(0-3-0)

Basic Engineering — 20 credits
2140301	Industrial Training	2(0-6-0)
2182210	Electrical Circuit	3(3-0-6)
2182213	Electric Circuit Laboratory	1(0-3-0)
2183101	Engineering Graphics	3(2-3-4)
2183211	Engineering Mechanics	4(4-0-8)

2184303	Engineering Management	3(3-0-6)		

Code	Course	Credits
2184303	Engineering Management	3(3-0-6)
2190101	Computer Programming	3(3-0-6)
2190151	Computer Programming Laboratory	1(0-3-0)

Compulsory for Nano Engineering		*33 credits*
2141290	Statistic and Research Methodology for Nano Engineers	3(3-0-6)
2141302	Nanofabrication Technology	3(3-0-6)
2141490	Nano Seminar	4(1-0-2)
2141498	Nano-Engineering Pre-Project	1(0-2-1)
2141499	Nano-Engineering Project	3(0-6-3)
2182201	Mathematics for Nano-Engineering	3(3-0-6)
2189202	Fundamental of Materials Science and Engineering	3(3-0-6)
2182312	Signal Processing and Instrumentation	3(3-0-6)
2302106	Basic Organic Chemistry	3(3-0-6)
2302203	Organic Chemistry Laboratory	1(0-3-0)
2185222	Physical Chemistry for Nano-Engineering	3(3-0-6)
2185333	Transport Phenomena	3(3-0-6)
2189341	Materials Characterization	3(3-0-6)

Major		
A. Biomedical Nanotechnology		*18 credits*
2141355	Introduction to Bioengineering	3(3-0-6)
2141357	Cells Biology and Human Body	3(3-0-6)
2189356	Materials for Biomedical Applications	3(3-0-6)
2302207	Basic Inorganic Chemistry	2(2-0-4)
2185373	Reaction Engineering	3(3-0-6)
2310380	Biochemistry for Bioengineers	3(3-0-6)
2310381	Biochemistry Laboratory for Bioengineers	1(0-3-0)

B. Nano Materials Science		*21 credits*
2141305	Nanostructures and Crystalline Defects	3(3-0-6)
2185302	Thermodynamics in Materials Engineering	3(3-0-6)
2185379	Polymer Engineering	3(3-0-6)
2189322	Phase Transformations and Kinetics	3(3-0-6)
2189370	Physical Metallurgy	3(3-0-6)
2189411	Mechanical behavior of materials	3(3-0-6)
2189450	Materials Design and Selection	3(3-0-6)

Approved Electives		
A .Biomedical Nanotechnology		*18 Credits*

Select 18 Credits in the following list

2141347	Introduction to Pharmaceutical Nanotechnology	3(3-0-6)
2141407	Nanomaterial Toxicology	3(3-0-6)
2141459	Biointerface Engineering	3(3-0-6)
2141457	Introduction to Biomedical Imaging	3(3-0-6)
2141458	Introduction to Assistive and Rehabilitation Technology	3(3-0-6)
2141556	Applied Genetic Engineering	3(3-0-6)
2141557	Engineering Systems for Regenerative Medicine	3(3-0-6)
2141561	Advance Topic in Bioengineering 1	1(1-0-2)
2141562	Advance Topic in Bioengineering 2	2(2-0-4)
2141563	Special Topic in Bioengineering 1	3(3-0-6)

2141564	Special Topic in Bioengineering 2	3(3-0-6)
2141565	Special Topic in Bioengineering 3	3(3-0-6)
2182450	Biomedical Instrumentation	3(3-0-6)
2183412	Micro and Nano-Electro Mechanical Systems	3(3-0-6)
2183452	Biomechanics	3(3-0-6)
2185379	Polymer Engineering	3(3-0-6)
2185452	Biosystems and Biotransport	3(3-0-6)
2185455	Bioreactor	3(2-1-6)
2190456	Introduction to Bioinformatics	3(3-0-6)

B. Nano Materials Science		*15 credits*

Select 15 Credits in the following list

2141405	Surfaces and Thin Films	3(3-0-6)
2141459	Biointerface Engineering	3(3-0-6)
2141501	Advance Topic in Advanced Material engineering I	1(1-0-2)
2141502	Advance Topic in Advanced Material engineering II	2(2-0-4)
2141503	Special Topic in Advanced Material engineering I	3(3-0-6)
2141504	Special Topic in Advanced Material engineering II	3(3-0-6)
2141505	Special Topic in Advanced Material engineering III	3(3-0-6)
2183412	Micro and Nano-Electro Mechanical Systems	3(3-0-6)
2185373	Reaction Engineering	3(3-0-6)
2302389	Intermediate Inorganic Chemistry	3(3-0-6)
2189356	Materials for Biomedical Applications	3(3-0-6)
2189405	Ceramics and Glasses	3(3-0-6)
2189415	Materials for Energy	3(3-0-6)
2189417	Composite materials	3(3-0-6)
2189570	Electronic Materials	3(3-0-6)
2189581	High Performance Metals and Alloys	3(3-0-6)
2190401	Computation, Modelling and Problem Solving	3(3-0-6)

3. Free Electives　　　　　　　　**6　credits**

Select 6 credits from any courses offered in English by any International Programs in Chulalongkorn University.

NANO ENGINEERING CURRICULUM
(INTERNATIONAL PROGRAM)

A. BIOMEDICAL NANOTECHNOLOGY

OURSE NO.	SUBJECT	CREDITS
FIRST SEMESTER		
2190101	Computer Programming	3
2190151	Computer Programming Laboratory	1
2301107	Calculus I	3
2140111	Exploring Engineering World	3
2304153	Physics for Engineers	3
2304193	Physics Laboratory for Engineers	1
5501112	Communicative English I	3
		17
SECOND SEMESTER		
2141100	Introduction to Nanotechnology	3
2183101	Engineering Graphics	3
2302105	Chemistry for Engineers	3
2302103	General Chemistry Laboratory	1
2301108	Calculus II	3
2304154	Physics and Electronics for Engineers	3
2304194	Physics and Electronics Lab for Eng	1
5501123	Communicative English II	3
		20
THIRD SEMESTER		
2182201	Mathematics for Nano-Engineering	3
2182210	Electrical Circuit	3
2183211	Engineering Mechanics	4
2189202	Fundamental of Materials Sci and Eng	3
2303111	Basic Organic Chemistry	3
2185221	Organic Chemistry Laboratory	1
5501214	Communication and Presentation Skills	3
		20
FOURTH SEMESTER		
2141290	Statist and Research Methodology for Nano-Eng	3
2182213	Electrical Circuit Laboratory	1
2303111	Biology for Engineers	3
2303112	Biology Laboratory for Engineers	1
2185222	Physical Chemistry for Nano – Eng	3
2302207	Basic Inoraganic Chemistry	2
5501225	Technical Writing	3
xxxxxxx	General Education	3
		19

COURSE NO.	SUBJECT	CREDITS
FIFTH SEMESTER		
2189341	Materials Characterization	3
2182312	Signal processing and instrumentation	3
2141355	Introduction to Bioengineering	3
2185373	Reaction Engineering	3
2310380	Biochemistry for Bioengineers	3
2310381	Biochemistry Lab for Bioengineers	1
xxxxxxx	General Education	3
		19
SIXTH SEMESTER		
2184303	Engineering Management	3
2141302	Nanofabrication Technology	3
2185333	Transport Phenomena	3
2141357	Cells Biology and Human Body	3
2189356	Material for Biomedical Applications	3
xxxxxxx	General Education	3
		18
SUMMER SEMESTER		
2140301	Industrial Training	2
		2
SEVENTH SEMESTER		
2141498	Nano - Engineering Pre-Project	1
xxxxxxx	Approved Electives	3
xxxxxxx	Approved Electives	3
xxxxxxx	Approved Electives	3
xxxxxxx	Approved Electives	3
xxxxxxx	Free Elective	3
		16
EIGTHTH SEMESTER		
2141490	Nano Seminar	1
2141499	Nano Engineering Project	3
xxxxxxx	Approved Electives	3
xxxxxxx	Approved Electives	3
xxxxxxx	Free Elective	3
xxxxxxx	General Education	3
		16

TOTAL CREDITS FOR GRADUATION   **147**

NANO ENGINEERING CURRICULUM
(INTERNATIONAL PROGRAM)

B. NANO MATERIALS SCIENCE

OURSE NO.	SUBJECT	CREDITS
	FIRST SEMESTER	
2190101	Computer Programming	3
2190151	Computer Programming Laboratory	1
2301107	Calculus I	3
2140111	Exploring Engineering World	3
2304153	Physics for Engineers	3
2304193	Physics Laboratory for Engineers	1
5501112	Communicative English I	3
		17
	SECOND SEMESTER	
2141100	Introduction to Nanotechnology	3
2183101	Engineering Graphics	3
2302105	Chemistry for Engineers	3
2302103	General Chemistry Laboratory	1
2301108	Calculus II	3
2304154	Physics and Electronics for Engineers	3
2304194	Physics and Electronics Lab for Eng	1
5501123	Communicative English II	3
		20
	THIRD SEMESTER	
2182201	Mathematics for Nano-Engineering	3
2182210	Electrical Circuit	3
2183211	Engineering Mechanics	4
2189202	Fundamental of Materials Sci and Eng	3
2303111	Basic Organic Chemistry	3
2303112	Biology Laboratory for Engineers	1
5501214	Communication and Presentation Skills	3
		20
	FOURTH SEMESTER	
2141290	Statist and Research Methodology for Nano-Eng	3
2182213	Electrical Circuit Laboratory	1
2303111	Biology for Engineers	3
2303112	Biology Laboratory for Engineers	1
2185222	Physical Chemistry for Nano – Eng	3
2302207	Basic Inoraganic Chemistry	2
5501225	Technical Writing	3
xxxxxxx	General Education	3
		17

COURSE NO.	SUBJECT	CREDITS
	FIFTH SEMESTER	
2189341	Materials Characterization	3
2182312	Signal processing and instrumentation	3
2141305	Nanostructures and Crystalline Defects	3
2185302	Thermodynamics in Materials Eng	3
2185379	Polymer Engineering	3
xxxxxxx	General Education	3
		18
	SIXTH SEMESTER	
2184303	Engineering Management	3
2141302	Nanofabrication Technology	3
2185333	Transport Phenomena	3
2189322	Phase Transformations and Kinetics	3
2189370	Physical Metallurgy	3
xxxxxxx	General Education	3
		18
	SUMMER SEMESTER	
2140301	Industrial Training	2
		2
	SEVENTH SEMESTER	
2141498	Nano - Engineering Pre-Project	1
2189411	Mechanical Behavior of Materials	3
xxxxxxx	Approved Electives	3
xxxxxxx	Approved Electives	3
xxxxxxx	Approved Electives	3
xxxxxxx	Free Elective	3
xxxxxxx	General Education	3
		19
	EIGTHTH SEMESTER	
2141490	Nano Seminar	1
2141499	Nano Engineering Project	3
2189450	Materials Design and Selection	3
xxxxxxx	General Education	3
xxxxxxx	General Education	3
xxxxxxx	Free Elective	3
		16

TOTAL CREDITS FOR GRADUATION   **147**

COURSES DESCRIPTIONS IN NANO ENGINEERING (B.ENG)

General Education (Special)

2140111 Exploring Engineering World   3(3-0-6)

Engineering topics related to daily life: energy, resources, environment, manufacturing process, industry, material, automotive, infrastructure, information system and bioengineering.

2141100   Introduction to Nanotechnology   3(3-0-6)

Overview of nanotechnology: What is nanotechnology, Nanotechnology in daily life, fundamental knowledge and its applications, working at nanoscale, trends of nanoscience in industry, life and health.

Foreign Language

5501112 Communicative English I   3(3-0-6)

Practice language skills in acquiring information and knowledge from different sources and media in subjects of students' interest under selected themes; collecting information, summarizing and presenting important issues.

5501123   Communicative English II   3(3-0-6)
        CONDITION: PRER 550112
        Communicative English I

Practice language skills in acquiring analyzing and synthesizing information and knowledge from different sources and media on topics of students' interest under selected themes; summarizing what they have learned, and presenting opinions from group discussion.

5501214   Communication and Presentation
        Skills   3(3-0-6)
        CONDITION: PRER 5501123
        Communicative English II

Practice using English for social communication and giving oral presentation on engineering-related topics.

5501225   Technical Writing   3(3-0-6)
        CONDITION: PRER 5501123
        Communicative English II

Practice in writing summaries composing different types and styles of writing in the field of engineering and writing reports of studies and experiments.

Core Courses
Basic Sciences

2301107   Calculus I   3(3-0-6)

Limits; continuity; differentiation; applications of differentiation; integration; applications of definite integral; transcendental functions; techniques of integration; improper integrals; first-order differential equations.

2301108   Calculus II   3(3-0-6)
        CONDITION: PRER 2301107 Calculus I

Sequences and infinite series; convergence tests; power series; Taylor series; lines; planes, and quadric surface in three-dimensional space; calculus of vector-valued functions; line integrals; limits and continuity of functions of several variables; partial derivatives; directional derivatives and gradients; Lagrange multipliers; multiple integrals.

2302103   General Chemistry Laboratory   1(0-3-0)

Standard solution preparation; qualitative analysis; titration; electrochemistry; pH metric titration; spectroscopy; calculation and evaluation of data; calibration curve; introduction to polymer.

2302105   Chemistry for Engineers   3(3-0-6)

Structure of atoms; chemical bonding; ionic bonding, covalent bonding, valence bond theory, hybridization-interaction coordination, intermolecular forces, molecular movement; state of matter: gases, structure of solid, liquid, and solutions; chemical reactions; interaction of matters with electromagnetic radiation and electrical energy; chemical thermodynamics.

2303111   Biology for Engineers   3(3-0-6)

Biological principles; cell structures and functions; functions of organelles and sub-cellular structures; chemical basis of life; metabolism and cellular energy processes including regulatory mechanisms; structural organization in relation to functions of organisms; cellular physiology; maintenance the homeostasis of life; continuity of life through inheritance; cellular and molecular basis of development; molecular genetics; evolution theory and evolution of populations; biological diversity; life responses to environmental changes; biological applications in nanotechnology.

2303112   Biology Laboratory for Engineers   1(0-3-0)

Biological experiments which accord with Biology for Engineer.

2304153   Physics for Engineers   3(3-0-6)

Mechanics of particles and rigid bodies; properties of matter; fluid mechanics; heat; vibrations and waves; elements of electromagnetism; optics; modern physics.

2304154 Physics and Electronics
        for Engineers   3(3-0-6)

Electricity; DC circuits; AC circuits; basic electronics; solid state devices; electrical actuators.

2304193   Physics Laboratory   1(0-3-0)
        for Engineers

Measurement and precision; experiments on simple harmonic motion; radius of gyration; dynamics of rotation; velocity of sound; viscosity of fluids.

2304194   Physics and Electronics   1(0-3-0)
        Laboratory for Engineers

Resistance and electromotive force measurements; experiments on ampmeter; voltmeter; oscilloscope; AC

circuit; transistor; lenses and mirrors; polarization; interference; diffraction.

Basic Engineering

2140301 Industrial Training   2(0-6-0)
Condition: PRER 2301108 Calculus II
Engineering practice in related areas under supervision of experienced engineers in private sectors or government agencies.

2182210 Electrical Circuit   3(3-0-6)
CONDITION: PRER 2304154 Physics and Electronics for Engineers
DC circuit analysis; Kirchhoff's laws; Thevenin's and Norton's theorem; Semiconductor devices; op-amps; digital circuit; DC motor.

2182213 Electrical Circuit Laboratory   1(0-3-0)
Condition: PRER 2301108 Calculus II
Electronic instruments; Multimeter; oscilloscope; DC circuit; Voltage regulators; Filter circuit; Transistor amplifier circuit; Op-amp circuits; Digital circuits; DC motor.

2183101 Engineering Graphics   3(2-3-4)
Lettering; orthographic projections; sketching and drawing; pictorial drawing; dimensioning' tolerancing and geometrical tolerancing; section; working drawing; mechanical parts drawing; introduction to CAD.

2183211 Engineering Mechanics 3(3-0-6)
Analysis of force systems and their equilibrium as applied to engineering systems; Stresses and strains; Mechanical properties of materials; Hooke's law, elastic modulus, stress in beam, shear force, bending moment diagram, torsion, buckling of columns, Mohr's circle.

2184303 Engineering Management   3(3-0-6)
Modern management principles; methods of increasing productivity; human relations; industrial safety; pollution problems; commercial laws; basics of engineering economy, finance, marketing, and project management.

2190101 Computer Programming   3(3-0-6)
Introduction to computer systems; problem-solving using computers; programming style and convention, control statements, data handling and processing; subprograms; classes and objects.

2190151 Computer Programming   1(0-3-0)
Laboratory
Computer programming in Engineering; reviews of computer programming concepts; hands-on experience on computer programming using contemporary engineering tools

Compulsory for Nano Engineering
2141290 Statistic and Research   3(3-0-6)
Methodology for Nano Engineers
Introduction to random process; Research formulation, research objectives, basic procedure for doing research; Statistical method for research; Analysis of data and its

implication; Integration of statistics in engineering applications.

2141302 Nanofabrication Technology   3(3-0-6)
Structure and performance of nanomaterials; Principle of nanostructured materials synthesis, crystal growth, stabilization of nanomaterials; Nanoparticle syntheses; Syntheses of nanowire; Fabrication of thin film, Lithography; Special techniques for nanostructured materials fabrication.

2141490 Nano Seminar   4(1-0-2)
Seminar on interesting topics related to Nano-Engineering

2141498 Nano-Engineering Pre-Project   1(0-2-1)
Problem–solving framework; Guidelines for problem solving and solution from Nano-Engineering project.

2141499 Nano-Engineering Project   3(0-6-3)
Group or individual project on a subject related to Nano or Bio-Nano-Engineering.

2182201 Mathematics for Nano-Eng   3(3-0-6)
Condition : PRER2301108 Calculus II
Systems of Linear Equations, Determinants, Vector Spaces, Subspaces, Null Space, Column Space, Row Space, Kernel and Range of a Linear Transformation, Linear Independence, Basis, Coordinate Systems, Dimension, Rank, Change of Basis, Eigenvalues, Eigenvectors, Diagonalization, First-order Differential Equation, Linear Second-order Differential Equation, Reduction of Order, Euler' Equation, Power Series Solution, Frobenius Method, Partial Differential Equation, Boundary Value Problem, Tensor and its Convention, Indicial Notation, Rank of Tensor, Kronecker Delta Tensor, Symmetric and Skew-Symmetric Tensor, Summation Convention, Tensor Operator, E-Permutation Tensor and its Relationship with Kronecker Delta Tensor, Indicial Manipulation in Vector Calculus, Gradient/Divergence/Curl in Tensor Formulation,Tensor Rotation, Introduction to Quantum Mechanics, Schrodinger's Equation, Particle in a Box, Hermitian, Dirac's BraKet, Eigenvalue, Eigenfunction, Expectation Values, Overview of Nanotechnology, Applications to Scanning Tunneling Microscope Image.

2189202 Fundamental of Materials   3(3-0-6)
Science and Engineering
Atomic structures and bonding in solids; Crystallography; Surfaces and interfaces; Crystal defects; Phase equilibrium diagrams; Solid solution and compounds; Polymeric materials; Amorphous materials; Material properties; Relationship between micro- and nano-structures and properties of engineering materials; Classes of engineering materials, material processing and real-world applications.

2182312 Signal Processing and   3(3-0-6)
Instrumentation

CONDITION: PRER 2182210 Electrical Circuit

Basic electromechanical techniques used in modern instrumentation and control systems; Use of transducers and actuators; Signal conditioning, grounding, and shielding; Analog and digital signal processing and feedback control methods with emphasis on frequency domain techniques; Low-level measurements; Lock-in technique frequency response of continuous and discrete systems.

2302106   Basic Organic Chemistry   3(3-0-6)

Structure and bonding, stereochemistry, spectroscopy, hydrocarbon, halogen-containing compounds, oxygen-containing compounds, nitrogen-containing compounds, biomolecules.

2302203   Organic Chemistry Laboratory   1(0-3-0)
CONDITION: PRER 2302103 General Chemistry Laboratory

Fundamental laboratory techniques concerning the separation, purification and determination of physical constants of organic compounds; Chemical reactions of organic compounds of various functional groups; Synthesis of certain target molecules.

2185222   Physical Chemistry for   3(3-0-6)
Nano-Engineering

Basic concept of thermodynamics; Thermodynamics laws; Phase rule; Phase equilibrium; Principal of chemical kinetics; Rate of chemical reactions; Chemical equilibrium

2185333   Transport Phenomena   3(3-0-6)

Viscosity, mathematical models of momentum transports in isothermal fluid systems; Thermal conduction and convection; Mathematical models of energy transports in solids and in fluids for isothermal systems and non-isothermal systems; Diffusion in binary mixtures; Mathematical models of mass transports in isothermal mixtures without chemical reactions and with chemical reactions; Simultaneous mass and energy transports in fluid mixtures.

2189341   Materials Characterization   3(3-0-6)

Optical Microscopy, Scanning Probe Microscopy (SPM), Field Emission Scanning Electron Microscopy (FE SEM), Transmission Electron Microscopy (TEM) and Scanning TEM (STEM), Focused Ion Beam (FIB), Energy Dispersive X-Ray Spectroscopy (EDS), X-ray Reflectivity and Total Reflection X-ray Fluorescence, Auger Electron Spectroscopy (AES), Secondary Ion Mass Spectrometry (SMS), Surface Secondary Ion Mass Spectrometry Extended Profile (Surface SIMS XP), Time of Flight Secondary Ion Mass Spectrometry (TOF SIMS), Liquid Chromatography with Mass Spectroscopy (LCMS), Gas Chromatography with Mass Spectroscopy (GCMS), Fourier Transform Infrared Spectroscopy (FTIR) and X-Ray diffraction (XRD).

Compulsory for Major
A. Biomedical Nanotechnology

2141355   Introduction to Bioengineering   3(3-0-6)

Introduction to Biological and Biomedical engineering, Engineering of life science and medical technology; Application of biomolecular systems for engineering of cells, biomechanics, biological micro-electromechanical systems (Bio-MEMS), bioinformatics, genomics, bioelectronics, biosensor, bioimaging technology, tissue engineering, drug delivery system, pharmaceutical engineering, etc; The uses of multidisciplinary engineering knowledges in chemical engineering, electrical engineering, computer engineering, mechanical engineering, metallurgical engineering, environmental, nuclear engineering, etc; Study trips.

2141357   Cells Biology and Human Body   3(3-0-6)

Biological mechanisms occurring in a cell that maintain cell activities; Physiological processes of cell in human body, such as membrane transport, neurotransmission and muscle contraction; Basic structure of major organs integrated into various systems in human body; Anatomy and physiology of human body.

2189356   Materials for Biomedical   3(3-0-6)
Applications
Condition: PRER 2303111 Biology for engineers, or consent by instructor

Introduction to the interactions between cells and the surfaces of biomaterials; Surface chemistry and physics of selected metals, polymers, and ceramics; Modification of biomaterials surfaces; Biocompatibility and biodegradability; Medical implants; Acute and chronic response to implanted biomaterials; Recent development in metallic prostheses, biosensors, drug delivery system, tissue engineering and anti-microbial surface.

2302207   Basic Inorganic Chemistry   2(2-0-4)

Fundamental concepts in inorganic chemistry; Atomic structure; Chemical periodicity; Chemical bonding and molecular structures; Crystal structures; Inorganic solids; Symmetry and group theory, Molecular orbitals

2185373   Reaction Engineering   3(3-0-6)
CONDITION: PRER: 2302105 Chemistry for Engineers, or consent by instructor

Fundamental of reaction engineering; reaction rate laws, kinetics, mechanisms of homogeneous and heterogeneous reactions, catalysis reactions, biological reactions, analysis of reaction rate data, basic design of reactors.

2310380   Biochemistry for Bioengineers   3(3-0-6)

Fundamental concepts in biochemistry and molecular biology; Chemical and biological properties of biomolecules; Biochemical Reactions; Enzymes; Metabolic Pathways; Molecular genetics; Protein synthesis; Basic of genetic engineering.

2310381   Biochemistry Laboratory for   1(0-3-0)
Bioengineers

Laboratory in biochemistry and molecular biology including the use of computer programs according to Biochemistry for Bioengineers course. Biochemistry Laboratory for Bioengineers

B. Nano Materials Science

2141305 Nanostructures and Crystalline   **3(3-0-6)**
      Defects

Laws and theories governing the synthesis and the control of nanomaterial system; Free energy and kinetic principles involved in synthesis, assembly, structure and performance of nanomaterials; Crystal interfaces and structures of nanomaterial; Defects in crystals; Point defects, line defects, planar defects; Motion of dislocations; Effect of impurities on solid-state material properties.

2185302 Thermodynamics in Materials   **3(3-0-6)**
      Engineering
      CONDITION: PRER 2185222 Physical
      Chemistry for Nano – Engineering

Treatment of the first, second and third law of thermodynamics; Free energies as a function of temperature, pressure and chemical potential; Numerical calculation of free energies from available thermodynamic data; Phase equilibria in single- and multi-component systems; Phase diagrams; Electrochemical equilibria and surface thermodynamics; Introduction to statistical thermodynamics; Application of thermodynamics to treat general phenomena in materials engineering.

2185379 Polymer Engineering   **3(3-0-6)**

Definitions and basic concepts; Crystalline and amorphous polymer; Molecular architecture; Conformation and morphology; Polymer synthesis; Transition phenomena; Mechanical properties affected by transition phenomena; Theory of rubber elasticity; Polymer rheology; Types of mechanical deformations; Basic rheological response; Viscoelastic properties of polymer; Linear viscoelastic models; Synthesis of controlled architecture polymers; Morphological characterization; Block copolymers; Polymer surfaces and interfaces; Nano-effects in polymer blends and composites; Applications of polymer nanotechnology for electronics and photonics

2189322 Phase Transformations and   **3(3-0-6)**
      Kinetics
      CONDITION: PRER 2185302* Thermodynamics
      in Materials Engineering

Phase equilibrium diagram; Phase transformation; Microstructure evolution; Diffusion; Rates of diffusion; Morphological instabilities; Crystal interfaces; Nucleation and growth; Effects of temperature and driving force on transformations and microstructure; Solid-state diffusion; Spinodal decomposition; Diffusionless transformations and kinetics.

2189370 Physical Metallurgy   **3(3-0-6)**

CONDITION: PRER 2189202* Fundamental of
      Materials Science and Engineering

Physical basis that links the structure of materials with their properties; Material processing including casting, welding, thermomechanical processing; Heat treatment; Plastic deformation; strengthening and toughening mechanism in metals and ceramics; Recovery, recrystallization, grain growth; Microstructural control; Oxidation and corrosion.

2189411 Mechanical behavior of materials   **3(3-0-6)**
      CONDITION: PRER 2183211 Engineering
      Mechanics

Theory elasticity; theory of plasticity; Dislocation theory; Mechanical failure; Fractures, fatigue, creep, embrittlement; Materials testing; Tension, hardness, torsion, impact, fatigue, creep; Fracture mechanics; Mechanical behavior of composite materials.

2189450 Materials Design and Selection   **3(3-0-6)**

Criteria and concept in design; Materials selection process; Production and cost functions; Materials property charts, and performance indices; Decision analysis; Case studies of materials design and selection in real-world applications.

Approved Electives
A .Biomedical Nanotechnology

2141347 Introduction to Pharmaceutical   **3(3-0-6)**
      Nanotechnology

Importance of nanotechnology in enhancing pharmaceutical technology; Fundamental pharmaco-kinetics for engineers; Reviews of the types and characteristics of physico-chemical properties of biomaterials produced in Thailand; Fabrication technology of nanomaterials: nanoparticles, micelles, vesicles, liposomes, microemulsions, nanocolloids, polymer multilayers, nanoporous materials and nanocapsules, as well as experimental techniques to characterize these nanomaterials; pharmaceutical technologies.

2141407 Nanomaterial Toxicology   **3(3-0-6)**
      Condition: PRER 2303111 Biology for
      engineers, or consent by instructor

Fundamentals of nanotoxicology; Exposure assessment for safe nanotechnology in environment and organisms; Biodistribution of engineered nanomaterials; Nanomaterial interactions with cell, genome and epigenome; Toxicity of nanoengineered materials in systemic organs; Use of nanomaterials in food and cosmetic products; Approach to Regulation of Nanotechnology Products; Laboratory evaluation of potential toxicity of engineered nanomaterials.

2141459 Biointerface Engineering   **3(3-0-6)**
      Condition: PRER 2189356* Materials for
      Biomedical Applications, or consent by
      instructor

Reviews of cell-material interactions and its applications. Surface energy and thermodynamics of biological molecules; Hydrophobicity of surfaces; Properties of extracellular matrics (ECM) of various types of cells; Cell migration, growth, and differentiation; Blood compatibility of materials; Physical and chemical technics for biosurface modifications; Morphology of surfaces; Evaluation of biocompatibility of materials; Case studies related to biointerfaces engineering such as biomineralization, biosensors, anti-microbial surface etc.

2141457 Introduction to Biomedical   3(3-0-6)
          Imaging
Various biomedical imaging modalities (x-rays, CT, MRI, ultrasound, PET, SPECT, etc.) and their applications in medicine and biology; Basic concepts of signal processing in two and three dimensions relevant to imaging physics, image reconstruction, image processing, and visualization.

2141458 Introduction to Assistive and   3(3-0-6)
          Rehabilitation Technology
Problems and basic rehabilitation techniques in various areas, e.g. visual and hearing disability, orthopaedics, stroke, etc.; Human centered concept and design of assistive and rehabilitation devices and technologies; Examples, e.g. wheelchairs, prostheses, hearings aids, visual aids, and specialized computer software and hardware.

2141556 Applied Genetic Engineering   3(3-0-6)
          Condition: PRER 2310380* Biochemistry for
          Bioengineering, or consent by instructor
Genetic coding; Mutation; Mutagenesis; Gene transfer; Genetically modified organisms (GMOs); Biomolecular engineering; Diagnostic DNA microarray; Large-Scale Protein Production; Antibody design and production for sensors/vaccines; DNA/RNA therapeutic delivery.

2141557 Engineering Systems for   3(3-0-6)
          Regenerative Medicine
          Condition: PRER 2303111 Biology for
          engineers, or consent by instructor
Basic knowledge of regenerative medicine and tissue regeneration; Components of tissue engineering; Cells and stem cells regeneration, biological signals and molecules, scaffolds, bioreactors, controlled release systems; Analysis and evaluation of tissue regeneration; Case studies in tissue engineering (such as skin, bone, vascular, etc.), cell therapy, drug and gene delivery, medical contrast agents, anti-aging medicine etc.

2141561 Advance Topic in   1(1-0-2)
          Bioengineering 1
Advance topics in the field of bioengineering

2141562 Advance Topic in   2(2-0-4)
          Bioengineering 2
Advance topics in the field of bioengineering

2141563 Special Topic in   3(3-0-6)
          Bioengineering I
Interesting topics in the field of bioengineering.

2141564 Special Topic in   3(3-0-6)
          Bioengineering II
Interesting topics in the field of bioengineering.

2141565 Special Topic in   3(3-0-6)
          Bioengineering III
Interesting topics in the field of bioengineering.

2182450 Biomedical Instrumentation   3(3-0-6)
Basic concepts of biomedical electronics and instrumentation, e.g. sensors, electrodes, amplifiers, etc.; Measurement of biopotential signals, heart rate, heart sound, blood pressure, blood flow and oxygen saturation; Therapeutic devices; Electrical safety in medical environment; Trend in biomedical instrumentation.

2183412 Micro and Nano-Electro   3(3-0-6)
          Mechanical Systems
Overview of MEMs; Scaling of micromechanical devices; Behavior and modeling of micromechanical devices; Mechanical properties of MEMs materials; Review of microfabrication; Bulk and surface micromachining; Applications of MEMs: pressure sensors, accelerometer; Micromotors; Micropumps and microvalves; Thermal sensors and actuators; Micromirror.

2183452 Biomechanics   3(3-0-6)
          Condition : PRER 2304153 Physics for
          engineers, or consent by instructor
Introduction to the biomechanics of human movement; Static and dynamic biomechanics; Forces and moments in human posture and movement; musculoskeletal anatomy; knowledge of joint mechanics and example of the analysis and design of artificial joints.

2185379 Polymer Engineering   3(3-0-6)
Definitions and basic concepts; Crystalline and amorphous polymer; Molecular architecture; Conformation and morphology; Polymer synthesis; Transition phenomena; Mechanical properties affected by transition phenomena; Theory of rubber elasticity; Polymer rheology; Types of mechanical deformations; Basic rheological response; Viscoelastic properties of polymer; Linear viscoelastic models; Synthesis of controlled architecture polymers; Morphological characterization; Block copolymers; Polymer surfaces and interfaces; Nano-effects in polymer blends and composites; Applications of polymer nanotechnology for electronics and photonics.

2185452 Biosystems and Biotransport   3(3-0-6)
Application of fundamental chemical engineering principles in the study of biological systems with emphasis on the current research in bioengineering, biochemical engineering and industrial applications

2185455 Bioreactor   3(2-1-6)

Condition: PRER 2185373 Reaction Engineering, or consent by instructor

Microbiological and enzymatic processes; Stoichiometry and kinetics of biotransformations; Kinetics of cell growth; Basic knowledge of bioreactor design and their cascades; Analysis of bioreactor dynamics; Batch vs. Continuous stirred tank bioreactors; Immobilized cell bioreactors extractive bioreactors; Animal cell and plant cell reactors; Examples of various types of bioreactors in foods, agricultural, environmental, pharmaceutical, and medical applications, such as stirred tank & rotating, packed bed, hollow-fiber, airlift, membrane bioreactors, etc.

2190456 Introduction to Bioinformatics 3(3-0-6)
Condition: PRER 2310380* Biochemistry for Bioengineer, or consent by instructor

Next Generation Sequencing (NGS) and -omics technologies; -omics data analysis e.g. genomics, transcriptomics, and proteomics and applications of these technologies in biomedicine e.g. translational medicine, precision/personalized medicine, and drug design.

B. Nano Materials Science

2141405 Surfaces and Thin Films 3(3-0-6)

Basic knowledge of modern nanoscale thin film technology; thin film deposition and epitaxial; fundamental of thin film nucleation and growth; emerging thin film materials and applications; various method of surface coating such as thermochemical, plating, fusion and vapor phase process; surface modification and methods to improve properties of coated surface.

2141459 Biointerface Engineering 3(3-0-6)
Condition: PRER: 2189356 Materials for Biomedical Applications, or consent by instructor

Reviews of cell-material interactions and its applications. Surface energy and thermodynamics of biological molecules; Hydrophobicity of surfaces; Properties of extracellular matrics (ECM) of various types of cells; Cell migration, growth, and differentiation; Blood compatibility of materials; Physical and chemical technics for biosurface modifications; Morphology of surfaces; Evaluation of biocompatibility of materials; Case studies related to biointerfaces engineering such as biomineralization, biosensors, anti-microbial surface etc.

2141501 Advance Topic in Advanced 1(1-0-2)
Material engineering I

Advance topics in the field of Advanced Material engineering

2141502 Advance Topic in Advanced 2(2-0-4)
Material engineering II

Advance topics in the field of Advanced Material engineering.

2141503 Special Topic in Advanced 3(3-0-6)
Material engineering I

Interesting topics in the field of Advanced Material engineering.

2141504 Special Topic in Advanced 3(3-0-6)
Material engineering II

Interesting topics in the field of Advanced Material engineering.

2141505 Special Topic in Advanced 3(3-0-6)
Material engineering III

Interesting topics in the field of Advanced Material engineering.

2183412 Micro and Nano-Electro 3(3-0-6)
Mechanical Systems

Overview of MEMs; Scaling of micromechanical devices; Behavior and modeling of micromechanical devices; Mechanical properties of MEMs materials; Review of microfabrication; Bulk and surface micromachining; Applications of MEMs: pressure sensors, accelerometer; Micromotors; Micropumps and microvalves; Thermal sensors and actuators; Micromirror.

2185373 Reaction Engineering 3(3-0-6)
CONDITION: PRER: 2302105 Chemistry for Engineers, or consent by instructor

Fundamental of reaction engineering; reaction rate laws, kinetics, mechanisms of homogeneous and heterogeneous reactions, catalysis reactions, biological reactions, analysis of reaction rate data, basic design of reactors.

2302389 Intermediate Inorganic Chemistry 3(3-0-6)

Atomic structure and periodicity; molecular geometry and symmetry; introduction to molecular orbital theory; reaction with electron transfer; inorganic solids; structures and bonding of coordination compounds; crystal and ligand field theories; electronic spectra; organometallic chemistry; 18 electron rule; organometallic reactions; applications in industry and medicine.

2189356 Materials for Biomedical 3(3-0-6)
Applications
Condition: PRER 2303111 Biology for engineers

Introduction to the interactions between cells and the surfaces of biomaterials; Surface chemistry and physics of selected metals, polymers, and ceramics; Modification of biomaterials surfaces; Biocompatibility and biodegradability; Medical implants; Acute and chronic response to implanted biomaterials; Recent development in metallic prostheses, biosensors, drug delivery system, tissue engineering and anti-microbial surface.

2189405 Ceramics and Glasses 3(3-0-6)

Family of ceramics and glasses; production of advanced ceramics, composites and glasses; bonding and atomic configurations; powder processing, forming, sintering, densification processes, slip casting, blow

molding, and material selection and design of compositions based on required properties; additives in ceramics and glasses; characterization of advanced ceramics and glasses; mechanical and reliability tests; applications of advanced ceramics and glasses.

2189415 Materials for Energy   3(3-0-6)

Overview of materials and materials research in the areas of fuel cells, batteries (electrochemical energy conversion and storage), catalysts and membrane separations (fossil fuel and biomass energy conversion), nuclear fuels, supercapacitors, thermoelectrics, solar cells, solar heat and other renewable energy sources; overview of life cycle assessment and material sustainability; applications and future trends.

2189570 Electronic Materials   3(3-0-6)

Electronic, optical and magnetic properties of materials; elementary quantum physics; kinetic molecular theory and thermally activated processes; band structure; electrical conductivity of metals and semiconductors; intrinsic and extrinsic semiconductors; elementary p-n junction theory; doping; dielectric materials and insulation; superconductivity; operating principles of light emitting diodes, solar cells, thermoelectrics, and transistors.

2189581 High Performance Metals   3(3-0-6)
**   and Alloys**

Overview of physical metallurgy fundamentals to achieving high performance metals, alloys and materials; applications of metals and alloys in petroleum, automotive, electronic, medical and automation industries; light weight metals and alloys for next generation electric vehicles. Metals, alloys and advanced materials using in renewable energy sector such as wind turbine, bearings, solar cells and fuel cells. Biomedical and health applications. Understanding the production processes from conventional to novel techniques: from casting to additive manufacturing, and from machining to laser cutting, etc.

2190401 Computation, Modelling and   3(3-0-6)
**   Problem Solving**

Introduction to modelling and simulation in materials engineering; development and design of models for materials processes and structure-property relations; understanding and prediction of material behavior at scales from atomistic to macroscopic through modelling and simulation; topics include symmetry and structure, thermodynamics, solid state physics, mechanics, phase transformations and kinetics; methods for visualizing solutions and graphical presentation of results.

AUTOMOTIVE DESIGN AND MANUFACTURING ENGINEERING (INTERNATIONAL PROGRAM) (B.ENG)

Automotive design and manufacturing engineering is a highly demanded profession, which is linked to the national and global boosted growth of automotive industry. Automotive design involves the development of motor vehicles with a primarily concern on design of mechanical compornants and the creation of the product concept. Manufacturing engineering deals with all aspects of manufacture, from production control to materials handling to automation.

Our ADME graduates, being specialized, are trained in both automotive design and manufacturing engineering. Our program trains students to have a solid background in both fields with a flexibility to choose to specialize in either topic. This advantage doubles the job opportunities for our graduates, whilst serving the local and international automotive industry with qualified and versatile engineers with a broad academic background.

Each student is required to accumulate a minimum of 146 credits to graduate for Bachelor of Engineering Program in Automotive Design and Manufacturing Engineering (International Program) which also includes 2 credits of industrial training and 3 credits of senior project.

Curriculum board

Phulporn Saengbangpla	M.Sc (Machester,UK)
Pramote Dechaumphai	Ph.D. (Virginia)
Ekachai Leelarasmee	Ph.D. (California)
Asi Bunyajitradulya	Ph.D. (California)
Siriporn Damrongsakkul	Ph.D. (London)
Atiwong Suchato	Ph.D. (Massachusetts)
Patama Visuttipitukul	Ph.D. (Tokyo)
Sunhapos Chatranuwathana	Ph.D. (Michigan)
Chaodit Aswakul	Ph.D. (London)
Yan Zhao	Ph.D. (London)
Surapong Sirikulvadhana	M.S. (Michigan)
Varong Pavarajarn	Ph.D. (Oregon)

Professors

Mechanical Engineering

Pramote Dechaumphai	Ph.D. (Old Dominion)
Somsak Chaiyapinunt	Ph.D. (Oregon State)
Viboon Sangveraphunsiri	Ph.D. (Georgia Tech)

Associate Professors

Electrial Engineering

Ekachai Leelarasmee	Ph.D. (California)
Chedsada Chinrungrueng	Ph.D. (California Berkeley (U.S.A.)

Mechanical Engineering

Asi Bunyajitradulya	Ph.D. (UC Irvine)
Kuntinee Maneeratana	Ph.D. (London)
Pongtorn Charunyakorn	Ph.D. (Miami)
Kanit Wattanavichien	Ph.D. (Melbourne)
Ratchatin Chancharoen	D.Eng. (Chula)

Industrial Engineering

Somkiat Tangjitsitchareon	D.Eng. (Kobe Japan)

Metallurgical and materials Engineering

Seksak Asavavisithchai	Ph.D. (Nottingham)

Assistant Professors

Electrial Engineering

Wanchalerm Pora	Ph.D. (London)
Suree Pumrin	Ph.D.(Washington)

Mechanical Engineering

Boonchai Lertnuwat	Ph.D. (Tokyo)
Sunhapos Chantranuwathana	Ph.D. (Michigan)
Witaya Wannasuphoprasit	Ph.D. (Northwestern)
Nopdanai Ajavakom	Ph.D. (UC.Berkeley)
Niphon Wansophark	D.Eng. (Chula)
Alongkorn Pimpin	D.Eng. (Tokyo)
Chanat Ratanasumawong	D.Eng. (Tokyo Tech)
Phongsaen Pitakwatchara	M.S.M.E.
Thanyarat Singhanart	Ph.D. (Tokyo) (Georgia Tech)

Industrial Engineering

Somchai Puajindanetr	Ph.D. (London)
Haruetai Lohasiriwat	MS. (VPI & SU)

Metallurgical and materials Engineering

Itthipon Diewwanit	Sc.D. (MIT)

Lecturer

Electrial Engineering

Boonchuay Supmonchai	M.Eng. (Chula)

Mechanical Engineering

Nuksit Noomwongs	D.Eng. (TUAT)
Chirdpun Vitooraporn	(MIT)
Tawan Paphapote	Ph.D.C.United States of America

Industrial Engineering

Oran Kittithreerapronchai	Ph.D. Georgia

ISE Staffs

Phulporn Saengbangpla	M.Sc.,ME(England)
Yan Zhao	Ph.D. (London)
Prabhath De Silva	Ph.D. (USA)

Guest lecturer

Suradej Voranutsoontorn	Private Consultant

| Somchai Peungperksuk | Ph.D. |
| Kaukeart Boonchukosol | Poitiers (Frence) |

Visiting Professor (USA)

| Arthur.J. McEvily Jr. | Emeritus Ph.D. (New York) |

Curriculum

Total number of credits requirement	147	credits
General Education	30	credits
Core Courses	111	credits
Basic Sciences	21	creditis
Basic Engineering	31	credits
Compulsory	50	credits
Approved Electives	9	credits
Free Electives	6	credits

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1. General Education

	30	credits
Social Science	3	credits
Humanity	3	credits
Science and Mathematics	3	credits
Interdisciplinary	3	credits
Foreign Language	12	credits
5501112	Communicative English I	3(3-0-6)
5501123	Communicative English II	3(3-0-6)
5501214	Communication and Presentation Skills	3(3-0-6)
5501225	Technical Writing	3(3-0-6)

General Education (Special)		6	credits
2140111	Exploring Engineering World	3(3-0-6)
2183281	Introduction to Automotive Eng.	3(3-0-6)

2. Core Course

	111	credits

Basic Sciences		21	credits
2301107	Calculus I	3(3-0-6)
2301108	Calculus II	3(3-0-6)
2301312	Differential Equations	3(3-0-6)
2302103	General Chemistry Laboratory	1(0-3-0)
2302105	Chemistry for Engineers	3(3-0-6)
2304153	Physics for Engineers	3(3-0-6)
2304154	Physics and Electronics for Eng.	3(0-3-0)
2304193	Physics Laboratory for Eng.	1(0-3-0)
2304194	Physics and Electronics Laboratory for Engineers	1(0-3-0)

Basic Engineering		31	credits
2140301	Industrial Training	2(0-6-0)
2142251	Manufacturing Process for Automotive Eng I	3(2-3-4)
2142252	Manufacturing Process for Automotive Eng II	3(2-3-4)
2182210	Electrical Circuit	3(3-0-6)
2182213	Electrical Circuit Laboratory	1(0-3-0)
2183101	Engineering Graphics	3(2-3-4)

2183212	Statics	3(3-0-6)
2184201	Probability and Statistics for Automotive Engineering	3(3-0-6)
2184303	Engineering Management	3(3-0-6)
2189101	Engineering Materials	3(3-0-6)
2190101	Computer Programming	3(3-0-6)
2190151	Computer Programming Laboratory	1(0-3-0)

Compulsory Courses		50	credits
2142201	Engineering First	3(3-0-6)
2142242	Vehicle Dynamics	3(3-0-6)
2142498	Automotive Engineering Pre-Project	1(0-2-1)
2142499	Automotive Engineering Project	3(0-6-3)
2182310	Electronics and Instrument For Automobile	3(3-0-6)
2183213	Mechanics of Material	3(3-0-6)
2183221	Thermodynamics	3(3-0-6)
2183222	Fluid Mechanics	3(3-0-6)
2183231	Dynamics	3(3-0-6)
2183261	Mechanical Engineering Laboratory	2(1-3-2)
2183271	Automotive Engineering Workshop	1(0-3-0)
2183272	Automotive Instrument Laboratory	1(0-3-0)
2183321	Heat Transfer	3(3-0-6)
2183322	Internal Combustion Engine	3(3-0-6)
2183331	Mechanics of Machinery	3(3-0-6)
2183332	CAD/CAM/CAE	3(2-3-4)
2183351	Machanical Engineering Design	3(3-0-6)
2183352	Motor Vehicle Design	3(2-3-4)
2184302	Product Development Process	3(3-0-6)

Approved Electives		9	credits
2142352	Finite Element Methods and Applications	3(3-0-6)
2142422	Vehicle Aerodynamics	3(3-0-6)
2142423	Power Train Systems	3(3-0-6)
2142426	Noise, Vibration and Harshness	3(3-0-6)
2142428	Automotive Diagnostics and Maintenance	3(3-0-6)
2142433	Failure Analysis and NDT	3(2-3-4)
2142461	Automation and Robotics	3(3-0-6)
2142488	Measurement, Instrumentation And Data Acquisition	3(3-0-6)
2142492	Selected Topics in Automotive Engineering I	3(2-3-4)
2142493	Selected Topics in Automotive Engineering II	3(2-3-4)
2142495	Independent Studies	3(0-6-3)
2182430	System Dynamics and Controls	3(3-0-6)
2182442	Embedded Systems in Automotive Engineering	3(3-0-6)
2183431	Mechanical Vibrations	3(3-0-6)
2184401	Engineering Experimental Design	3(3-0-6)
2184404	Process Management and Lean Manufacturing	3(3-0-6)
2184405	Product Planning and Control	3(3-0-6)
2184406	Quality Control and Management For Automotive Industry	3(3-0-6)

2184407	Quality Design and Innovation Management	3(3-0-6)
2184409	Value Engineering	3(3-0-6)
2189102	Engineering Materials II	3(3-0-6)
2190216	Information Technology for Professional Communications	2(1-3-2)

3. Free Electives   **6 credits**

Select 6 credits from any courses offered in English by any International Programs in Chulalongkorn University.

AUTOMOTIVE DESIGN AND MANUFACTURING
ENGINEERING CURRICULUM
(INTERNATIONAL PROGRAM) (B.ENG)

COURSE NO.	SUBJECT	CREDITS
FIRST SEMESTER		
2190101	Computer Programming	3
2190151	Computer Programming Laboratory	1
2301107	Calculus I	3
2302103	General Chemistry Laboratory	1
2302105	Chemistry for Eng.	3
2304153	Physics for Eng.	3
2304193	Physics Lab for Engineers	1
5501112	Communicative Eng I	3
		18
SECOND SEMESTER		
2140111	Exploring Engineering World	3
2183101	Engineering Graphics	3
2189101	Engineering Materials	3
2301108	Calculus II	3
2304154	Physics and Electronics for Eng.	3
2304194	Physics and Electronics Lab for Eng.	1
5501123	Communicative English II	3
		19
THIRD SEMESTER		
2142251	Manufacturing Process for Automotive Eng I	3
2183212	Statics	3
2183221	Thermodynamics	3
2183271	Automotive Engineering Workshop	1
2183281	Introduction to Automotive Eng.	3
2184201	Probability and Statistics for Auto Eng.	3
2301312	Differential Equations	3
		19
FOURTH SEMESTER		
2142201	Engineering First	3
2142252	Manufacturing Process for Auto Eng II	3
2182210	Electrical Circuit	3
2182213	Electrical Circuit Laboratory	1
2183213	Mechanics of Materials	3
2183231	Dynamics	3
5501214	Communication and Presentation Skills	3
		19

COURSE NO.	SUBJECT	CREDITS
FIFTH SEMESTER		
2182310	Electronics and Instrumentation for Auto	3
2183222	Fluid Mechanics	3
2183261	Mechanical Engineering Laboratory	2
2183272	Automotive Instrument Laboratory	1
2183331	Mechanics of Machinery	3
2184302	Product Development Process	3
5501225	Technical Writing	3
		18
SIXTH SEMESTER		
2142424	Vehicle Dynamics	3
2183321	Heat Transfer	3
2183332	CAD/CAM/CAE	3
2183351	Mechanical Engineering Design	3
2184303	Engineering Management	3
xxxxxxx	General Education	3
		18
SUMMER SEMESTER		
2140301	Industrial Training	2
SEVENTH SEMESTER		
2142498	Automotive Engineering Pre-Project	1
2183322	Internal Combustion Engine	3
2183352	Motor Vehicle Design	3
xxxxxxx	Approved Elective	3
xxxxxxx	Approved Elective	3
xxxxxxx	General Education	3
xxxxxxx	General Education	3
xxxxxxx	Free Elective	3
		22
EIGHTH SEMESTER		
2142499	Automotive Engineering Project	3
xxxxxxx	Approve Electives	3
xxxxxxx	General Education	3
xxxxxxx	Free Elective	3
		12

TOTAL CREDITS FOR GRADUATION   **147**

General Education

2140111 Exploring Engineering World 3(3-0-6)

Engineering topics related to daily life: energy, resources, environment manufacturing, process, industry, material, automotive, infrastructure, information system and bio engineering.

**2183281 Introduction to Automotive 3(3-0-6)
Engineering**

Basic Principles of automotive systems, components, and design; internal combustion engine; transmission; chassis; suspension; steering; brake; body; vehicle aerodynamics and automotive electronics; basic vegicle dynamics; performance and handling.

5501112 Communicative English I 3(3-0-6)

Practice language skills in acquiring information and knowledge from different sources and media in subjects of students' interest under selected themes; collecting information, summarizing and presenting important issues.

**5501123 Communicative English II 3(3-0-6)
Condition: PRER 5501112***

Practice language skills in acquiring analyzing and synthesizing information and knowledge from different sources and media on topics of students' interest under selected themes; summarizing what they have learned, and presenting opinions from group discussion.

**5501214 Communication and Presentation 3(3-0-6)
Skills Condition: PRER 5501123***

Practice using English for social communication and giving oral presentation on engineering related topics.

**5501225 Technical Writing 3(3-0-6)
Condition: PRER 5501123***

Practice in writing summaries composing different types and styles of writing in the field of engineering and writing reports of studies and experiments.

Core Course

2301107 Calculus 1 3(3-0-6)

Limit, continuity, differentiation and integration of real-valued functions of a real variable and their applications; techniques of integration; improper integrals.

**2301108 Calculus 2 3(3-0-6)
Condition: PRER 2301107**

Mathematical induction; sequences and series of real numbers; Taylor series expansion and approximation of elementary functions; numerical integration; vectors, lines and planes in three dimensional space; calculus of vector valued functions of one variable; calculus of real valued functions of two variables; introduction to differential equations and their applications.

**2301312 Differential Equations 3(3-0-6)
Condition: PRER 2301108**

Existence and uniqueness theorem of solution of first order equations; initial value problem; Laplace transform; Taylor series expansion of elementary functions; numerical methods; general linear equations; solution in series; linear partial differential equations boundary value problems.

2302103 General Chemistry Laboratory 1(0-3-0)

Standard solution preparation; qualitative analysis; titration; electrochemistry, pH metric titration; spectroscopy; calculation and evaluation of data; calibration curve; introduction to polymer.

2302105 Chemistry for Engineers 3(3-0-6)

Stoichiometry and basis of the atomic theory; properties of the three states of matter and solution; thermodynamics; chemical equilibrium; Oxidation-reduction; chemical kinetics; the electronic structures of atoms and the chemical bond; periodic table; nonmetal and transition metal.

2304153 Physics for Engineers 3(3-0-6)

Mechanics of particles and rigid bodies; properties of matter; fluid mechanics; heat; vibrations and waves; elements of electromagenetism; optics; modern physics.

2304154 Physics and Electronics for Engineers 3(3-0-6)

Engctricity DC circuits; AC circuits; basic electronics; electrical actuators.

2304193 Physics Laboratory for Engineers 1(0-3-6)

Measurement and precision; experiments on simple harmonic motion; radius of gyration; dynamics of rotation; velocity of sound; viscosity of fluids.

**2304194 Physics and Electronics 3(3-0-6)
Laboratory for Engineers**

Resistance and electromotive force measurements; experiments on ampmeter; voltmeter; oscilloscope; AC circuit; transistor; lenses and mirrors; polarization; interference; diffraction.

2140301 Industrial Training 2(0-6-0)

Engineering practice in related areas under supervision of experienced engineers in private sectors or government agencies.

**2142251 Manufacturing Process for 3(2-3-4)
Automotive Engineering I**

Introduction to the principles of manufacturing as related to automotive engineering; relationship between manufacturing process, material properties and structure; fundamentals of bulk deformation, sheet metal forming processes; fundamentals of solidification processing; fundamentals of metal joining; principles of heat treatment and surface modification.

2142252 **Manufacturing Process for** **3(2-3-4)**
Automotive Engineering II
Condition: PRER 2142251*

Metal removal and machining processes; processes of non-metallic materials: glass, polymers, and ceramics; surface and tribological characteristics; application of automation and computer integrated manufacturing systems in automotive part manufacturing: fundamentals of automotive part designs and technology management; supply chains and structure of automotive part manufacturing.

2182210 **Electrical Circuit Laboratory** **3(3-0-6)**

DC circuit; analysis; Kirchhoff's laws; The venin's abd Birtib's theorem; transistor amplifier circuit; semiconductor devices; op-amp circuits; digital circuits; DC motor.

2182213 **Electrical Circuit Laboratory** **1(0-3-0)**

Eletronic instruments; multimeter; oscilloscope; DC circuit; Voltage regolators; filter circuit; transistor amplifer circuit; op-amp circuits; digital Circuits; DC motor.

2183101 **Engineering Graphics** **3(2-3-4)**

Lettering; orthographic projections; sketching and drawing; pictorial drawing; dimensioning; tolerancing and geometrical tolerancing; section; working drawing; mechanical parts drawing; introduction to CAD.

2183212 **Statics** **3(3-0-6)**

Force systems; resultants; equilibrium; structure; distributed force; friction; virtual work; stability.

2184201 **Probability and Statistics for** **3(3-0-6)**
Automotive Engineering

Engineering basis in statistics and probability; discrete and continuous probability distribution; joint probability distribution; parameter estimation: esto,atpr. Bias, consistency; point estimation; interval estimation; automotive engineering applications in measurement and uncertainty, linear regression, introduction to random process; integration of statistics in automotive engineering applications; case studies.

2184303 **Engineering Management** **3(3-0-6)**

Modern management principles; methods of increasing productivity; human relations; industrial safety; pollution problems; commercial laws; basics of engineering economy, finance, marketing, and project management.

2189101 **Engineering Materials** **3(3-0-6)**

Important engineering materials: metals, plastics, asphalt, wood and concrete; phase diagram and its interpretation; testing and meaning of various properties; macroscopic and microscopic structure which are correlating with properties of theengineering materials; production process of products from engineering materials.

2190101 **Computer Programming** **3(3-0-6)**

Introduction to computer systems; problem-solving using computers; programming in highlevel languages; program structure, programming style and convention; control statements, data handling and processing; subprograms; classes and objects.

2190151 **Computer Programming** **1(0-3-0)**
Laboratory
Condition: COREQ 2190101*

Computer programming in Engineering; reviews of computer programming concepts; hands-on experience on computer programming using contemporary Engineering tools.

2142201 **Engineering First** **3(3-0-6)**

Basic skills in engineering; problem solving, communication skills, team work skills through small class projects; dissection skills.

2142424 **Vehicle Dynamics** **3(3-0-6)**
Condition: PRER 2183231

Dynamics of motor vehicles; properties of pneumatic tire; suspension and steering mechanism; vehicle longitudinal dynamics; linear bicycle models; stability; linear engine models; pleasure in driving.

2142498 **Automotive Engineering** **1(0-2-1)**
Pre-Project

Preliminary study for automotive engineering; project formulation and proposal.

2142499 **Automotive Engineering Project** **1(0-3-0)**

Group or individual project on a subject related to automotive engineering and manufacturing.

2182310 **Electronics and Instrument for** **3(3-0-6)**
Automobile Condition: PRER 2182210

Introduction to digital circuits; introduction to microprocessors and microprocessors based systems; basic instrumentation; application of different types of instrumentations to automotive systems.

2183213 **Mechanics Material** **3(3-0-6)**
Condition: PRER 2183212

Force and stress; stresses and strains relationship; Hooke's law; modulus of elasticity; stresses in beams; shear force; bending moment diagrams; deflection of beams; torsion; buckling of columns; Mohr's circle; combined stresses; failure criterion; safety factors.

2183221 **Thermodynamics** **3(3-0-6)**

Basic concepts; thermodynamic state and process; properties of pure substances and ideal gases; energy; the first law of thermodynamics and the first law analysis for isolated, closed, and open systems; entropy; the second law of thermodynamics and the second law analysis for isolated, closed, and opens systems; gas power cycles; Carnot, Otto, and Brayton cycles; refrigeration

cycle; introduction to gas mixtures; introduction to combustion.

2183222 Fluid Mechanics   3(3-0-6)
Basic concepts in physics: physical quantity and physical quantity relations, dimensions of physical quantity and the principle of dimensional homogeneity, dimensionless variables; basic concepts in fluid mechanics: continuum assumption, methods of description: Lagrangian and Eulerian descriptions, field quantity and classification of flow fields: geometric and kinematics of fluid motion: pathlines, streamlines, and streaklines; forces and stresses in fluids: pressure and pressure force, shear stress and shear force; convection flux and Reynold's transport theorem; physical laws of finite control volume: conservations of mass, linear momentum, and energy; conservation of angular momentum with application to turbomachines; physical laws of infinite control volume: conservation of mass and linear momentum, introduction to Navier-Stokes and Euler's equations; Bernoulli's equation from momentum and conservation of mechanical energy viewpoints; introduction to vorticity and vortex; dimensional analysis: Buckingham's PI theorem, similarity, and model testing; internal viscous flows, energy consideration in pipe flows and piping system; system; external flows, boundary layer, and aerodynamic force and moment; applications: turbomachines, model testing, piping and pumping system, aerodynamic force and moment.

2183231 Dynamics   3(3-0-6)
Kinematics of three-dimensional curvilinear motion of a particle; kinetics of a particle: force and acceleration, work and energy, impulse and momentum; kinematics of planar motion of a rigid body: absolute and relative motion analysis; kinetics of planar motion of a rigid body: absolute and relative motion analysis; kinetics of planar motion at a rigid body; force and acceleration, work and energy, impulse and momentum; introduction to kinematics and kinetics of three-dimensional motion of a rigid body.

2183261 Mechanical Engineering Laboratory 2(1-3-2)
Experimentation and basic concepts; error and uncertainty analysis; measurement and instrumentation; data analysis; interpretation of experimental results; reporting of experimental results; basic experiments in solid mechanics, thermodynamics, fluid mechanics and basic engine testing.

2183271 Automotive Engineering Workshop 1(0-3-0)
Hand-on study of automotive systems and components; names and functions of components and parts; basic mechanical parts; engine; electronic systems; power train; brake systems; steering mechanism; basic diagnosis.

2183272 Automotive Instrument Laboratory 1(0-3-0)
Basic electronics; electronic systems in automobiles; engine performance testing; basic automotive diagnosis.

2183321 Heat Transfer   3(3-0-6)
Condition: PRER 2183222*
Modes of heat transfer; general forms of heat conduction equations; steady one-dimensional heat conducton; steady two-dimensional heat conduction; transient one-dimensional heat conduction; introduction of convection and boundary layer; external flow; internal flow; free convection; heat exchangers; introduction of radiation of black body and gray surfaces; view factors; radiation exchange between gray, diffuse surfaces in an enclosure.

2183322 Internal Combustion Engine 3(3-0-6)
Internal combustion engines; basic principles; fluid flow; thermodynamics; fuels and combustion; ideal fuel air cycle; heat transfer; friction and lubrication; efficiency and emission; different types of engines; spark-ignition and compression-ignition; ignition systems; supercharging and scavenging; performance and testing.

2183331 Mechanics of Machinery   3(3-0-6)
Basic mechanisms; gear trains; displacements; velocity and acceleration in machines; statics and dynamics force analysis; balances of rotating and reciprocating masses; gyroscopic effects.

2183332 Computer Aided Design/Computer 3(2-3-4)
          Aided Manufacturing and Computer
          Aided Engineering
Introduction to CAD/CAM/CAE, 3D solid modeling, design concepts and implementation; link to manufacturing interface.

2183351 Mechanical Engineering Design 3(3-0-6)
Fundamentals of mechanical engineering design; properties of materials; theory of filure; fatigue; design of basic machine elements; design project of a simple mechanical machine.

2183352 Motor Vehicle Design   3(3-0-6)
Systematic approach to automotive design; space defining components; ergonomics; automotive safety and legal regulations.

2184302 Product Development Process 3(3-0-6)
Product requirements and specifications; reverse engineering; use of CMM; product design by CAD.

2142352 Finite Element Methods and   3(3-0-6)
          Applications
Basic principles of finite element methods; applications of finite elements in analysis using computer programs.

2142422 Vehicle Aerodynamics   3(3-0-6)
Effects of vegicle design on aerodynamics; wind tunnel testing; boundary layers and wakes; friction and pressure drag; aerodynamic forces and moments; center of pressure and vehicle stability.

2142423 Power Train Systems 3(3-0-6)

Manual and automatic transmission; basic operation of transmission; peripheral components.

2142426 Noise, Vibration and Harshness 3(3-0-6)

NVH and its importance for automotive industry. Sources of sound and vibration. Noise quality. Acceleration. Velocity, displacement, and sound pressure/intensity. DB Scales. Introduction to vibration. Free and forced vibration response of one and two degrees of freedom systems. Methods for determining natural frequencies and mode shapes for multi-degrees of freedom systems. Vibration measurement and control. Suspensions mounting systems. Road Simulators and wind tunnels. Noise and vibrations standards.

**2142428 Automotive Diagnostics and 2(1-3-2)
              Maintenance**

Basic knowledge in Automobile components and its functions; troubleshooting guides, diagnostic tools for automobiles; do-it-yourself car care; knowledge in schedule services, maintenances and repair; defensive driving techniques.

**2142433 Failure Analysis and 3(2-3-4)
              Nondestructive Testing**

Analysis and diagnosis of the causes of failure; physics of failure; concepts of reliability, the use of failure analysis as part of the design process, time based/related failure modes, safety factors; case studies; elimination of failures through proper material selection, treatment and use; case histories; examination of fracture surfaces; laboratory investigations of different failure mechanisms.

2142461 Automation and Robotics 3(3-0-6)

Basic automation systems, equipment, sensors, actuators, material handling system, robots and their applications.

**2142488 Measurement, Instrumentation 3(3-0-6)
              and Data Acquisition**

Basic electromechanical techniques used in modern instrumentation and control systems; use of transducers and actuators; signal conditioning, grounding, and shielding; signal processing and feedback control methods with emphasis on frequency domain techniques; low-level measurements; lock-in technique.

**2142492 Selected Topics in Automotive 3(2-3-4)
              Engineering I**

Selected interesting topics in automotive engineering.

**2142493 Selected Topics in Automotive 3(2-3-4)
              Engineering II**

Selected interesting topics in automotive engineering.

2142495 Independent Studies 3(0-6-3)

Self study on topics related to automotive engineering with consent of the instructor, the study may be theoretical or experimental in nature.

**2182430 System Dynamics and Controls 3(3-0-6)
              Condition: PRER 2182210**

System dynamics modeling; responses; introduction to control systems; feedback control system characteristics; the performance of feedback control systems; the stability of linear feedback systems; essential principles of feedback; the root locus method; time-domain analysis and design of control systems; frequency response method; stability of the frequency domain and compensation; use of computer in the design of control systems.

**2142442 Embedded Systems in Automotive 3(3-0-6)
              Engineering**

Microprocessor architecture; introduction to embedded systems; programming concepts in C; software engineering practices; buses; device drivers and interrupt; inter-process communication; real-time operating system; hardware/software co-design.

2183431 Mechanical Vibrations 3(3-0-6)

Analysis of system with single and multi degree of freedom; torsional vibration; free and forced vibration; determination of natural frequencies of structures; discrete system; Model analysis; methods and techniques to reduce and control vibration; Lagrange's equations.

2184401 Engineering Experimental Design 3(3-0-6)

Factorial design; 2k factorial design; blocking and confound; fractional factorial design; factorial experiments with random factors; nested and split-plot design; non-linear regression analysis; response surface analysis.

**2184404 Process Management and Lean 3(3-0-6)
              Manufacturing**

Introduction to process management; key techniques and managing approaches commonly used in automotive industry; application and case studies.

2184405 Product Planning and Control 3(3-0-6)

The role of production planning and control in the manufacturing system; strategic planning of manufacturing systems; demand forecasting; inventory control, planning, scheduling, and control of operation; capacity planning.

**2184406 Quality Control and Management 3(3-0-6)
              for Automotive Industry**

Introduction to metrology and characterization; principles of destructive and non-destructive testing as applied in automotive part manufacturing. Concept of quality control, quality improvement, quality assurance, quality management, cost of quality; quality management systems: ISO series; failure mode and effects analysis; basic quality control tools; statistical process control:

control charts, process capability analysis, measurement system analysis, acceptance sampling plans.

2184407 Quality Design and Innovation   3(3-0-6)
**   Management**

Kay issues and core concept of quality design and innovation management, innovation strategy; project management, concept fomation and selection, quality design and innovation development processes, business plan, risk management, techniques and tools for effective implementation of innovation.

2184409 Value Engineering   3(3-0-6)

Introduction to value engineering methodology; application of value engineering techniques to product design; procurement and manufacturing in order to reduce cost without the loss of quality.

2189102 Engineering Materials II   3(3-0-6)
            Condition: PRER 2189101

Advanced topics and other specific applications as related to automative materials; specific automotive materials; introduction to engineered materials specifically developed for automotive applications; composite materials; tyre and rubber technology, modification of surface characteristics as related to tribological and corrosion properties.

2190216 Information Technology for   2(1-3-2)
**   Professional Communications**

IT skills in professional communication; presentation skills; use of computer software for effective professional communication.

INFORMATION AND COMMUNICATION ENGINEERING CURRICULUM (INTERNATIONAL PROGRAM)

ICE is a new and exciting integration of Computer Engineering, Electrical Engineering, and Industrial Engineering, key subjects at the very core of Chulalongkorn's Engineering School. You will learn the fundamental of computing, become equipped with skills in communication, and complement all this with a solid grounding in management science. Our combination will prepare you for the many stimulating challenges of the IT world.

The ICE program offers students a chance to become hardcore programmers, serving the international community with IT architecture for enterprises, software on mobile devices, satellite communications, game programming, computer networking, and software engineering, to name but a few. The discipline will be strengthened with training in management science that will heighten your competency to an international level. ICE is your future.

Each student is required to accumulate a minimum of 140 credits to graduate for Bachelor of Engineering Program in Information and Communication Engineering (International Program) which has already includes 2 credits of industrial training and 3 credits of senior project.

= 140 Credits

Curriculum Board

Phulporn Saengbangpla	M.Sc (Machester,UK)
Pramote Dechaumphai	Ph.D. (Virginia)
Ekachai Leelarasmee	Ph.D. (California)
Asi Bunyajitradulya	Ph.D. (California)
Siriporn Damrongsakkul	Ph.D. (London)
Atiwong Suchato	Ph.D. (Massachusetts)
Patama Visuttipitukul	Ph.D. (Tokyo)
Sunhapos Chatranuwathana	Ph.D. (Michigan)
Chaodit Aswakul	Ph.D. (London)
Yan Zhao	Ph.D. (London)
Surapong Sirikulvadhana	M.S (Michigan)
Varong Pavarajarn	Ph.D. (Oregon)

Professor

Prabhas Chongstitvattana,	Ph.D.(Edinburgh U.)
Associate Professors Kultida	Rojviboonchai
Ph.D.(Computer	
	Networks)

Lecturer

Electrial Engineering

Boonchuay Supmonchai,	M.Eng.(Chula)

Computer Engineering

Chairat Phongphanphanee,	Ph.D.(Radio Frequenct

		Telecommunications)
Chate	Patanothai,	M.Sc.(Elec&comEng)
Thit	Siriboon,	Ph.D.(Oregon State)

Industrial Engineering

Oran	Kittithreerapronchai	Ph.D.(Georgia Institute of Technology)

Guest lecture

Pahnit	Seriburi	Ph.D.(Washington)
Thaisiri	Watewai	Ph.D.(Berkeley)
Dechanuchit	Katanyutaveetip,	Ph.D.(Chula)

ISE Staffs

Yan	Zhao,	Ph.D.(London)
Sipat	Triukose	Ph.D.(Ohio)
Derrick	Lim	Ph.D.(Arizona)

Electrial Engineering

Chedsada	Chinrungrueng,	Ph.D.(Berkeley and computer Science)
Lunchakorn	Wuttisittikulkij,	Ph.D.(Essex)
Prasit	Teekaput,	Ph.D(Virginia)
Watcharapong	Khovidhungij,	Ph.D.(UCLA)
Watit	Benjapolakul,	D.Eng.(Tokyo)
Nisachon	Tangsangiumvisai,	Ph.D.(London)
Duangrudee	Worasucheep,	Ph.D.(Stanford)

Industrial Engineering

Parames	Chutima,	Ph.D.(Nottingham)

Computer Engineering

Pornsiri	Muenchaisri,	Ph.D.(Sydney)
Atiwong	Suchato,	Ph.D.(MIT)

Assistant Professors

Electrial Engineering

Chaiyachet	Saivichit,	Ph.D.(Communications Networking)
Chaodit	Aswakul,	Ph.D.(Communications Networking)
Charnchai	Pluempitiwiriyawej	Ph.D.(Carnegie Mellon and Computer Engineering)
Pasu	Kaewplung,	Ph.D(Chula)
Supavadee	Aramrith,	Ph.D.(Washington)
Tuptim	Angkaew,	Ph.D.(Communications Networking)
Widhyakorn	Asdornwised,	Ph.D.(Chula)

Computer Engineering

Athasit	Surarerks,	Dr.Inf.(Informatique)
Attawith	Sudsang,	Ph.D.(Illinois)
Chalermeak	Intanakornwiwat	Ph.D.(Southern California)
Chotirat	Ratanamahatana	Ph.D.(Roversode)
Krerk	Piromsopa	Ph.D.(Michigan State)

Nakornthip	Prompoon	M.Sc.(George Washington)
Pizzanu	Kanongchaiyos	Ph.D.(Compater Graphies)
Sukree	Sinthupinyo	Ph.D. (Chula)
Vishnu	Kotrajaras	Ph.D.(London)
Nattee	Niparnan	Ph.D.(Chula)

Manufacturing Engineering Opertions Management

| Natcha | Thaweesaengsakulthai,Ph.D.(Nottingham) |

Industrial Engineering

Wipawee	Thammaphornphilas,Ph.D.(Pittsburgh)
Seeronk	Prichanont,	Ph.D.(Biotechnology)
Surapong	Sirikulvadhana	M.S.(Michigan-Ann Arbor)

Curriculum

| Total number of credits requirement | 146 | credits |

| General Education | 30 | credits |

Core Courses	110	credits
Basic Sciences	18	credits
Basic Engineering	18	credits
Compulsory	59	credits
Approved Electives	15	credits

| Free Electives | 6 | credits |

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1. General Education **30** **credits**

Social Science	3	credits
Humanity	3	credits
Science and Mathematics	3	credits
Interdisciplinary	3	credits

Foreign Language	12	credits
5501112	Communicative English I	3(3-0-6)
5501123	Communicative English II	3(3-0-6)
5501214	Communication and Presentation Skills	3(3-0-6)
5501225	Technical Writing	3(3-0-6)

General Education (Special)	6	credits
2140111	Exploring Engineering World	3(3-0-6)
2143101	Introduction to ICE	3(3-0-6)

2. Core Courses **110** **credits**

Basic Sciences

	18	creditis
2301107	Calculus I	3(3-0-6)
2301108	Calculus II	3(3-0-6)
2302103	General Chemistry Laboratory	1(0-3-0)
2302105	Chemistry for Engineers	3(3-0-6)
2304153	Physics for Engineers	3(3-0-6)
2304154	Physics and Electronics for Engineers	3(3-0-6)
2304193	Physics Lab. For Engineers	1(0-3-0)
2304194	Physics and Electronics Lab For Engineers	1(0-3-0)

Basic Engineering | 18 | credits |

2140301	Industrial Training	2(0-6-0)
2182203	Probability and Statistics for Eng.	3(3-0-6)
2183101	Engineering Graphics	3(2-3-4)
2184202	Technology and Eng. Management	3(3-0-6)
2189101	Engineering Materials	3(3-0-6)
2190101	Computer Programming	3(3-0-6)
2190151	Computer Programming Laboratory	1(0-3-0)

Compulsory Courses | 59 | credits |

2143399	ICE Capstone	3(3-0-6)
2143491	ICE Pre-Project	1(0-2-1)
2143499	ICE project	3(0-6-3)
2182202	Advanced Mathematics Methods	3(3-0-6)
2182204	Signals and Linear Systems	3(3-0-6)
2182211	Electrical Circuit for ICE	2(2-0-4)
2182212	Fundamental of Circuit and Digital Electronics Lab.	1(0-3-0)
2182370	Introduction to Digital Communications	3(3-0-6)
2182371	Principles of Data Communication	3(3-0-6)
2182372	Principle of Telecommunications	3(3-0-6)
2184301	Eng. Economy and Applications	3(3-0-6)
2184304	Fundamental of Operations Management	3(3-0-6)
2190102	Advanced Computer Programming	2(2-0-4)
2190152	Advanced Computer Programming Laboratory	1(0-3-0)
2190200	Discrete Structures	3(3-0-6)
2190213	Principles of Information System	3(3-0-6)
2190221	Fundamental Data Structure and Algorithm	3(3-0-6)
2190250	Computer Architecture and Organization	3(3-0-6)
2190261	Fundamental Data Structure and	1(0-3-0)
2190415	Enterprise Information System	3(3-0-6)
2190422	Database Systems	2(2-0-4)
2190423	Software Engineering	3(3-0-6)
2190462	Database System Laboratory	1(0-3-0)
2190472	Netcentric Architecture	3(3-0-6)

Approved Electives | 15 | credits |

2143423	High Technology Entrepreneurship	3(3-0-6)
2143480	Independent Study I	1(0-3-2)
2143481	Independent Study II	1(0-3-2)
2143482	Independent Study III	1(0-3-2)
2143485	Special Topics in ICE I	2(2-0-4)
2143486	Special Topics in ICE II	2(2-0-4)
2143487	Special Topics in ICE III	2(2-0-4)
2143495	Selected Topics in ICE I	3(3-0-6)
2143497	Selected Topics in ICE II	3(3-0-6)
2143498	Selected Topics in ICE III	3(3-0-6)
2182420	Discrete-Time Signal Processing	3(3-0-6)
2182421	Multimedia Engineering	3(3-0-6)
2182470	Telecommunication Management	3(3-0-6)
2182471	Optic Fiber Communications	3(3-0-6)
2182472	Principle of Wireless Communications	3(3-0-6)
2182473	Signal Transmission System	3(3-0-6)
2182474	System Integration	3(3-0-6)

2182475	Teletraffic Engineering and Network Optimization	3(3-0-6)
2184402	Introduction to Stochastic Models	3(3-0-6)
2184403	Theory and Applications of Optimization	3(3-0-6)
2184408	Supply Chain Management	3(3-0-6)
2190317	Fundamental of Distributed System	3(3-0-6)
2190332	System Analysis and Design	3(3-0-6)
2190413	System Security	3(3-0-6)
2190414	Large Scale Computing System	3(3-0-6)
2190424	Software Project Management	3(3-0-6)
2190425	Software Testing and Quality Assurance	3(3-0-6)
2190436	Data Warehousing	3(3-0-6)
2190442	Object-Oriented Techniques	3(3-0-6)
2190443	User Interface Design	3(3-0-6)
2190473	Ubiquitous Computer and Networking	3(3-0-6)
2190479	Graphics Computing	3(3-0-6)
2190511	Game Design and Development Process for International Market	3(3-0-6)

3. Free Electives   6   credits

Select 6 credits from any courses offered in English by any International Programs in Chulalongkorn University.

INFORMATION AND COMMUNICATION
ENGINEERING CURRICULUM
(INTERNATIONAL PROGRAM)

COURSE NO.	SUBJECT	CREDITS
FIRST SEMESTER		
2190101*	Computer Programming	3
2190151*	Computer Programming Laboratory	1
2301107	Calculus I	3
2302103	General Chemistry Laboratory	1
2302105	Chemistry For Engineers	3
2304153	Physics for Engineers	3
2304193	Physics Laboratory for Engineers	1
5501112*	Communicative English I	3
		18
SECOND SEMESTER		
2140111*	Exploring Engineering World	3
2183101*	Engineering Graphics	3
2189101*	Engineering Materials	3
2301108	Calculus II	3
2304154	Physics and Electronics for Engineers	3
2304194	Physics and Electronics Lab. for Eng.	1
5501123*	Communicative English II	3
		19
THIRD SEMESTER		
2143101	Introduction to ICE	3
2182202*	Advanced Mathematics Methods	3
2182211*	Electrical Circuit for ICE	2
2182212*	Fundamental of Circuit and Digital Electronics Lab.	1
2190102*	Advanced Computer Programming	2
2190152*	Advanced Computer Programming Lab.	1
2190200*	Discrete Structure	3
xxxxxxx	General Education	3
		18
FOURTH SEMESTER		
2182203	Probability and Statistic for Engineers	3
2182204	Signals and Linear Systems	3
2184202	Technology and Eng. Management	3
2190221*	Fundamental Data Structure and Algorithm	3
2190250*	Computer Architecture and Organization	3
2190261*	Fundamental Data Structure and Algorithm Lab.	1
xxxxxxx	General Education	3
		19

COURSE NO.	SUBJECT	CREDITS
FIFTH SEMESTER		
2182370*	Introduction to Digital Communications	3
2182371*	Principles of Data communication	3
2184301*	Engineering Economy and Application	3
2190213*	Principles of Information System	3
2190472*	Netcentric Architecture	3
5501214	Communication and Presentation Skills	3
		18
SIXTH SEMESTER		
2143399*	ICE Capstone	3
2182372*	Principles of Telecommunications	3
2184304*	Fundamental of Operations Management	3
2190422*	Database Systems	2
2190423*	Software Engineering	3
2190462*	Database Systems Laboratory	1
5501225	Technical Writing	3
		18
SUMMER SEMESTER		
2140301	Industrial Training	2
		2
SEVENTH SEMESTER		
2143491*	ICE Pre-project	1
2190415*	Enterprise Information Systems	3
xxxxxxx	General Education	3
xxxxxxx	Approved Elective	6
xxxxxxx	Free Elective	3
		16
EIGHTH SEMESTER		
2143499	ICE Project	3
xxxxxxx	Approved Elective	9
xxxxxxx	General Education	3
xxxxxxx	Free Elective	3
		18

TOTAL CREDITS FOR GRADUATION　　**146**

COURSES DESCRIPTIONS IN AUTOMOTIVE DESIGN AND MANUFACTURING ENGINEERING (B.ENG)

General Education

2140111 Exploring Engineering World 3(3-0-6)

Engineering topics related to daily life: energy, resources, environment manufacturing, process, industry, material, automotive, infrastructure, information system and bio engineering.

2143101 Introduction to ICE 3(3-0-6)

Essential basic computer and telecommunication concepts for Information Systems; Technology and trends underlying current and future uses of information and communication technology; Introduction to engineering management including important aspects of management science; Real-world experience sharing and tools related to each topic.

5501112 Communicative English I 3(3-0-6)

Practice language skills in acquiring information and knowledge from different sources and media in subjects of students' interest under selected themes; collecting information, summarizing and presenting important issues.

5501123 Communicative English II 3(3-0-6)
Condition: PRER 5501112*

Practice language skills in acquiring analyzing and synthesizing information and knowledge from different sources and media on topics of students' interest under selected themes; summarizing what they have learned, and presenting opinions from group discussion.

5501214 Communication and Presentation 3(3-0-6)
Skills Condition: PRER 5501123*

Practice using English for social communication and giving oral presentation on engineering related topics.

5501225 Technical Writing 3(3-0-6)
Condition: PRER 5501123*

Practice in writing summaries composing different types and styles of writing in the field of engineering and writing reports of studies and experiments.

Core Course

2301107 Calculus 1 3(3-0-6)

Limit, continuity, differentiation and integration of real-valued functions of a real variable and their applications; techniques of integration; improper integrals.

2301108 Calculus 2 3(3-0-6)
Condition: PRER 2301107

Mathematical induction; sequences and series of real numbers; Taylor series expansion and approximation of elementary functions; numerical integration; vectors, lines and planes in three dimensional space; calculus of vector valued functions of one variable; calculus of real valued functions of two variables; introduction to differential equations and their applications.

2302103 General Chemistry Laboratory 1(0-3-0)

Standard solution preparation; qualitative analysis; titration; electrochemistry, pH metric titration; spectroscopy; calculation and evaluation of data; calibration curve; introduction to polymer.

2302105 Chemistry for Engineers 3(3-0-6)

Stoichiometry and basis of the atomic theory; properties of the three states of matter and solution; thermodynamics; chemical equilibrium; Oxidation-reduction; chemical kinetics; the electronic structures of atoms and the chemical bond; periodic table; nonmetal and transition metal.

2304153 Physics for Engineers 3(3-0-6)

Mechanics of particles and rigid bodies; properties of matter; fluid mechanics; heat; vibrations and waves; elements of electromagenetism; optics; modern physics.

2304154 Physics and Electronics for 3(3-0-6)
Engineers

Engctricity DC circuits; AC circuits; basic electronics; electrical actuators.

2304193 Physics Laboratory for Engineers 1(0-3-6)

Measurement and precision; experiments on simple harmonic motion; radius of gyration; dynamics of rotation; velocity of sound; viscosity of fluids.

2304194 Physics and Electronics 3(3-0-6)
Laboratory for Engineers

Resistance and electromotive force measurements; experiments on ampmeter; voltmeter; oscilloscope; AC circuit; transistor; lenses and mirrors; polarization; interference; diffraction.

2140301 Industrial Training 2(0-6-0)

Engineering practice in related areas under supervision of experienced engineers in private sectors or government agencies.

2182203 Probability and Statistic for 3(3-0-6)
Engineers

Engineering basis is statistic and probability; discrete and continuous probability distribution; joint probability distribution; parameter estimation: estimator, bias, consistency; point estimation;interval estimation; engineering applications in measurement and uncertainty, linear regression,introduction to random process; integration of statistics in engineering application; case studies.

2183101 Engineering Graphics 3(2-3-4)

Lettering; orthographic projections; sketching and drawing; pictorial drawing; dimensioning; tolerancing and

geometrical tolerancing; section; working drawing; mechanical parts drawing; introduction to CAD.

**2184202 Technology and Engineering 3(3-0-6)
Management**

Technology and engineering management principles; SWOT analysis; operations strategy; organization and process design; cost and budget; productivity management; marketing concept; quality system; human relationship; risk management; project management; innovation management.

2189101 Engineering Materials 3(3-0-6)

Important engineering materials: metals, plastics, asphalt, wood and concrete; phase diagram and its interpretation; testing and meaning of various properties; macroscopic and microscopic structure which are correlating with properties of theengineering materials; production process of products from engineering materials.

2190101 Computer Programming 3(3-0-6)

Introduction to computer systems; problem-solving using computers; programming in highlevel languages; program structure, programming style and convention; control statements, data handling and processing; subprograms; classes and objects.

**2190151 Computer Programming 1(0-3-0)
Laboratory**

Computer programming in Engineering; reviews of computer programming concepts; hands-on experience on computer programming using contemporary Engineering tools.

**2143399 Information and Communication 3(3-0-6)
Engineering Capstone**

Culminating and applying of knowledge to develop information and communication systems; developing a software starting from gathering all the needs of the system to its application under the instructor's supervision; peer collaboration; giving presentations

**2143491 Information and Communication 1(0-2-1)
Engineering Pre-project**

Specifying topics or problems, scope, problem-solving methodologies and expected benefits from projects on information and communication engineering

**2143499 Information and Communication 3(0-6-3)
Engineering Project
CONDITION:PRER 2143491***

Group or individual projects on a subject related to information and communication engineering.

**2182202 Advanced Mathematics Methods 3(3-0-6)
CONDITION:PRER 2301108**

Complex analysis: complex functions, analytic functions, line integral in complex plane, Cauchy Integral Theorem, Laurent Series, Residue Theorem; advanced matrix algebra: systems of linear equations, linear independence, Eigenvalues, Eigenvectors; Ordinary differential equations (ODE): First-order ODE, Second-order ODE, Higher-order linear ODE; Series solutions to linear ODE

**2182204 Signals and Linear Systems 3(3-0-6)
CONDITION: PRER 2182202***

Classification of Signals and Systems; Linear-Time Invariant (LTI) System; Continuous-Time System; Discrete-time System; Linear Convolution; Frequency Response: Fourier Series, Fourier Transform, Laplace Transform, Z-Transform, Discrete-time Fourier Transform.

**2182211 Electrical Circuit for ICE 2(2-0-4)
CONDITION: PRER 2304154**

Basic circuit elements: resistor, capacitor, inductor, diode and transistor; Kirchhoff's laws; Node and Mesh analysis; DC and AC circuit analysis; Thevenin's and Norton's theorem; logic and digital circuits.

**2182212 Fundamental of Circuit and 1(0-3-0)
Digital Electronics Laboratory
CONDITION: Co-requisite 2182211***

Electronic instruments: multimeter, oscilloscope, DC circuit, voltage regulators, filter circuit, transistor amplifier circuit, digital circuits.

**2182370 Introduction to Digital 3(3-0-6)
Communications**

Overview of digital communication systems; signal and noise analysis; PCM encoding: Nyquist's sampling theorem, quantization and companding; digital baseband systems: NRZ, RZ, bi-phase, bipolar RZ, AMI; digital bandpass systems: ASK, PSK, FSK, MSK and QAM; information theory: entropy, source and channel models, channel capacity, Shannon's theorem and introduction to source coding, error detection/correction codes; examples of communication systems in practice.

**2182371 Principles of Data 3(3-0-6)
Communication**

Introduction to data communication and networking: layer modeling protocols and architectural network; basic data transmission, physical layer transmission, data link layer protocols, review on network layer protocols and transport layer protocols, standardization, IP-based network protocols, delay models, performance analysis, system design and implementation issues.

2182372 Principles of Telecommunications 3(3-0-6)

Introduction to telecommunications; layered communication architectures; transmission medium: wired and wireless; data link layer protocols: flow control and

error control; medium access control; circuit switching and packet switching; throughput and delay performance analysis of communication link; introduction to network topology, flows and graph theory; routing principles in circuit-switched and packet-switched networks; introduction to queuing theory and basic simulation techniques; overviews of cellular mobile phone networks, optical networks, Internet and satellite systems.

2184301 Engineering Economy and   3(3-0-6)
Applications

Interest calculation; time value of money; equivalent value and rate of return; project analysis and evaluation; break-even point; sensitivity analysis; decisions under risk and uncertainty; economic life and replacement analysis.

2184304 Fundamental of Operations   3(3-0-6)
Management

Nature of operations; production capacity management; aggregate planning; master production scheduling; material requirements planning; operation scheduling; inventory and distribution management; project time management; lean management.

2190102 Advanced Computer   2(2-0-4)
Programming
CONDITION: PRER 2190101*

Concepts and practice of object-oriented programming; usage of design patterns in object-oriented programming; programming in application development frameworks: graphical user interface and event-driven programming, collection framework, concurrent programming, socket programming, and/or frameworks of contemporary interest; hands-on practice in developing application software through the application of development frameworks.

2190152 Advanced Computer   1(0-3-0)
Programming Laboratory

Hands-on experience in software development through the application of contemporary development frameworks.

2190200 Discrete Structures   3(3-0-6)

Sets, relations, functions, theorem and proof; combinatorics; counting, principle of inclusion exclusion, recurrent relations, generating functions; graphs and trees; introduction to number theory.

2190213 Principles of Information System   3(3-0-6)
CONDITION:PRER 2190102*

Information system architecture; internet and web protocols; web application framework; MVC pattern; middleware, remote procedure call, message oriented middleware; authentication, authorization, directory services; information security, basic cryptography, digital signature.

2190221 Fundamental Data Structure   3(3-0-6)
and Algorithm

Basic data types, trees, basic operations on sets, sorting and searching, algorithm design techniques, memory management

2190250 Computer Architecture   3(3-0-6)
and Organization

Computer evolution and performance; computer structure, function, and interconnection; memory hierarchy; cache memory; virtual memory; storage; input/output; operating system support; process; interrupt; system call; instruction set; processor structure and function; RISC vs CISC; pipelining; super-scalar processors; multi-core computers.

2190261 Fundamental Data Structure   1(0-3-0)
and Algorithm Laboratory
CONDITION: Co-requisite 2190221*

Hands-on programming in high-level language to supplement the theoretical concepts of data structure and algorithm; practical application in writing and analyzing programs: data abstraction, modular program composition.

2190415 Enterprise Information Systems   3(3-0-6)

Enterprise information systems; information technology infrastructure and integration; impact of information systems on organizations; information technology and business strategies; e-business and e-commerce; ethical and social issues related to technology; technology decisions; business value of information systems.

2190422 Database Systems   2(2-0-4)

Database design and implementation: data models, database and schema design, relational algebra, relational calculus, query processing and optimization, constraints; storage and indexing: memory hierarchy, RAID, file organization and indexing, tree-structured/hash-based indexing; database design and tuning: schema refinement, functional dependencies, normal forms, physical design and tuning.

2190423 Software Engineering   1(0-2-1)

Design tools and techniques; top-down design, modular design, software tools, debugging and test data; software reliability, theory and concepts, error and fault estimation, reliability models, availability models; management techniques, cost estimation, software maintenance.

2190462 Database Systems Laboratory   1(0-3-0)
CONDITION: Co-requisite 2190422*

Database design and implementation of Relational Database Management Systems (RDBMS): hands-on introduction to SQL Basics including RDBMS installation,

configuration, troubleshooting, basic knowledge of relational databases and how to effectively maintain them.

2190472   Netcentric Architecture   3(3-0-6)
**   CONDITION:PRER 2190101***

TCP/IP architecture; application layer: principles of network applications, File Transfer Protocol (FTP), electronic mail, Domain Name Systems (DNS), web caching, Content Distribution Networks (CDN) through multi-media, peer-to-peer applications, socket programming, client-server model, peer-to-peer model; transport layer: User Datagram Protocol (UDP), reliable data transfer protocols, Transmission Control Protocol (TCP), 78 principles of congestion control; network layer: virtual circuit and datagram networks, internet Protocol (IP), routing in the Internet; multimedia networking: streaming stored audio and video, protocols for real-time interactive applications; security in computer networks.

2143423   High Technology   3(3-0-6)
**   Entrepreneurship**

Establishing technological or new businesses based on knowledge in technology and innovation, starting from basic ideas to ideas that can be implemented in terms of business; project analysis in terms of technical and business readiness, seting up business plan to prepare to investors who are interested; use of problem-based teaching to achieve results and exchange knowledge among all segments involved.

2143480   Independent Study I   1(0-3-2)

Independent study and investigation in topics related to information and communication engineering under the supervision of an instructor.

2143481   Independent Study II   1(0-3-2)

Independent study and investigation in topics related to information and communication engineering under the supervision of an instructor.

2143482   Independent Study III   1(0-3-2)

Independent study and investigation in topics related to information and communication engineering under the supervision of an instructor.

2143485   Special Topics in ICE I   2(2-0-4)

Review and discussion of special topics in information and communication engineering

2143486   Special Topics in ICE II   2(2-0-4)

Review and discussion of special topics in information and communication engineering.

2143487   Special Topics in ICE III   2(2-0-4)

Review and discussion of special topics in information and communication engineering.

2143495   Selected Topics in ICE I   3(3-0-6)

Topics of current interest and in new developments in information and communication engineering

2143497   Selected Topics in ICE II   3(3-0-6)

Topics of current interest and in new developments in information and communication engineering

2143498   Selected Topics in ICE III   3(3-0-6)

Topics of current interest and in new developments in information and communication engineering

2182420   Discrete-Time Signal Processing   3(3-0-6)

Discrete-time signal and systems; discrete-time processing of continuous-time signals; Linear Time Invariant (LTI) Systems; sampling Theory; Finite Impulse Response(FIR) filters, Infinite Impulse Response (IIR)filters; Signal Flow Graph Representation ; Transversal Filters. Discrete-Time Fourier Transform (DTFT), Fast Fourier Transform (FFT) algorithm; Decimation; Interpolation; Sampling Rate Conversion; Filter Bank; Aliassing; Finite-Precision Numerical Effects.

2182421   Multimedia Engineering   3(3-0-6)

Introduction to multimedia engineering; text coding standards image codig standards, video coding standards, audio coding standard; speech coding standards; IP networks, wireless networks; multimedia communication protocols; multimedia communication applications.

2182470   Telecommunication Management   3(3-0-6)

Telecommunication technology and trends; telecommunication markets; telecommunication economics; telecommunication law and policy; telecommunication licensing; competition in telecommunication business; telecommunication project management.

2182471   Optical Fiber Communication   3(3-0-6)

Overview of optical fiber communications; wave guiding in optical fibers, mode theory for dielectric circular waveguides; signal distortion in optical fibers due to loss and dispersion; optical sources, laser diodes; modulation techniques; photodetector, optical receiver 82 operation; digital transmission systems, power budget analysis; dispersion management; optical fiber amplifiers; principle and components in WDM systems

2182472   Principle of Wireless   3(3-0-6)
**   Communications**

Introduction to design analysis and fundamental limits of wireless transmission systems; wireless channel and system model, multipath fading; equalization, channel coding and diversity; resource management and power control; multiple antenna and MIMO systems; space-time codes and decoding algorithms; multiple-access techniques and multiuser detection; ad-hoc network

topologies; OFDM and ultrawideband systems; wireless LANs , MANs and cellular system standards.

2182473   Signal Transmission System   3(3-0-6)
Transmission lines; transmission line equation; transmission line analysis for sinusoidal waveforms; transmission line analysis for pulse waveforms; basic of plan wave propagation in free space; basic of signal transmission in optical fiber; signal frequency dispersion in optical fiber, fundamental of antenna; basic antenna parameters; design of transmission link; link budget.

2182474   System Integration   3(3-0-6)
System integration definition; communication systems; intelligent building automation; networking technology and cabling system management; introduction to communication system design; related standards for communication systems integration; compatibility and interoperability analysis; hardware vs. software integration; network integration; enterprise application integration; management of risk from Integration; interpersonal skills and communications for system engineer; case studies in system integration.

2182475   Teletraffic Engineering   3(3-0-6)
and Network Optimization
Teletraffic engineering overview; quality of service and network performance optimization; classification of teletraffic engineering systems and teletraffic parameters; teletraffic data collection techniques and statistics; modeling of non-queuing/loss-type system and queuing/delay-type system; modeling of system with mobile users; fundamentals of modeling network of by computer program ; simulation program; real-time network management and long-term network planning; application of optimization techniques in network controls; case studies in network design

2184402   Introduction to Stochastic   3(3-0-6)
Models
Unconditional and conditional probability; discrete and continuous random variables; moments; Poisson processes; discrete time Markov chain and applications; stochastic analysis and modeling.

2184403   Theory and Applications   3(3-0-6)
of Optimization
Introduction to theory, algorithms, and applications of optimization; optimization methodologies: linear programming, network optimization, and integer programming.

2184408   Supply Chain Management   3(3-0-6)
Definition of supply chain; coordination difficulties; pitfalls and opportunities in supply chain management; inventory/service level tradeoffs; performance measurement and incentive; extensive supply chain management; mass customization; supplier management; design and redesign of products and process for supply chain management; analytical tools; industrial applications; current industry initiatives.

2190317   Fundamental of Distributed   3(3-0-6)
Systems
Interprocess communication and remote procedure call; logical clock and ordering; centralized transaction and concurrency control; distributed transaction; two-phase commit protocol; distributed concurrency control; deadlock and distributed deadlock; load distribution; fault tolerance: fault model, recovery; replication: view and vector clock; distributed transaction under failure conditions; security; distributed services.

2190332   System Analysis and Design   3(3-0-6)
Data processing systems and system life cycle; analysis methodology, tools, cost analysis, problem specification; proposal, writing and feasibility study; design methodology: design tools, database approach, system design, file and form design, program design, documentation; implementation methodology: coding, program testing and software maintenance.

2190413   System Security   3(3-0-6)
Techniques for achieving security in multi-user computer systems and distributed computer system; physical security; discretionary and mandatory access control; biometrics; information-flow models of security; covert chanels; elementary cryptography; public-key cryptography; logic of authentication; electronic money; virus; firewall; electronic voting; risk assessment; secure web browsers.

2190414   Large-Scale Computing Systems   3(3-0-6)
High-performance and large-scale computing infrastructure: cluster, peer-to-peer, grid, cloud; virtualization; software architecture and middleware; HPC applications and algorithms for highly competent computers; HPC software development for highly competent computers.

2190424   Software Project Management   3(3-0-6)
Essence of software project management; scope of software projects; project management concepts; project estimation; software quality assurance; case studies on project life cycle.

2190425   Software Testing and Quality   3(3-0-6)
Assurance
Technical and managerial views of Software Testing and Software Quality Assurance (SQA) quality concepts; black and white box testing techniques; test coverage; test planning; levels of testing; the formation of a testing organization; testing-in-the-large; documentation for testing; inspections and walkthroughs; Quality Principle:

Quality Assurance, Quality Control, Cost of Quality and Quality Models.

2190436 Data Warehousing   3(3-0-6)

Introduction to data warehouse design including data modeling, database design and database access, issues in data warehouse planning, design, implementation, and administration; overview of OLAP(On-Line Analytical Processing) systems and data marts; components of data warehouse architecture and infrastructure; tools to build data warehouse.

2190442 Object-oriented Techniques   3(3-0-6)

Techniques of Object-Oriented Analysis (OOA) and Design(OOD) covering managing complexity,using data and procedural abstraction, encapsulation, hierarchies, and decomposition of problems into classes and objects; concepts about overloading, multiple inheritance and polymorphism; analysis, design, implementation and software development, Use Case Driven object-oriented development methodology; design patterns and Unified Modeling Language(UML).

2190443 User Interface Design   3(3-0-6)

Design, implementation, and evaluation of human-computer interfaces; human capabilities, including the human information processing, perception, Fitts's Law, memory, attentions and colors; task analysis, user-centered design, design principles; low-fidelity prototyping; heuristic evaluation; formative evaluation; controlled experiments; model-view-controller; input models, output models; constraints, layout and toolkits; review of current literature, short assignments, and substantial programming projects.

2190473 Ubiquitous Computing and   3(3-0-6)
              Networking

Introduction to ubiquitous computing, overview and basic terminologies; visions and fundamental challenges; wireless MACs; mobile IP; wireless ad hoc networks; wireless sensor networks; programming wireless networks of embedded systems; adaptive topology; time synchronization; localization; IPv6; internet of things; energy saving; smart grid.

2190479 Graphics Computing   3(3-0-6)

Hierarchy of graphics software, use of graphics API: simple color models (RGB, HSB, CMYK); homogeneous coordinates, affine transformations: scaling, rotation and translation; viewing transformation clipping, raster and vector graphics system.

2190511 Game Design and Development 3(3-0-6)
              Process for International Market

Player psychology; brainstorming techniques; game creation process; teamwork; design documentd; setting design; artificial intelligence; storytelling; gaming business in international market.

AEROSPACE ENGINEERING CURRICULUM
(INTERNATIONAL PROGRAM)

Aerospace engineers play an invaluable role in the development of modern aircraft and spacecraft. Ever since the advent of the first flying machines, new technologies have propelled us faster, further and more efficiently than ever before. Today there is an ever-increasing need for human resources with the capability to not only repair, maintain and construct today's aircraft, but also to look to the future and design those of tomorrow.

Global air travel is expanding at an unprecedented pace, prompting the foundation of many new commercial airlines in Southeast Asia. What's more, only aerospace engineers can provide the necessary innovation to advance strategic defence and satellite technologies. At a time when the big players in space travel are looking to set up lunar bases and manned missions to Mars, aerospace engineers are in high demand. Our AERO curriculum, developed by a collaboration of Chulalongkorn University with the Royal Thai Air Force, is tailor-made to meet this new hunger for aerospace expertise. Are you a high flyer?

Each student is required to accumulate a minimum of 139 credits to graduate for Bachelor of Engineering Program in Aerospace Engineering (International Program) which also includes 2 credits of industrial training and 3 credits of senior project.

Curriculum board

Phulporn Saengbangpla	M.Sc (Machester,UK)
Pramote Dechaumphai	Ph.D. (Virginia)
Ekachai Leelarasmee	Ph.D. (California)
Asi Bunyajitradulya	Ph.D. (California)
Siriporn Damrongsakkul	Ph.D. (London)
Atiwong Suchato	Ph.D. (Massachusetts)
Patama Visuttipitukul	Ph.D. (Tokyo)
Sunhapos Chatranuwathana	Ph.D. (Michigan)
Chaodit Aswakul	Ph.D. (London)
Yan Zhao	Ph.D. (London)
Surapong Sirikulvadhana	M.S (Michigan)
Varong Pavarajarn	Ph.D. (Oregon)

Professors
Electrical Engineering
Pramote	Dechaumphai,	Ph.D.(USA)

Associate Professors
Mechanical Engineering
Asi	Bunyajitradulya	Ph.D.(UC.Lrvine)
Kuntinee	Maneeratana	Ph.D.(London)
Pongtorn	Charunyakorn	Ph.D.(Miami)

Metallurgical Engineering
Seksak	Asavavisithchai	Ph.D.(Nottingham)

Computer Engineering

Atiwong	Suchato	Ph.D.(MIT)

Assistant Professors
Electrical Engineering
Thavatchai	Tayjasanant	Ph.D.(Alberta)
Manap	Wongsaisuwan	Ph.D.

Mechanical Engineering
Niphon	Wansophark,	D.Eng.(Chula)
Chittin	Tangthieng,	Ph.D.(Penn State)
Nopdanai	Ajavakom	Ph.D.(UC Berkeley)
Alongkorn	Pimpin,	Ph.D.(Tokyo)
Phongsaen	Pitakwatchara	Ph.D.(Tokyo)
Thanyarat	Singhanart	Ph.D.(Tokyo)

Metallurgical and materials Engineering
Itthipon	Diewwant,	Sc.D.(MIT)

Lecturer
Mechanical Engineering
Chirdpun	Vitoonraporn	Ph.D.
Tawan	Papapote	Ph.D.(Lllinois)
Sawat	Luengruengrit	D.Eng.(Tokyo)

ISE Staff
Prabhath	De Silva	Ph.D.(USA)
Pinunta	Rojratsirikul	Ph.D.(Bath, UK)
Borrdephong	Rattanagraikanakorn	Ph.D.(London)
Joshua	Staubs	Ph.D.(Virginia)

Guest Lecturer
Boonchai	Watjatrakul	Ph.D.
Wasunthara	Manklasavadi	Ph.D.
Pinanta	Rojratsirikul	Ph.D.
Anurak	Athasit	Ph.D.(France)
Jeerasak	Pitakarnnop	Ph.D.(France)
Sant	Sangwornrachasup	Ph.D.
Wicha	Mektrakran	B.Eng(USA)
Agaphas	Teparagul	

Curriculum

Total number of credits requirement	146	credits
General Education	31	credits
Core Courses	109	credits
Basic Sciences	18	credits
Basic Engineering	31	credits
Compulsory	54	credits
Approved Electives	6	credits
Free Electives	6	credits

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1. General Education	**31**	**credits**
Social Science	3	credits
Humanity	3	credits
Science and Mathematics	3	credits
Interdisciplinary	3	credits
Foreign Language	16	credits

5501112	Communicative English I	3	3(3-0-6)
5501123	Communicative English II	3	3(3-0-6)
5501213	Technical Communication I	2	2(2-0-4)
5501224	Technical Communication II	2	2(2-0-4)
5501315	Technical Communication III	2	2(2-0-4)
5501326	Technical Communication IV	2	2(2-0-4)
5501417	Technical Communication V	2	2(2-0-4)

	General Education (Special)	3	credits
2140111	Exploring Engineering World	3	3(3-0-6)

2. Core Courses   109   credits

Basic Sciences		*18*	*credits*
2301107	Calculus I		3(3-0-6)
2301108	Calculus II		3(3-0-6)
2302103	General Chemistry Laboratory		1(0-3-0)
2302105	Chemistry for Engineers		3(3-0-6)
2304153	Physics for Engineers		3(3-0-6)
2304154	Physics and Electronics for Engineers		3(3-0-6)
2304193	Physics Laboratory for Engineers		1(0-3-0)
2304194	Physics and Electronics Laboratory for Engineers		1(0-3-0)

Basic Engineering		*31*	*credits*
2140301	Industrial Training		2(0-6-0)
2182203	Probability and Statistics For Engineers		3(3-0-6)
2183101	Engineering Graphics		3(2-3-4)
2183211	Engineering Mechanics		4(4-0-8)
2183231	Dynamics		3(3-0-6)
2189101	Engineering Materials		3(3-0-6)
2190101	Computer Programming		3(3-0-6)
2190151	Computer Programming Laboratory		1(0-3-0)
2301215	Multivariable Calculus		3(3-0-6)
2301216	Linear Algebra and Differential Equations		3(3-0-6)
2301317	Methods of Applied Mathematics		3(3-0-6)

Compulsory		*54*	*credits*
2145211	Introduction to Aerospace Engineering		3(3-0-6)
2145221	Introduction to Aircraft Design		1(1-0-4)
2145230	Aircraft Electricity and Electronics		3(3-0-6)
2145290	Aerospace Engineering Seminar I		1(1-0-2)
2145311	Aerodynamics I		3(3-0-6)
2145312	Aerodynamics II		3(3-0-6)
2145321	Aircraft Structure I		3(3-0-6)
2145322	Aircraft Structure II		3(3-0-6)
2145324	Modeling and Control of Dynamic Systems		3(3-0-6)
2145325	Flight Mechanics		3(3-0-6)
2145361	Aerospace Engineering Experimentation and Laboratory I		2(1-3-2)
2145362	Aerospace Engineering Experimentation and Laboratory II		2(1-3-2)

2145363	Aerospace Engineering Experimentation and Laboratory III		2(1-3-2)
2145390	Aerospace Engineering Seminar II		1(1-0-2)
2145402	Aircraft Propulsion		4(4-0-8)
2145451	Aircraft Design		4(4-0-8)
2145490	Aerospace Engineering Seminar III		1(1-0-2)
2145499	Aerospace Engineering Project		3(3-0-6)
2183221	Thermodynamics		3(3-0-6)
2183222	Fluid Mechanics		3(3-0-6)
2183381	Numerical Methods for Engineers		3(3-0-6)

Approved Electives		*6*	*credits*
2145420	Avionics		3(3-0-6)
2145421	Introduction to Computational Fluid Dynamics		3(3-0-6)
2145422	Gas Dynamics		3(3-0-6)
2145460	Aircraft Repair Philosophy		3(3-0-6)
2145471	Flight Experience		3(2-3-4)
2145481	Introduction to Unmanned aerial Vehicle		3(3-0-6)
2145495	Independent Studies		3(0-6-3)
2145497	Selected Topics in Aerospace Engineering I		3(2-3-4)
2145498	Selected Topics in Aerospace Engineering II		3(2-3-4)
2183431	Mechanical Vibrations		3(3-0-6)
2184303	Engineering Management		3(3-0-6)

3. Free Electives   6   credits

Any two subjects at the university level that are taught in English

AEROSPACE ENGINEERING CURRICULUM

OURSE NO.	SUBJECT	CREDITS	COURSE NO.	SUBJECT	CREDITS
	FIRST SEMESTER			**FIFTH SEMESTER**	
2190101	Computer Programming	3	2145311	Aerodynamics I	3
2190151	Computer Programming Laboratory	1	2145321	Aircraft Structure I	3
2301107	Calculus I	3	2145324	Modeling and Control of Dynamic Systems	3
2302103	General Chemistry Laboratory	1			
2302105	Chemistry for Engineers	3	2145361	Aerospace Engineering Experimentation and Laboratory I	2
2304153	Physics for Engineers	3			
2304193	Physics Laboratory for Engineers	1	2183381	Numerical Methods for Engineers	3
5501112	Communicative English I	3	5501315	Technical Communication III	2
		18	xxxxxxx	General Education	3
					19
	SECOND SEMESTER				
2140111	Exploring Engineering World	3		**SIXTH SEMESTER**	
2183101	Engineering Graphics	3	2145312	Aerodynamics II	3
2189101	Engineering Materials	3	2145322	Aircraft Sturcture II	3
2301108	Calculus II	3	2145325	Flight Mechanics	3
2304154	Physics and Electronics for Engineers	3	2145362	Aerospace Engineering Experimentation and Laboratory II	2
2304194	Physics and Electronics Laboratory for Engineers	1	2145390	Aerospace Engineering Seminar II	1
5501123	Communicative English II	3	5501326	Technical Communication IV	2
		19	xxxxxxx	General Education	3
					17
	THIRD SEMESTER				
2145211	Introduction to Aerospace Engineering	3		**SUMMER SEMESTER**	
2183211	Engineering Mechanics	4	2140301	Industrial Training	2
2183221	Thermodynamics	3			**2**
2301215	Multivariable Calculus	3			
2301216	Linear Algebra and Differential Equations	3		**SEVENTH SEMESTER**	
5501213	Technical Communication I	2	2145363	Aerospace Engineering Experimentation and Laboratory III	3
		18	2145402	Aircraft Propulsion	4
			2145451	Aircraft Design	4
	FOURTH SEMESTER		5501417	Technical Communication V	2
2145221	Introduction to Aircraft Design	1	xxxxxxx	Approved Elective	3
2145230	Aircraft Electricity and Electronics	3	xxxxxxx	General Education	3
2145290	Aerospace Engineering Seminar I	1			**18**
2182203	Probability and Statistics for Eng.	3			
2183222	Fluid Mechanics	3		**EIGTHTH SEMESTER**	
2183231	Dynamics	3	2145499	Aerospace Engineering Project	3
2301317	Methods of Applied Mathematics	3	xxxxxxx	Approved Elective	3
5501224	Technical Communication II	2	xxxxxxx	Free Elective	3
		19	xxxxxxx	Free Elective	3
			xxxxxxx	General Education	3
			2145490	Aerospace Engineering Seminar III	1
					16

TOTAL CREDITS FOR GRADUATION   **146**

1. General Education
Foreign Language

5501112   Communicative English I   3(3-0-6)

Practice language skills in acquiring information and knowledge from different sources and media in subjects of students' interest under selected themes; collecting information, summarizing and presenting important issues.

5501123   Communicative English II   3(3-0-6)
CONDITION: PRER 5501112*

Practice language skills in acquiring analyzing and synthesizing information and knowledge from different sources and media on topics of students' interest under selected themes; summarizing what they have learned, and presenting opinions from group discussion.

5501213   Technical Communication I   2(2-0-4)

Students are to practice academic writing at paragraph level. Selected readings in the related field are included. Discussion and presentation skills are to be taught including listening input.

5501224   Technical Communication II   2(2-0-4)
CONDITION: PRER 5501213

Students are to practice extensive academic writing at paragraph level. Selected readings in the related field are included. More discussion and presentation skills are to be taught including listening input.

5501315   Technical Communication III   2(2-0-4)
CONDITION: PRER 5501224*

Students are to develop ability in technical writing and academic essay writing. Selected readings in the related field are included. Academic presentation skills are to be taught including listening input in the related field.

5501326   Technical Communication IV   2(2-0-4)
CONDITION: PRER 5501315*

Students are to write technical reports and do academic presentations. Selected readings in technical discourse and listening input are included.

5501417   Technical Communication V   2(2-0-4)
CONDITION: PRER 5501326*

Students are to write academic articles and do academic presentations. Students are to develop their writing processes and presentation skills to bring their proficiency to the highest level in the related field.

General Education (Special)
2140111   Exploring Engineering World   3(3-0-6)

Engineering topics related to daily life: energy, resources, environment manufacturing, process, industry, material, automotive, infrastructure, information system and bio engineering

2. Core Courses
Basic Sciences
2301107   Calculus I   3(3-0-6)

Limit, continuity, differentiation and integration of real-valued functions of a real variable and their applications; techniques of integration; improper integrals

2301108   Calculus II   3(3-0-6)
CONDITION: PRER 2301107

Mathematical induction; sequences and series of real numbers; Taylor series expansion and approximation of elementary functions; numerical integration; vectors, lines and planes in three dimensional space; calculus of vector valued functions of one variable; calculus of real valued functions of two variables; introduction to differential equations and their applications.

2302103   General Chemistry Laboratory   1(0-3-0)

Standard solution preparation; qualitative analysis; titration; electrochemistry; pH metric titration; spectroscopy; calculation and evaluation of data; calibration curve; introduction to polymer.

2302105   Chemistry for Engineers   3(3-0-6)

Stoichiometry and basis of the atomic theory; properties of the three states of matter and solution; thermodynamics; chemical equilibrium; Oxidation; chemical kinetics; the electronic structures of atoms and the chemical bond; periodic table; nonmetal and transition metal.

2142153   Physics for Engineers   3(3-0-6)

Mechanics of particles and rigid bodies, properties of matter, fluid mechanics, heat, vibrations and waves, elements of electromagnetism, optics, modern physics.

2304154   Physics and Electronics for   3(3-0-6)
Engineers

Electricity; DC circuit; AC circuit; basic electronics; solid state devices; electrical actuators.

2304193   Physics Laboratory for   1(0-3-0)
Engineers

Measurement and precision; experiments on simple harmonic motion, radius of gyration, dynamics of rotation, velocity of sound, viscosity of fluids.

2304194   Physics and Electronics   1(0-3-0)
Laboratory for Engineers PHYS ELEC LAB
ENGS

Resistance and electromotive force measurements; experiments on amp meter, voltmeter, oscilloscope, AC circuit, transistor, lenses and mirrors, polarization, interference, diffraction.

Compulsory Courses
2140301   Industrial Training   2(0-6-0)

Engineering practice in related areas under supervision of experienced engineers in private sectors or government agencies.

2182203 Probability and Statistics for   **3(3-0-6)**
        Engineers
        CONDITION: PRER 2301108

Engineering basis in statistics and probability; discrete and continuous probability distribution; joint probability distribution; parameter estimation: estimator, bias, consistency; point estimation; interval estimation; engineering applications in measurement and uncertainty, linear regression, introduction to random process; integration of statistics in engineering applications; case studies.

2183101 Engineering Graphics   **3(2-3-4)**

Lettering; orthographic projections; sketching and drawing; pictorial drawing; dimensioning; to lerancing and geometrical tolerancing; section; working drawing; mechanical parts drawing; introduction to CAD.

2183211 Engineering Mechanics   **4(4-0-8)**

Analysis of force systems and their equilibrium as applied to engineering systems; stresses and strains; mechanical properties of materials; Hooke's law, elastic modulus, stress in beam, shear force, bending moment diagram, torsion, buckling of columns,Mohr's circle.

2183231 Dynamics   **3(3-0-6)**

Kinematics of three-dimensional curvilinear motion of a particle; kinetics of a particle: force and acceleration, work and energy, impulse and momentum; kinematics of planar motion of a rigid body: force and acceleration, work and energy, impulse and momentum; introduction to kinematics and kinetics of three-dimensional motion of a rigid body.

2189101 Engineering Materials   **3(3-0-6)**

Important engineering materials: metals, plastics, asphalt, wood and concrete; macroscopic and microscopic structure which are correlating with properties of the engineering materials; production process of products from engineering materials.

2190101 Computer Programming   **3(3-0-6)**

Introduction to computer systems; problem-solving using computers; programming in high-level languages; program structure, programming style and convention; control statements, data handling and processing; subprograms; classes and objects.

2190151 Computer Programming Laboratory 1(0-3-0)

Computer programming in Engineering; reviews of computer programming concepts; hands on experience on computer programming using contemporary engineering tools.

2301215 Multivariable Calculus   **3(3-0-6)**
        CONDITION: PRER 2301108

Vector; curves, planes and surfaces; derivatives of vector-valued functions; partial, total and directional derivatives; implicit differentiation; maxima-minima; gradient, divergence, curl; scalar and vector fields; line integral; surface integral and volume integral; integral theorems of vector analysis.

2301216 Linear Algebra and Differential   **3(3-0-6)**
        Equations
        CONDITION: PRER 2301108

System of linear algebraic equations; linear spaces; inner products; eigenvalues and eigenvectors; principal axic theorem; higher-order linear differential equations; method of variation of parameters; system of first-order linear differential equations; qualitative analysis and dynamical system.

2301317 Methods of Applied Mathematecs   **3(3-0-6)**
        CONDITION: PRER 2301215

Series solution; special functions; Laplace transforms; Fourier series and Fourier transforms; convergence theory; boundary value problems; linear partial differential equations; introduction to tensors; complex variables; analytic functions; line and contour integral; Laurent series; residue theorem.

2145211 Introduction to Aerospace   **3(3-0-6)**
        Engineering

Basic aerodynamic phenomena and simplified theory, elementary aerospace vehicle performance, stability and control, and design.

2145221 Introduction to Aircraft Design   **1(1-0-4)**

Introduction to aircraft systems, fundamental to aircraft systems, elements of aerodynamics, airfoils, and wings, aspect of vehicle conceptual design.

2145230 Aircraft Electricity   **3(3-0-6)**
        and Electronics

DC and AC circuits analysis, electrical control devices, analog and digital electronics, electric measuring instruments, electric motors, aircraft electrical systems, radio theory, aircraft communication and navigation systems, autoflight systems.

2145290 Aerospace Engineering Seminar I   **1(1-0-2)**

Discussion on the topics of aerospace engineering

2145311 Aerodynamics I   **3(3-0-6)**
        CONDITION: PRER 2183222*

Properties of air, standard atmosphere, conservation principles, continuity, momentum, Euler's Equation, rotationality, circulation, vortex, lift, drag, potential flow, airfoil characteristics, thin airfoil theory, cambered and flapped airfoil, high lift devices, finite wing theory, panel and vortex lattice methods.

2145312 Aerodynamics II   **3(3-0-6)**
        AERODYNAMICS II

Fundamental of compressible flow, acoustic waves, normal and oblique shock waves, expansion waves, Prandtl-Meyer flow, convergent-divergent nozzle, flow with friction and heat transfer, unsteady wave motion, perturbation theory, linearized flow and theory of characteristics.

2145321   Aircraft Structure I   3(3-0-6)

Introduction to design of aerospace structures, review of concepts of stress, deformation, strain, and displacement and the equations of elasticity, two-dimensional problems in elasticity, energy methods of structural analysis, principles of virtual displacements and virtual forces, bending of thin plates, structural instability, introduction to finite element.

2145322   Aircraft Structure II   3(3-0-6)
CONDITION: PRER 2145321

Principles of stressed skin construction, thin-walled beam, bending, shear and torsion of open and closed thin-walled beam, stress analysis of aircraft components, tapered beam, fuselage, wings, fuselage frames and wing rib, airworthiness and aeroelasticity, factors of safety flight envelop, load factor determination, fatigue.

2145324   Modeling and Control   3 (3-0-6)
of Dynamic Systems

Introduction to modeling, analysis, and control of dynamic systems; modeling of mechanical, electrical and electromechanical system; Laplace Transforms and transfer function techniques; frequency response and Bode diagrams; analysis and design of feedback control systems; control system representation and characteristics; system performance specifications; stability analysis and conditions; Root-Locus and frequency response analysis and design; systems compensation and controller design.

2145325   Flight Mechanics   3(3-0-6)
CONDITION: PRER 2183231
and 2145324

Performance, stability, and control of aircraft; general equations of motion for rigid aircraft, aerodynamic forces and moments; flight paths; small disturbance theory, stability derivatives, longitudinal and lateral stability; response to control inputs and to atmospheric disturbances; automatic flight control.

2145361   Aerospace Engineering   2(1-3-2)
Experimentation and Laboratory I

Concepts in experimentation; introduction to systematic design of an experiment using data reduction diagram (DRD): setting up objectives of an experiment, constructing the set of data reduction diagrams (DRDs) of the experiment according to the objectives; measurement and instrument; uncertainty analysis; basic experiments and laboratories in thermodynamics; fluid mechanics and aerodynamics; dynamics; solid mechanics.

2145362   Aerospace Engineering   2(1-3-2)
Experimentation and Laboratory II
CONDITION: PRER 2145361

Experiments and laboratories in aerodynamics, structure, propulsion, performance, dynamics and control.

2145363   Aerospace Engineering   2(1-3-2)
Experimentation and Laboratory III
CONDITION: PRER 2145362

Concepts in experimentation and design of an experiment; setting up specifications and objectives of an experiment; systematic design of an experiment according to the specifications and objectives using different kinds of tools; outlining the process of extracting experimental results and conclusions from the designed experiment; outlining data collection and data analysis schemesl outlining experimental project phases, tasks, and schedule; design documentation and review by oral and written presentation; practices in the design of an experiment in the project-based setting; introduction to modern instrumentation and data acquisition through demonstration.

2145390   Aerospace Engineering   1(1-0-2)
Seminar II

Discussion on the topics of aerospace engineering.

2145402   Aircraft Propulsion   4(4-0-8)
CONDITION: PRER 2183221
and 2183222

Introduction to propulsion, air-breathing and non-air-breathing engines; brief review of the thermodynamics and compressible flow; basic thrust equation of aircraft gas turbine engines; Brayton cycle, propellers, momentum theory and blade element theory; gas turbine component performance, inlet, compressor, turbine and nozzle; cycle analysis of gas turbine engines, ramjet, turbojet, turbofan and turboprop.

2145451   Aircraft Design   4(4-0-8)
CONDITION: PRER 2145221

Fundamentals of aircraft design process, wing design consideration, tail design consideration, undercarriage arrangement consideration, initial take-off mass estimation, detailed mass calculation, mission fuel requirement; center of gravity calculation, basic aerodynamics estimation, static stability and control analysis, propulsion consideration and analysis, performance analysis, aircraft cost prediction, preliminary and detailed design concepts, quality control of aircraft design.

2145490   Aerospace Engineering   1(1-0-2)
Seminar III

Discussion on the topics of aerospace engineering.

2145499   Aerospace Engineering Project   3(0-6-3)

Group or individual projects on a subject related to aerospace engineering.

2183221   Thermodynamics   3(3-0-6)
Basic concepts; thermodynamic state and process; properties of pure substances and ideal gases; energy; the first law of thermodynamics and the first law analysis for isolated, closed, and open systems; entropy; the second law of thermodynamics and the second law analysis for isolated, closed, and opens systems; gas power cycles; Carnot, Otto, and Brayton cycles; refrigeration cycle; introduction to gas mixtures; introduction to combustion.

2183222   Fluid Mechanics   3(3-0-6)
Basic concepts in physics: physical quantity and physical quantity relations, dimensions of physical quantity and the principle of dimensional homogeneity, dimensionless variables; basic concepts in fluid mechanics: continuum assumption, methods of description: Lagrangian and Eulerian descriptions, field quantity and classification of flow fields; geometric and kinematics of fluid motion: pathlines, streamlines, and streaklines; forces and stressed in fluids: pressure and pressure force, shear stress and shear force: convection flux and Reynold's transport theorem; physical laws of finite control volume: conservations of mass, linear momentum, and energy; conservation of angular momentum with application to turbomachines; physical laws of infinite control volume: conservation of mass and linear momentum, introduction to Navier-Stokes and Euler's equations; Bernoulli's equation from momentum and conservation of mechanical energy viewpoints; introduction to vorticity and vortex; dimensional analysis: Buckingham's PI theorem, similarity, and model testing; internal viscous flows, energy consideration in pipe folws and piping system; external flows, boundary layer, and aerodynamic force and moment; applications: turbomachines, model testing, piping and pumping system, aerodynamic force and moment.

2183381   Numerical Methods for Engineers   3(3-0-6)
Basic methods for obtaining numerical solutions by a digital computer, including methods for the solutions of algebraic and transcendental equations, simultaneous linear equations, ordinary and partial differential equations, and curve fitting techniques, comparison of various methods with respect to computational efficiency and accuracy.

Approved Electives
2145420   Avionics   3(3-0-6)
Basic avionic system, air data systems, flight instruments, terrestrial en-route – radio navigation systems, terrestrial landing aids, satellite navigation system, radar systems, indicators and displays, airborne radio communications, autopilot and flight-management system, avionic systems integration.

**2145421   Introduction to Computational   3(3-0-6)
           Fluid Dynamics**
Physical and mathematical foundations of computational fluid mechanics with emphasis on applications; solution methods for model equations, the Euler and the Navier-Stokes equations; classification of partial differential equations and solution techniques.

2145422   Gas Dynamics   3(3-0-6)
Introduction to gas dynamics, covering fundamental concepts in thermodynamics and fluid dynamics; molecular and continuum concepts for fluids, first and second laws of thermodynamics, conservation laws for moving fluids, one-dimensional compressible flows, shock and expansion waves, flows in nozzles, and two- and three-dimensional compressible flows.

**2145497   Selected Topics in Aerospace   3(2-3-4)
           Engineering I**
Selected interesting topics in aerospace engineering.

**2145498   Selected Topics in Aerospace   3(2-3-4)
           Engineering II**
Selected interesting topics in aerospace engineering.

2183431   Mechanical Vibrations   3(3-0-6)
Analysis of system with single and multi degree of freedom; torsional vibration; free and forced vibration; determination of natural frequencies of structures; discrete system; Modal analysis; methods and techniques to reduce and control vibration; Lagrange's equations.

2184303   Engineering Management   3(3-0-6)
Modern management principles; methods of increasing productivity; human relations; industrial safety; pollution problems; commercial laws; basics of engineering economy, finance, marketing and project management.

2301107   Calculus I   3(3-0-6)
Limit, continuity, differentiation and integration of real-valued functions of a real variable and their applications; techniques of integration; improper integrals.

2301108   Calculus II   3(3-0-6)
Mathematical induction; sequences and series of real numbers; Taylor series expansion and approximation of elementary functions; numerical integration; vectors, lines and planes in three dimensional space; calculus of vector valued functions of one variable; calculus of real valued functions of two variables; introduction to differential equations and their applications.

2301201   Advanced Calculus I   4(4-0-8)
Algebra and calculus of vectors, vector differential operators (gradient, divergence and curl), cylindrical and spherical coordinates, Green's Gauss's and Stokes' theorems, tensors

2301312   Differential Equations   3(3-0-6)
Existence and uniqueness theorem for first-order equations; numerical methods; general linear equations; solution in series form; linear partial differential equations; boundary value problems.

2302103   General Chemistry Laboratory   1(0-3-0)
Standard solution preparation; qualitative analysis; titration; electrochemistry; pH metric titration; spectroscopy; calculation and evaluation of data; calibration curve; introduction to polymer.

2302105   Chemistry for Engineers   3(3-0-6)
Stoichiometry and basis of the atomic theory; properties of the three states of matter and solution; thermodynamics; chemical equilibrium; Oxidation-reduction; chemical kinetics; the electronic structures of atoms and the chemical bond; periodic table; nonmetal and transition metal.

2302203   Organic Chemistry Laboratory   1(0-3-0)
Fundamental laboratory techniques concerning the separation, purification and determination of physical constants of organic compounds; chemical reactions of organic compounds of various functional groups; synthesis of certain target molecules.

2302207   Basic Organic Chemistry   3(3-0-6)
Structure and bonding, stereochemistry, spectroscopy, hydrocarbon, halogen-containing compounds, oxygen-containing compounds, nitrogen-containing compounds, biomolecules.

2302231   Physical Chemistry I   3(3-0-6)
The nature of physical chemistry; gases and liquids; solid states; symmetry; atomic structure and quantum chemistry; chemical bonding; the investigation for molecular structure; nuclear chemistry; the laws of chemical thermodynamics; free energy and chemical equilibrium; phase rule.

2303111   Biology for Engineers   3(3-0-6)
Biological principles: the modern cell concept, life energy, principles of classification, comparative aspects of anatomy and physiology, genetics, DNA, behavior and relationships of organisms and their environments.

**2303112   Biology Laboratory for   1(0-3-0)
           Engineers**
Biological experiments which accord with biology for engineer.

2304153   Physics for Engineers   3(3-0-6)
Mechanics of particles and rigid bodies, properties of matter, fluid mechanics, heat, vibrations and waves, elements of electromagnetism, optics, modern physics.

**2304154   Physics and Electronics for   3(3-0-6)
           Engineers**
Electricity; DC circuit; AC circuit; basic electronics; solid state devices; electrical actuators

**2304193   Physics Laboratory for   1(0-3-0)
           Engineers**
Measurement and precision; experiments on simple harmonic motion, radius of gyration, dynamics of rotation, velocity of sound, viscosity of fluids.

**2304194   Physics and Electronics   1(0-3-0)
           Laboratory for Engineers**
Resistance and electromotive force measurements; experiments on amp meter, voltmeter, oscilloscope, AC circuit, transistor, lenses and mirrors, polarization, interference, diffraction.

**5501111   English for   3(3-0-6)
           Engineering I (S/U)**
Grammar; use of simple sentences; writing mechanics and process; writing and vision aids to good English.

**5501122   English for   3(3-0-6)
           Engineering II (S/U)**
Use of more complex sentences; expressive and creative writing; writing research papers and technical reports.

The Regional Centre for Manufacturing Systems Engineering

The Regional Centre for Manufacturing Systems Engineering was established in the Faculty of Engineering, with the initial support of the Federation of Thai industries and the British Council, to be the focal point of graduate-level teaching and research in engineering management and manufacturing systems engineering in the South-East Asian region. Since the first group in January 1996, the Centre has graduated several hundred master degree graduates in its unique dual-degree programme with the University of Warwick.

Established in 1996 the Regional Centre for Manufacturing Systems Engineering offers a postgraduate programme leading to the degree of Master of Engineering in Engineering Management. It is based on the successful model at the University of Warwick which is supported by a number of leading international companies. The current programme in Thailand is supported by The Federation of Thai industries. It allows the transfer of leading edge technologies and manufacturing strategies to Thai companies.

Academic staff from both the Warwick Manufacturing Group and Chulalongkorn University contribute to teaching of the programme. The Master of Engineering award is granted by Chulalongkorn University and the Master of Science award is granted, concurrently, by the University of Warwick providing truly international credibility.

ENGINEERING MANAGEMENT
(International Program)

NAME OF THE DEGREE

: Master of Engineering
: M . Eng.

ADMISSION

1. The applicant must hold a Bachelor's Degree of Engineering or equivalent with the minimum TOEFL score of 550 or with the certificate of proficiency in English (IELTS 6.0) from the British Council or with WELT B,C,C.

2. The Applicant must meet other qualifications set by the regulations of the Graduate School, Chulalongkorn University , which will be annually announced. Otherwise the applicant must earn the approval by the graduate study committee of the Faculty of Engineering.

DEGREE REQUIREMENTS

Number of credits for curriculum not less than 42 credits: 2 credits for required courses (non-credit), 22 credits for elective courses, 18 credits for thesis.

PROFESSORS :

Parames   Chutima,   Ph.D. (Nottingham)

ASSOCIATE PROFESSORS :

Jeerapat	Ngaoprasertwong,	M.S. M.A. (Iowa) B.Eng. Hons. (Chula)
Natcha	Thawesaengskulthai,	Ph.D. (Nottingham) M.S. (Linköping)
Somkiat	Tangjitsitchareon,	Ph.D. (Kobe)

ASSISTANT PROFESSORS :

Krerk	Piromsopa,	Ph.D. (Michigan)
Oran	Kittithreerapronchai,	Ph.D. , M.S. (Georgia Tech)
Naragain	Phumchusri, Ph.D. ,	M.S. (Georgia Tech)
Pisit	Jarumaneeroj,	Ph.D. , M.S. (Georgia Tech)

INSTRUCTORS :

| Arisara | Jiamsanguanwong, | Ph.D. , M.S. (Tokyo Tech) |

COURSE REQUIREMENTS

1) Required Courses   2 credits

2163601	Fundamentals of Integrated Engineering Business Management	2(2-0-6)

2) Approved Electives 10 credits

2163610	Service Support Technologies	2(2-0-6)
2163620	Logistics and Operation Management	2(2-0-6)
2163630	Business Strategy and Strategic Management	2(2-0-6)
2163631	Project Planning Management and Control	2(2-0-6)
2163632	Organisations, People and Performance	2(2-0-6)

3) Elective Courses 12 credits

Technology

2163611	Computer Aided Design and Manufacture	2(2-0-6)
2163612	Automation and Robotics	2(2-0-6)
2163613	E-Commerce Technologies	2(2-0-6)
2163614	Metallic Materials: Properties Processes and Applications	2(2-0-6)
6163615	Polymer Materials: Processes and Applications	2(2-0-6)
2163616	Information and Communication Technologies	2(2-0-6)
2163617	Manufacturing Process Technology	2(2-0-6)
2163618	Design for the Environment	2(2-0-6)

Operation

2163621	Supply Chain Management	2(2-0-6)
2163622	Technology Management	2(2-0-6)
2163623	Product Design and Development Management	2(2-0-6)
2163624	Quality Management and Techniques	2(2-0-6)
2163625	Applied Statistical Methods	2(2-0-6)

Management

2163633	Operations Strategy for Industry	2(2-0-6)
2163634	Strategic Marketing	2(2-0-6)
2163635	Information System Strategy	2(2-0-6)
2163636	Innovative Strategy	2(2-0-6)
2163637	Financial Analysis and Control Systems	2(2-0-6)
2163638	Financial Strategy	2(2-0-6)
2163639	Management of Change	2(2-0-6)
2163640	International Joint Venture	2(2-0-6)
2163641	Establishing New Business	2(2-0-6)
2163642	Business Environment and Economics	2(2-0-6)

General

2163691	Advanced Topics in Engineering Management I	2(2-0-6)
2163692	Advanced Topics in Engineering Management II	2(2-0-6)
2163693	Advanced Topics in Engineering Management III	2(2-0-6)
2163694	Advanced Topics in Engineering Management IV	2(2-0-6)
2163695	Advanced Topics in Engineering Management V	2(2-0-6)
2163696	Advanced Topics in Engineering Management VI	2(2-0-6)

3) Thesis

2163813	Thesis	18 credits

COURSE DESCRIPTIONS

**2163601   Fundamentals of Integrated   2(2-0-6)
                   Engineering Business Management**

Introduction to engineering business management; manufacturing and engineering industry today; international challenge; the change of management process; IEBM programmer rationale; introduction to strategic planning tools; introduction to manufacturing operations strategy; manufacturing operations strategy formulation process; systems approach; product strategy and innovation; role of technology; tools and techniques of operational management.

2163610   Service Support Technologies   2(2-0-6)

The Service Support Technologies looks at the technologies available to both deliver and support service. It will consider diagnostic tools both in terms of healthcare diagnostics and machinery diagnostics. The secondary level of technological support in terms of information systems and global business implications will also be covered.

**2163620   Logistics and Operation   2(2-0-6)
                   Management**

The logistics function in the supply chain; establishing a logistics strategy; customer and supplier relationship; operations planning and control; material requirements planning; just-in-time philosophies; the use of computers in logistics and operations management; distribution networks; measuring logistics performance.

**2163630   Business Strategy and Strategic   2(2-0-6)
                   Management**

Introduction and International economic background; economic and business trends in the Asia Pacific area; the strategic management process; analysis of the external environment; analysis of the internal environment;

Alternative approaches to strategic thinking; financial aspects of strategic management; organizational and human resource aspects; global business strategies; Cross-cultural aspects of strategic management; Case studies.

**2163631   Project Planning Management and   2(2-0-6)
             Control**

Project organization, planning and content analysis; estimating; and tendering; budgeting and cost control; network planning; project monitoring; partnership/contractor relationships.

**2163632   Organisations People and   2(2-0-6)
             Performance**

Company organization, cultures and management styles; payment schemes; trade unions and industrial relations; legislation; the role of the individual, career and personal development; technological implications; manpower and succession planning, selection and motivation; communications; conflicts between company and individual objectives.

**2163611   Computer Aided Design and   2(2-0-6)
             Manufacture**

Basis CAD concepts; 3-D concepts; 2 ½ axis NC. Programming; finite element analysis; surface modeling; coding and classification; cell control; computer aided inspection; 3 axis NC.Programming; computer aided process planning; parametric; knowledge based systems in CAD/CAM; CAD/CAM-design to manufacture demonstration; role of CAD/CAM; introduction to computer integrated manufacture (CIM); emerging technologies; case study.

2163612   Automation and Robotics   2(2-0-6)

Principles and implementation of automatic and robotics systems; automatic process control logic and sequence; automated materials handling and storage; economic justification for AMT projects; flexible manufacturing systems; vision engineering; robots at work; importance of design in automation; case studies, syndicate exercises and a visit.

2163613   e-Commerce Technologies   2(2-0-6)

E-Commerce in perspective; the application of E-Commerce tools and techniques; Internet, Intranet and Extranet; communication and network technologies; privacy and security; collaborative product commerce; data warehouses, mining and knowledge engineering; evaluation of e-commerce in functional operations; legal implications; virtual enterprises; the future of e-commerce technologies.

**2163614   Metallic Materials: Properties   2(2-0-6)
             Processes and Applications**   The structure/property relationship - mechanical properties of metals and alloys, methods of measuring and increasing them, and their influence on process ability   and application; Properties and selection of steels; heat treatment; effect of alloying; Properties and selection of cast irons; introduction to tool materials; properties and selection of non-ferrous metals; failure investigation; introduction to engineering ceramics; electronic and optical materials; metal matrix composites; introduction to primary production processes.

**2163615   Polymer Materials: Processes and   2(2-0-6)
             Applications**

Polymers as an engineering material; manufacturing technologies for polymeric materials; economics of material selection and aspects of environmental considerations; computer simulation: component, tooling and manufacturing techniques; high and low volume production manufacturing technologies; plastic component market opportunities; case study; laboratory visit

**2163616   Information and Communication   2(2-0-6)
             Technologies**

Systematic project management methodology; data modeling; database design and management; computer architectures and operating environments; system development tools and programming; data communication and network technologies; internet and world-wide-web technologies; emerging technologies; human aspects of systems implementation.

2163617   Manufacturing Process Technology 2(2-0-6)

An appreciation of the application capabilities and limitation of primary and secondary manufacturing processes.

2163618   Design for the Environment   2(2-0-6)

Train a new generation of product designers and managers who will play a major role in the move towards sustainable development. Integrate the needs of the customer with those of the environment to ensure that the society can reach a more balanced trade-off between economy and environment. An appreciation of sustainable buisness practice, energy, design, materials and life cycle analysis is key. New eco-friendly products and clean production technologies need to be developed and utilised in our drive towards sustainable development at national and global level.

2163621   Supply Chain Management   2(2-0-6)

Meaning of supply chain management; designing the supply base and selecting suppliers; supply chain relationships; measuring suppliers and the supply chain; supplier development and continuous improvement; organization design; technology
in supply chain management.

2163622   Technology Management   2(2-0-6)

Technology and its importance; case studies on the benefits/consequences of adopting/ignoring technology; how business needs and product strategy drive technological requirements; evaluation of capability of the competitors, companies to deliver technology: SWOT and benchmarking exercises; formulating company

technology strategy - accessing technology; justifying technological investment - persuading decision makers; tools and techniques for assessing technology and delivering it at acceptable risk; implementation of strategy for technological change; future opportunities and developments.

2163623   Product Design and Development 2(2-0-6)
                Management

The role of the marketing organization; methods to turn concepts into engineering solutions; content of a design specifications; sources of costs associated with introduction of a new product; prevention of defects and scrap of rejects during manufacture and assembly; cost of ownership concept; design for simple maintenance.

2163624   Quality Management and   2(2-0-6)
                Techniques

Management for Quality; Motivation and Employee Involvement; Economics of Quality; Design for Quality; Basic Tools of Quality Improvement; Variability in Processes; Product Liability; Quality Systems; Failure Modes, Effects and Criticality Analysis; Quality Function Deployment.

2163625   Applied Statistical Methods   2(2-0-6)

Descriptive statistics; probability; distributions: binomial, Poisson, exponential and normal: exploratory data analysis; sampling and testing; analysis of variance; regression analysis; goodness of fit; distribution-free (non parametric) statistics; design of experiments; statistics on computer.

2163633   Operations Strategy for Industry   2(2-0-6)

The company and corporate strategy; the market requirements; products and product design; subcontracting, sourcing, make and buy decision; technology, processes, plant replacement and investment; total quality; manufacturing operations organization; diversification factoring and acquisition; joint venture and collaboration; human factors; company structure; external factors; financial controls.

2163634   Strategic Marketing   2 (2-0-6)

Introduction to marketing; types of market; marketing research and analysis; managing the marketing mix regarding product, price, place and promotion as well as the impact on it of information technology; strategic market planning perquisites and methods and management.

2163635   Information System Strategy   2 (2-0-6)

Information systems evolution; data and information presentation and management; business activity and information analysis; organizational implications; information systems architecture and selection; strategy

development; legal and financial implications; industrial sector comparisons.

2163636   Innovative Strategy   2(2-0-6)

Environments for learning and innovation; The barriers to creative thinking; Understanding mind-sets through a manufacturing strategy role play; the design/development of business processes for innovation; an innovation strategy workshop; approaches to business strategies; the world of systems thinking; a business systems simulation; national issues for innovation policy; leadership styles; development of innovation action plans.

2163637   Financial Analysis and Control   2(2-0-6)
                Systems

Financial objectives; profitability and liquidity; analysis and interpretation of published financial statements; cost behavior analysis; profit/volume analyses; budget preparation and control; standard costing; divisional/segmental performance measurement; capital investment; risk and uncertainty analysis; effects of inflation and taxation; introduction to computer-based financial modeling.

2163638   Financial Strategy   2(2-0-6)

Capital expenditure appraisal and present value concept; taxation. Inflation and life cycle costing; financial modeling; risk and return on investment; sources of finance and market efficiency; mergers and acquisitions; international financial markets.

2163639   Management of Change   2(2-0-6)

Concept and consideration of mapping the organization, people's used in reaction to changes, concepts and consideration of individual territories, journeys to success, tools and techniques, major change programs, planning and implementing change, model for change, continuous learning and change, planning for the future

2163640   International Joint Ventures   2(2-0-6)

Collaboration strategy, concepts and types of collaborative venture, international joint venture management, guidelines for practice and culture, low and finance, negotiation and international joint venture exercises.

2163641   Establishing New Business   2(2-0-6)

Explores the personal motivators and implementation issues in setting up a new business. It explores options on the types of businesses, and the resulting legal requirements and operational regulations that may apply and how these impact on the operational structure of the business. It explores the personal compromises that will be required.

2163642   Business Environment and   2(2-0-6)
                Economics

Economics data; econometrics; demand/supply and the market; national and international level of economic activity; microeconomic at industry level; markets and efficiency; market failure; industry structure.

2163691 Advanced Topics in Engineering 2(2-0-6)
Management I
Study of current interesting topics and new development in engineering management I.

2163692 Advanced Topics in Engineering 2(2-0-6)
Management II
Study of current interesting topics and new development in engineering management II.

2163693 Advanced Topics in Engineering 2(2-0-6)
Management III
Study of current interesting topics and new development in engineering management III.

2163694 Advanced Topics in Engineering 2(2-0-6)
Management IV
Study of current interesting topics and new development in engineering management IV.

2163695 Advanced Topics in Engineering 2(2-0-6)
Management V
Study of current interesting topics and new development in engineering management V.

2163696 Advanced Topics in Engineering 2(2-0-6)
Management VI
Study of current interesting topics and new development in engineering management VI.

2163813 Thesis 18 Credits

BIOMEDICAL ENGINEERING PROGRAM
(INTERDISCIPLINES)

Biomedical Engineering (BME) Program was founded in 2006 with the main purpose to educate the graduates who are interested in BME.

BME program involved in application of principle and practice for engineer in order to create the novel knowledge for medicine purposes and to develop the diagnosis and the treatment of diseases. For examples, the applications of sound wave and electromagnetic wave for diagnosis, the applications of nanotechnology for tissue transplantation and artificial organs.

After year 2010, BME was transferred the administration from Graduate School to the Faculty of Engineering. Nowadays, BME program provides Master of Science (M.Sc.), Master of Engineering (M.Eng.), and Doctor of philosophy (Ph.D.) degrees.

HEAD:

Siriporn	Damrongsakkul	Ph.D. (London)

PROFESSORS:

Siriporn	Damrongsakkul	Ph.D. (London)
Areerat	Suputtitada	M.D. (Mahidol)
Prabhas	Chongstitvatana	Ph.D. (Edinburgh)
Suthiluk	Patumraj	Ph.D. (New Jersey)

ASSOCIATE PROFESSORS :

Chedsada	Chinrungrueng,	Ph.D.
Mana	Sriyudthsak,	D.Eng. (T.I.T.)
Sompol	Sanguanrungsirikul	M.D., M.Sc. (Chula)
Watcharapong	Khovidhungij,	Ph.D. (UCLA)

ASSISTANT PROFESSORS :

Arporn	Teeramongkonrasmee	Ph.D. (Chula)
Charnchai	Pluempitiwiriyawej	Ph.D.(Carnegie Mellon)
Cherdkul	Sopavanit	M.Eng. (Chula)
Sorada	Kanokpanont	Ph.D. (Drexel)
Tanom	Bunaprasert	M.D. (Prince of Songkla)
Tayard	Desudchit	M.D. (Chula)
Pairat	Tangpornprasert	D.Eng. (Tokyo)
Juthamas	Ratanavaraporn	Ph.D. (Chula)

INSTRUCTORS :

Apiwat	Lek-Uthai	Dr.Ing. (Karlsruhe)
Bunchauy	Supmonchai	M.Eng. (Chula)
Pakpum	Somboon	Ph.D. (T.I.T)
Peerapat	Thongnuek	Ph.D. (Cambridge)

NAME OF THE DEGREE

: Master of Science
: M.Sc.

ADMISSION

The applicants must hold a Bachelor degree in any fields of Science, Health Science (Medicine, Dentistry, Veterinary Medicine, Pharmacy, Nursing, or Allied Health Sciences), or Engineering and also passed the requirements of the Graduate School or got approval from the program committee for admission.

DEGREE REQUIREMENTS

1. The students have to pass a minimum of 6 credits of required course, 12 credit of elective courses, and 18 credits of thesis, a total of them not less than 36 credits.
2. The students have to pass an oral thesis examination. Some part of thesis has to be published or accepted for publication in a journal or was presented in an academic conference having proceedings.
3. The degree will be awarded for the student who has fulfilled the requirements as followed; G.P.A. not less than 3.00, and period of study not less than 4 semesters and not more than 8 semesters.

STUDY PROGRAM

The First Semester

2100600	Introduction to Biomedical Engineering	3
2100601	Basic Engineering Knowledge for Biomedical Engineering	3
XXXXXXX	Free Elective	3
2100791	Biomedical Engineering Seminar I	(2)*
		9

The Second Semester

XXXXXXX	Free Elective	9
2100792	Biomedical Engineering Seminar II	(2)*

Remarks:
* No credit will be granted, evaluation will be only S/U

The Third Semester

2100813	Thesis	9
		9

The Fourth Semester

2100813	Thesis	9
		9

COURSE REQUIREMENTS

1) Required Courses   6 credits

2100600	Introduction to Biomedical Engineering	3(2-3-7)
2100601	Basic Engineering Knowledge for Biomedical Engineering	3(2-3-7)
2100791	Biomedical Engineering Seminar I	2(2-0-6)
2100792	Biomedical Engineering Seminar II	2(2-0-6)

2) Elective Courses 12 credits

3017767	Human Body for Biomedical Engineering	3(2-3-7)
2100603	Research Methodology and Research Instrumentation	3(3-0-9)
2109556	Biomaterials	3(3-0-9)
3000748	Tissue and Cell Engineering	3(3-0-9)
3000749	Biosystems and Biotransport	3(3-0-9)
3000750	Drug Delivery System	3(3-0-9)
2102611	Medical Instrumentation	3(3-0-9)
2102646	Power Electronics for Biomedical Engineering Applications	3(3-0-9)
2100623	Technology for Seniors and the Disabled	3(3-0-9)
2102631	Mathematical Modeling and Analysis of Physiological Systems	3(3-0-9)
2102523	Biomedical Signal Processing	3(3-0-9)
2102524	Medical Imaging Technology	3(3-0-9)

2110675	Biomedical Information and Communication Systems	3(3-0-9)
3016725	Biomechanics	3(3-0-9)
2100636	Biomedical Analytical Technique	3(3-0-9)
2100696	Special Problems in Biomedical Engineering	3(0-0-12)
2100697	Individual Study	3(0-0-12)
2100796	Advanced Topics in Biomedical Engineering I	3(3-0-9)
2100797	Advanced Topics in Biomedical Engineering II	3(3-0-9)
2102505	Introduction to Optimization Techniques	3(3-0-9)
2102507	Computational Techniques for Engineers	3(3-0-9)
2102531	System Identification	3(3-0-9)
2102635	Control System Theory	3(3-0-9)
2102668	Biosensors	3(3-0-9)
2102546	Analog Integrated Circuits	3(3-0-9)
2102784	Measurement System Design and Simulation	3(3-0-9)
2102785	Advanced Sensor Theory	3(3-0-9)
2102876	Adaptive Signal Processing	3(3-0-9)
2105641	Biodegradable Material Engineering	3(3-0-9)
2111602	Radiation Physics for Medical Science	2(2-0-6)
2100604	Strategic Tissue Engineering and Controlled Release System	3(3-0-9)
2100605	Biomedical Embedded System	3(3-0-9)

3) Thesis

2100813	Thesis	18 credits

NAME OF THE DEGREE

: Master of Engineering
: M.Eng.

ADMISSION

The applicants must hold a Bachelor degree in Engineering and also passed the requirements of the Graduate School or got approval from the program committee for admission.

DEGREE REQUIREMENTS

1. The students have to pass a minimum of 6 credits of required course, 12 credit of elective courses, and 18 credits of thesis, a total of them not less than   36 credits.
2. The students have to pass an oral thesis examination. Some part of thesis has to be published or accepted for publication in a journal or was presented in an academic conference having proceedings.

3. The degree will be awarded for the student who has fulfilled the requirements as followed; G.P.A. not less than 3.00, and period of study not less than 4 semesters and not more than 8 semesters.

STUDY PROGRAM

The First Semester

2100600	Introduction to Biomedical Engineering	3
3017767	Human Body for Biomedical Engineering	3
XXXXXXX	Free Elective	3
2100791	Biomedical Engineering Seminar I	(2)*
		9

The Second Semester

XXXXXXX	Free Elective	9
2100792	Biomedical Engineering Seminar II	(2)*
		9

Remarks:
* No credit will be granted, evaluation will be only S/U

The Third Semester

2100813	Thesis	9
		9

The Fourth Semester

2100813	Thesis	9
		9

COURSE REQUIREMENTS

1) *Required Courses   6 credits*

2100600	Introduction to Biomedical Engineering	3(2-3-7)
3017767	Human Body for Biomedical Engineering	3(2-3-7)
2100791	Biomedical Engineering Seminar I	2(2-0-6)
2100792	Biomedical Engineering Seminar II	2(2-0-6)

2) *Elective Courses 12 credits*

2100601	Basic Engineering Knowledge for Biomedical Engineering	3(2-3-7)
2100603	Research Methodology and Research Instrumentation	3(3-0-9)
2109556	Biomaterials	3(3-0-9)
3000748	Tissue and Cell Engineering	3(3-0-9)
3000749	Biosystems and Biotransport	3(3-0-9)
3000750	Drug Delivery System	3(3-0-9)
2102611	Medical Instrumentation	3(3-0-9)
2102646	Power Electronics for Biomedical Engineering Applications	3(3-0-9)
2100623	Technology for Seniors and the Disabled	3(3-0-9)
2102631	Mathematical Modeling and Analysis of Physiological Systems	3(3-0-9)

2102523	Biomedical Signal Processing	3(3-0-9)
2102524	Medical Imaging Technology	3(3-0-9)
2110675	Biomedical Information and Communication Systems	3(3-0-9)
3016725	Biomechanics	3(3-0-9)
2100636	Biomedical Analytical Technique	3(3-0-9)
2100696	Special Problems in Biomedical Engineering	3(0-0-12)
2100697	Individual Study	3(0-0-12)
2100796	Advanced Topics in Biomedical Engineering I	3(3-0-9)
2100797	Advanced Topics in Biomedical Engineering II	3(3-0-9)
2102505	Introduction to Optimization Techniques	3(3-0-9)
2102507	Computational Techniques for Engineers	3(3-0-9)
2102531	System Identification	3(3-0-9)
2102635	Control System Theory	3(3-0-9)
2102668	Biosensors	3(3-0-9)
2102546	Analog Integrated Circuits	3(3-0-9)
2102784	Measurement System Design and Simulation	3(3-0-9)
2102785	Advanced Sensor Theory	3(3-0-9)
2102876	Adaptive Signal Processing	3(3-0-9)
2105641	Biodegradable Material Engineering	3(3-0-9)
2111602	Radiation Physics for Medical Science	2(2-0-6)
2100604	Strategic Tissue Engineering and Controlled Release System	3(3-0-9)
2100605	Biomedical Embedded System	3(3-0-9)

3) *Thesis*

2100813	Thesis	18 credits

NAME OF THE DEGREE

: Doctor of Philosophy
: Ph.D.

ADMISSION

The applicants have to pass the following basic requirements:

For Pattern 1:
For applicants who held the Master degree in Biomedical Engineering and have got the thesis qualification as the excellence level and also passed the requirements of the Graduate School or got approval from the program committee for admission.

For Pattern 2:
Pattern 2(1) for applicants who held a Master degree in Biomedical Engineering, Master degree in Engineering or

Science and have got the thesis qualification as the good level, and also passed the requirements of the Graduate School or got approval from the program committee for admission.

Pattern 2 (2) for applicants who held a Bachelor degree in Engineering or Science and have got the second honor degree or have G.P.A. not less than 3.25 based on 4 point grading system, and also passed the requirements of the Graduate School or got approval from the program committee for admission.

DEGREE REQUIREMENTS
For Pattern 1:
The students have to get 60 credits, also passed an oral examination and some part of thesis has to be published or accepted for publication in a journal of 2 papers, at least 1 paper has to be published in an international journal.

For Pattern 2(1):
The students have to get 12 credits of elective courses and 48 credits of thesis, total of 60 credits, also passed an oral examination and some part of thesis has to be published or accepted for publication in an international journal.For

Pattern 2(2):
The students have to get 24 credits of elective courses and 48 credits of thesis, total of 72 credits, also passed an oral examination and some part of thesis has to be published or accepted for publication in an international journal.

Remark:
For Pattern 1 may require additional courses or other academic activities (no credit will be granted, evaluation will be only S/U) that will benefit for the thesis, under consent of the advisor and the program committee.

STUDY PROGRAM

Pattern 1

The First Semester

2100791	Biomedical Engineering Seminar I	(2)*
2100829	Dissertation	12
		12

The Second Semester

2100792	Biomedical Engineering Seminar II	(2)*
2100829	Dissertation	12
		12

The Third Semester

2100793	Biomedical Engineering Seminar III	(2)*
2100829	Dissertation	12
		12

The Fourth Semester

2100794	Biomedical Engineering Seminar IV	(2)*
2100829	Dissertation	12
		12

The Fifth Semester

2100894	Doctoral Dissertation Seminar	(0)*
2100829	Dissertation	12
		12

The Sixth Semester
-
Remarks:
* No credit will be granted, Evaluation will be only S/U

<u>Pattern 2(1)</u>

The First Semester

2100791	Biomedical Engineering Seminar I	(2)*
XXXXXXX	Free Elective	9
		9

The Second Semester

2100792	Biomedical Engineering Seminar II	(2)*
2100828	Dissertation	6
XXXXXXX	Free Elective	3
		9

The Third Semester

2100793	Biomedical Engineering Seminar III	(2)*
2100828	Dissertation	9
		9

The Fourth Semester

2100794	Biomedical Engineering Seminar IV	(2)*
2100828	Dissertation	9
		9

The Fifth Semester

2100894	Doctoral Dissertation Seminar	(0)*
2100828	Dissertation	12
		12

The Sixth Semester

2100894	Doctoral Dissertation Seminar	(0)*
2100828	Dissertation	12
		12

<u>Pattern 2(2)</u>

The First Semester

2100791	Biomedical Engineering Seminar I	(2)*
XXXXXXX	Free Elective	9
		9

The Second Semester

2100792	Biomedical Engineering Seminar II	(2)*
XXXXXXX	Free Elective	9
		9

The Third Semester

2100793	Biomedical Engineering Seminar III	(2)*
2100828	Dissertation	3
XXXXXXX	Free Elective	6
		9

The Fourth Semester

2100794	Biomedical Engineering Seminar IV	(2)*
2100828	Dissertation	9
		9

The Fifth Semester

2100894	Doctoral Dissertation Seminar	(0)*
2100828	Dissertation	9
		9

The Sixth Semester

2100894	Doctoral Dissertation Seminar	(0)*
2100828	Dissertation	9
		9

The Seventh Semester

2100894	Doctoral Dissertation Seminar	(0)*
2100828	Dissertation	9
		9

The Eighth Semester

2100894	Doctoral Dissertation Seminar	(0)*
2100828	Dissertation	9
		9

COURSE REQUIREMENTS

Elective Courses
Pattern 2.1 = 12 credits and Pattern 2.2 = 12 credits

2100600	Introduction to Biomedical Engineering	3(2-3-7)
2100601	Basic Engineering Knowledge for Biomedical Engineering	3(2-3-7)
2111602	Radiation Physics for Medical Science	2(2-0-6)
2100604	Strategic Tissue Engineering and Controlled Release System	3(3-0-9)
2100605	Biomedical Embedded System	3(3-0-9)
2100791	Biomedical Engineering Seminar I	2(2-0-6)
2100792	Biomedical Engineering Seminar II	2(2-0-6)
3017767	Human Body for Biomedical Engineering	3(2-3-7)
2100603	Research Methodology and Research Instrumentation	3(3-0-9)
2109556	Biomaterials	3(3-0-9)
3000748	Tissue and Cell Engineering	3(3-0-9)
3000749	Biosystems and Biotransport	3(3-0-9)
3000750	Drug Delivery System	3(3-0-9)
2102611	Medical Instrumentation	3(3-0-9)
2102646	Power Electronics for Biomedical Engineering Applications	3(3-0-9)
2100623	Technology for Seniors and the Disabled	3(3-0-9)
2102631	Mathematical Modeling and Analysis of Physiological Systems	3(3-0-9)
2102523	Biomedical Signal Processing	3(3-0-9)
2102524	Medical Imaging Technology	3(3-0-9)

2110675	Biomedical Information and Communication Systems	3(3-0-9)
3016725	Biomechanics	3(3-0-9)
2100636	Biomedical Analytical Technique	3(3-0-9)
2100696	Special Problems in Biomedical Engineering	3(0-0-12)
2100697	Individual Study	3(0-0-12)
2100796	Advanced Topics in Biomedical Engineering I	3(3-0-9)
2100797	Advanced Topics in Biomedical Engineering II	3(3-0-9)
2102505	Introduction to Optimization Techniques	3(3-0-9)
2102507	Computational Techniques for Engineers	3(3-0-9)
2102531	System Identification	3(3-0-9)
2102635	Control System Theory	3(3-0-9)
2102668	Biosensors	3(3-0-9)
2102546	Analog Integrated Circuits	3(3-0-9)
2102784	Measurement System Design and Simulation	3(3-0-9)
2102785	Advanced Sensor Theory	3(3-0-9)
2102876	Adaptive Signal Processing	3(3-0-9)
2105641	Biodegradable Material Engineering	3(3-0-9)

2) Thesis

2100828	Thesis	48 credits
2100829	Thesis	60 credits

COURSE DESCRIPTIONS IN BIOMEDICAL ENGINEERING
(M.Eng., M.Sc., Ph.D.)

2100600   Introduction to Biomedical   3(2-3-7)
Engineering

Definition of biomedical engineering and other related fields; role of biomedical engineers; introduction to technology, instruments and basic application programs required for biomedical engineering; ethics in biomedical engineering; case studies : problem and application in biomedical engineering fields; hospital and laboratory visit, and assigned projects to explore the breadth and depth of the biomedical engineering field.

2100601   Basic Engineering Knowledge for   3(2-3-7)
Biomedical Engineering

Review of differential equations and transform techniques; signals, circuits and electronics; feedback mechanism, biomaterials; biomedical measurements and instrumentation; technological applications in medical practices; computer applications in biomedical engineering.

2100791   Biomedical Engineering Seminar I   2(2-0-6)

Current topics in biomedical engineering.

2100792   Biomedical Engineering Seminar II 2(2-0-6)

Current topics in biomedical engineering.

3017767   Human Body for Biomedical   3(2-3-7)
Engineering

Anatomy, physiology and biochemistry of the human body, including the musculoskeletal, nervous, respiratory, cardiovascular, alimentary, urinary, endocrine and reproductive systems; physiological laboratories of systems related to biomedical engineering.

2100603   Research Methodology and   3(3-0-9)
Research Instrumentation

Experimental and research methods; experimental design; statistics analysis of experimental results; operating principles of biomedical engineering tools and equipment.

2100604   Strategic Tissue Engineering   3(3-0-9)
and Controlled Release System

Basic principle, strategies and components of tissue engineering and controlled release system; combination and interaction of biomaterial scaffolds, cells, and biological signaling molecules; requirements and criteria of material design for strategic tissue engineering and controlled release system; functions, applications and limitations of materials in strategic tissue engineering and controlled release system; biological response to biomaterials; mechanism of material-induced tissue regeneration and material-governed controlled release.

2100605   Biomedical Embedded System   3(3-0-9)

Embedded system technology and its biomedical applications; types and selection of embedded system for biomedical applications; basic design of embedded system; hardware and sensor interface; real-time processing based on embedded system; advanced, design of embedded system for biomedical applications.

2109556   Biomaterials   3(3-0-9)

Biological system that interacts with materials, types of materials currently used for biomedical applications; appropriate analytical techniques pertinent to biomaterial research and evaluation; selected important medical fields in which biomaterials play a critical role.

3000748   Tissue and Cell Engineering   3(3-0-9)

Basic concept for engineering of new cells and tissues: components, tissue and organ healing and regeneration processes, ligands and receptors, adhesion and migration of cells; roles of hormones, proteins, stem cells, and immunology on organ transplantation; technology for cell and tissue engineering, scaffolds, nanomaterials, controlled release of metabolites and proteins, surface modification, cell culture in 2- and 3-dimensions; including current clinical applications and future trends.

3000749   Biosystems and Biotransport   3(3-0-9)

Applications of fundamental chemical engineering principles to the study of biological systems with emphasis on current bioengineering research.

3000750 Drug Delivery System   3(3-0-9)

Applications of physical principles and modern methods of analysis to pharmaceutical systems; a conceptual introduction to the way that drugs act and are processed in vivo, including receptor theory, ligand-macromolecule binding, biopharmaceutics, drug metabolism, pharmacokinetics and pharmacodynamics.

2102611 Medical Instrumentation   3(3-0-9)

Basic concepts of amplifiers, signal processing, electrodes, biopotential, sensors, medical devices, therapeutic devices, medical imaging, electrical safety; measurement of blood pressure, blood flow, and biopotential signals; designing and constructing simple medical instruments.

**2102646 Power Electronics for Biomedical 3(3-0-9)
          Engineering Applications**

Fundamental theories of power electronics for biomedical equipment; ac-dc and dc to dc converters as well as inverters circuit topologies and operations; converter and inverter control techniques and circuits; switching and control characteristics of semiconductor power devices: diodes, transistors and thyristors; power and control circuit components: inductors, transformers, capacitors, resistors; converter and inverter applications for biomedical equipment: switching power supplies, dc and ac motor drive.

**2100623 Technology for Seniors and the   3(3-0-9)
          Disabled**

Limitations of the seniors and the disabled; geriatric ergonomics and ergonomics of the disabled; classification of tools and equipment for seniors and the disabled; design and construction technology of tools and equipment for daily life, education and work of the seniors and the disabled.

**2102631 Mathematical Modeling and   3(3-0-9)
          Analysis of Physiological Systems**

Cellular physiology; biochemical reactions and enzyme kinetics; cellular homeostasis; ion channel; cell excitation; electrical conductions in nerve cells and cardiac muscles; mathematical modeling and analysis of physiological systems.

2102523 Biomedical Signal Processing   3(3-0-9)

Nature of biomedical signals; impulse response; frequency response; noise removal and signal compensation; modeling of continuous-time signals, discrete-time signals and stochastic signals; non-linear models of signals.

2102524 Medical Imaging Technology   3(3-0-9)

Introduction to the formation of various medical imaging modalities: computed tomography (CT), magnetic resonance imaging (MRI), and ultrasonography; image reconstruction, image enhancement, image segmentation, image representation and analysis, image registration, and image visualization.

**2110675 Biomedical Information and   3(3-0-9)
          Communication Systems**

Selected topics in information systems: multimedia technology, database system, data security and encryption; selected topics in communication systems: telecommunication, data network technology, Internet; biomedical applications of information and communication systems: telemedicine, medical data communication system in hospitals, role of information and communication technology on health care.

3016725 Biomechanics   3(3-0-9)

Review of basic solid and fluid mechanics: statics and dynamics, strength of material and basic of rheology: characteristics of skeletal system, muscular system, blood circulation system: modeling in biomechanics, with applications in various areas: human movement, artificial organs, sports, sports science; applications of biomechanics in human system and prosthetics.

2100636 Biomedical Analytical Technique 3(3-0-9)

Principles of analytical techniques for Biomedical samples related to drug delivery system.

**2100696 Special Problems in Biomedical 3(0-0-12)
          Engineering**

Literature review in the field of interest from basic to new innovation, summarizing and presenting reports.

2100697 Individual Study   3(0-0-12)

Literature review, asking research questions, conducting preliminary studies, summarizing and presenting reports.

**2100796 Advanced Topics in Biomedical 3(3-0-9)
          Engineering I**

Interesting problems or new development in Biomedical Engineering I

**2100797 Advanced Topics in Biomedical 3(3-0-9)
          Engineering II**

Interesting problems or new development in Biomedical Engineering II

**2102505 Introduction to Optimization   3(3-0-9)
          Techniques**

Review of linear algebra; solution of nonlinear equations; optimality conditions for unconstrained optimization; numerical methods for unconstrained optimization: steepest descent, Newton's, variable metric, and conjugate gradient methods; optimality conditions for constrained optimization; numerical methods for constrained optimization: penalty and barrier functions,

and sequential quadratic programming; solution of linear programming by simplex method.

2102507   Computational Techniques for   3(3-0-9) Engineers

Mathematical preliminaries; computer arithmetic; solution of nonlinear equations; solving systems of linear equations; approximating functions; numerical differentiation and integration; numerical solution of ordinary differential equations.

2102531   System Identification   3(3-0-9)

Models for linear time-invariant and time-varying systems; nonparametric time- and frequency-domain methods; parameter estimation methods; convergence and consistency; asymptotic distribution of parameter estimates computing the estimate; recursive identification methods; experiment design; choice of identification criterion; model structure selection and model validation.

2102635   Control System Theory   3(3-0-9)

Mathematical descriptions of dynamic systems; solutions of linear dynamic equations; stability, controllability and observability; internal stability of interconnected systems; state feedback; optimal regulation; observers and observer-based compensation; introduction to optimal control.

2102668   Biosensors   3(3-0-9)

Necessary concepts relevant to the principle of measuring chemical and biological phenomena with emphasis on integrating these concepts of development to apply and to construct novel instruments for observing, examining and controlling various phenomena in the field of biotechnology, medical sciences and chemical engineering for both fundamental research and process development in 'industrial production.

2102546   Analog Integrated Circuits   3(3-0-9)

IC Technology; analog circuit modeling; device characterization; analog subcircuits; amplifiers; comparators; operational amplifiers; digital-analog and analog-digital converters; other analog circuits and systems; reference sources; multipliers.

2102784   Measurement System Design and   3(3-0-9) Simulation

Analysis of measuring system; design of measuring system for sensors; remote sensing and non-invasive measurement; automation system; flow injection analysis; modeling of sensor system; numerical modeling; simulation of the sensor response.

2102785   Advanced Sensor Theory   3(3-0-9)

Principle and theory of physical and chemical sensors; thermodynamics and sensor operation; sensor fabrication technology; micro-machining; sensor fusion; intelligent sensors; data processing and analytical methods.

2102876   Adaptive Signal Processing   3(3-0-9)

Performance analysis of the linear and non-linear adaptive filtering; the linear filtering: method of steepest descent, least-mean square algorithm; non-linear filtering: artificial neural network using the back-propagation algorithm, radial basis function network, and (unsupervised learning based on) k-means clustering.

2105641   Biodegradable Material   3(3-0-9) Engineering

Types of biodegradable materials : synthetic and natural materials, sources and production, properties, biocompatibility, biodegradation mechanism, test methods for biodegradable plastics:polysaccharides, biopolyester, and protein (collagen, gelatin), biodegradable polymers for tissue engineering and controlled release.

2111602   Radiation Physics for Medical   2(2-0-6) Science

Atomic structure and atomic radiation, and particles, radioisotope, radioactivity, interaction of radiation and particles with matters, principles of radiation dosimetry, exposure dose, absorbed dose, radiation protection radiation effects on humans, X-ray equipment, radiation measurement radiation counting statistics phosphorescence and fluorescence screen, factors affecting radiation image quality, calculation of X-ray room shielding.

2100894   Doctoral Dissertation Seminar   0(0-0-0)

2100897   Qualifying Examination   0(0-0-0)

DEFENSE ENGINEERING AND TECHNOLOGY

This curriculum was created according to Her Royal Highness Princess Sirindhorn's wish to establish the academic collaborations between Chulachomkloa Royal Military Academy and Chulalongkorn University. The Memorandum of Understanding between two institutes was signed on September 23th, 2013 with 5-year duration. The Faculty of Engineering has initiate the academic collaborations by co-developing Master Program in Defense Engineering and Technology which is the result of merging engineerings and military defense technologies. Now, the program is open in 7 majors; Civil Engineering and Explosives, Electrical Engineering for Defense, Mechanical Engineering for Defense, Metallurgy Engineering for Defense, Computer Engineering for Defense, Environment Engineering for Defense, and Nuclear Engineering for Defense.

HEAD:

| Withit | Pansuk, | Ph.D. (Hokkaido) |
| Col.Chuan | Chuntavan | Ph.D. (Cincinnati) |

ASSOCIATE PROFESSORS:

| Withit | Pansuk, | Ph.D. (Hokkaido) |
| Sunchai | Nilsuwankosit, | Ph.D. (Wisconsin) |

ASSISTANT PROFESSORS:

Col.Chuan	Chuntavan	Ph.D. (Cincinnati)
Widhyakorn	Asdornwised	Ph.D. (Chula)
Suebskul	Phiphobmongkol	Ph.D. (AuBurn)
Alongkorn	Pimpin	D.Eng. (Tokyo)
Pichaya	Rachdawong	Ph.D. (Wisconsin-Milwaukee)
Panyawat	Wangyao	Ph.D. (Kosice)
Krerk	Piromsopa,	Ph.D. (Michigan)
Col.Phaderm	Nangsue	Ph.D. (Clarkson)
Col.Anotai	Suksangpanomrung	Ph.D. (Victoria)
Col.Preecha	Apiwantragoon	Ph.D. (Wisconsin)
Col.Nuthaporn	Nuttayasakul	Ph.D. (Virginia Polytechnic)

INSTRUCTORS:

| Kanok | Weerawong | Ph.D. (Purdue) |
| Maj.Banchachit | Saensunon | Ph.D. (New South Wales) |

NAME OF THE DEGREE

: Master of Engineering
: M.Eng.

ADMISSION

The applicants must hold a Bachelor degree in Engineering, Science, or equivalent and also passed the requirements of the Graduate School or got approval from the program committee for admission.

DEGREE REQUIREMENTS

1. **Pattern 1(1)** program consists of

1.1	Thesis	36 credits
1.2	2120601 Defense Engineering and Technology Principles	S/U
1.3	Seminar (2 credits)	S/U

2. **Pattern 1(2)** program consists of

2.1 Core course		**3 credits**
	2120601 Defense Engineering and Technology Principles	3(3-0-9)
2.2 Approve elective course		**0−9 credits**
1)	Explosive and civil engineering	6 credits
2)	Nuclear Engineering for Defense Engineering	9 credits
3)	Electrical Engineering for Defense/ Mechanical Engineering for Defense/ Metallurgy Engineering for Defense/ Computer Engineering for Defense/ Environment Engineering for Defense	
	No prerequisite requirement	

2.3 Free Elective		**6-15 credits**
1)	Explosive and civil engineering	9 credits
2)	Nuclear Engineering for Defense Engineering	6 credits
3)	Electrical Engineering for Defense Engineering	15 credit
4)	Mechanical Engineering for Defense Engineering	15 credit
5)	Environmental Engineering for Defense Engineering	15 credit
6)	Metallurgy Engineering for Defense Engineering	15 credit
7)	Computer Engineering for Defense Engineering	15 credit

Students in Electrical Engineering for Defense/Mechanical Engineering for Defense/Metallurgy Engineering for Defense/Computer Engineering for Defense/ Environment Engineering for Defense must take signified course for their major at least 9 credits and take other course this program for 6 more credits.

| **2.4** | **Thesis** | **18 credits** |
| **2.5** | **Seminar (2 credits)** | **S/U** |

COURSE REQUIREMENTS

1. *Required Courses*
   1) Pattern 1(1)

2120601	Defense Engineering and Technology Principles	S/U
2120603	Defense Engineering and Technology Seminar I	S/U
2120604	Defense Engineering and Technology Seminar II	S/U

   2) Pattern 1(2) **3 credits**

2120601	Defense Engineering and Technology Concept	3(3-0-9)
2120603	Defense Engineering and Technology Seminar I	S/U
2120604	Defense Engineering and Technology Seminar II	S/U

2. *Approve Elective course* **0-9 credits**
   1.1) Explosive and civil engineering **6 credits**

2101607	Advanced Mechanics of Materials	3(3-0-9)
2121677	Principles of Explosives Engineering	3(2-3-7)

   1.2) Nuclear Engineering for Defense **9 credits**
   Engineering

2111610	Nuclear Security	3(3-0-9)
2111651	Weapon Mass Destruction Nonproliferation	3(3-0-9)
2131501	Nuclear Technology for Military	3(3-0-9)

   1.3) Electrical Engineering for Defense/
   Mechanical Engineering for Defense/
   Metallurgy Engineering for Defense/
   Computer Engineering for Defense/
   Environment Engineering for Defense
   No prerequisite requirement

   3) *Free Elective Courses* **6-15 credits**
   2.1) Explosive and civil engineering 9 credits

2101535	Tunnel Engineering	3(3-0-9)
2101566	Dynamics of Structures	3(3-0-9)
2101567	Rail Transport System	3(3-0-9)
2101615	Advanced Prestressed Concrete Structures	3(3-0-9)
2101617	Structural Building Components	3(3-0-9)
2101619	Seismic Design of Structures	3(3-0-9)
2121670	Explosives Handling and safety	3(3-0-9)
2121671	Blasting Design and Technology	3(2-3-7)
2121672	Demolition of Building and Structures	3(2-3-7)
2121673	Scientific Instrumentation for Explosives Testing & Blasting	3(2-3-7)
2121674	Theory of High Explosive	3(3-0-9)
2121675	Advanced Explosives Engineering	3(3-0-9)
2121676	Exterior Ballistics	3(3-0-9)

   2.2) Nuclear Engineering for **6 credits**
   Defense Engineering

2111613	Radiation Safety and Shielding	3(3-0-9)

2111642	Nuclear Reactor Engineering	3(3-0-9)
2111646	Radioactive Waste Management	3(3-0-9)
2111653	Nuclear Safeguards	3(3-0-9)
2111654	Nuclear Fuel Cycle and Environmental Impacts	3(3-0-9)
2111656	Physical Protection of Nuclear Materials and Facilities I	3(3-0-9)
2111657	Advanced Detection Technologies of Radioactive and Nuclear materials	3(3-0-9)
2111658	Methods and Instrumentation for Nuclear Security and Safeguards	3(3-0-9)
2111678	Nuclear Materials Engineering	3(3-0-9)

   2.3) Students in Electrical Engineering for Defense/Mechanical Engineering for Defense/Metallurgy Engineering for Defense/Computer Engineering for Defense/ Environment Engineering for Defense must take signified course for their major at least 9 credits and take other course this program for 6 more credits.

   2.3.1) Electrical Engineering for **15 credits**
   Defense Engineering

2102505	Introduction to Optimization Techniques	3(3-0-9)
2102531	System Identification	3(3-0-9)
2102544	Advanced Embedded Systems	3(3-0-9)
2102571	Multimedia Communication	3(3-0-9)
2102601	Electrical Power and Energy Technology in Smart Grids	3(3-0-9)
2102602	Information and Communication Technologies in Smart Grids	3(3-0-9)
2102620	Electromagnetic Theory	3(3-0-9)
2102623	Antennas and Radar Systems	3(3-0-9)
2102627	Reliability and Survivability of Communication Networks and Systems	3(3-0-9)
2102631	Optimal Control Systems	3(3-0-9)
2102635	Control System Theory	3(3-0-9)
2102642	Computer Vision and Video Electronics	3(3-0-9)
2102645	Embedded System Design	3(3-0-9)
2102668	Biosensors	3(3-0-9)
2102675	Pattern Recognition	3(3-0-9)
2102676	Digital Image Processing	3(3-0-9)

   2.3.2) Mechanical Engineering **15 credits**
   for Defense Engineering

2103510	Mechanics of Composite Materials	3(3-0-9)
2103511	Introduction to Continuum Mechanics	3(3-0-9)
2103532	Computer Aided Design and Computer Aided Manufacturing	3(2-3-7)
2103535	Mechatronics	3(3-0-9)
2103540	Failure Analysis and Nondestructive Testing	3(2-3-7)
2103566	Compressible Fluid Dynamics	3(3-0-9)
2103571	Micro and Nano Electromechanical Systems	3(3-0-9)

2103601	Advanced Engineering Mathematic	3(3-0-9)
2103625	Advanced Finite Element Method	3(3-0-9)
2103631	Control of Dynamic Systems	3(3-0-9)
2103664	Design of Thermal Systems	3(3-0-9)
2103665	Advanced Computational Fluid Dynamics	3(3-0-9)

2.3.3) Environmental Engineering for Defense Engineering — 15 credits

2107607	Environmental Analysis	3(3-0-9)
2107616	Air Quality Management	3(3-0-9)
2107630	Treatment and Disposal of Industrial Wastes	3(3-2-7)
2107641	Air Pollution Control Technology	3(3-0-9)
2107642	Engineering Practices for Solid Wastes Disposal	3(3-0-9)
2107657	Energy and Environment	3(3-0-9)
2107658	Theory and Design of Advanced Water Treatment Processes	4(3-3-10)
2107659	Theory and Design of Advanced Wastewater Treatment Processes	4(3-3-10)
2107661	Fundamental Chemistry for Environmental Engineering	3(3-2-7)
2127675	Military Waste Management	3(3-0-9)
2107676	Management of Environmental Emergencies	3(3-0-9)

2.3.4) Metallurgy Engineering for Defense Engineering — 15 credits

2109509	Stainless Steel Technology	3(3-0-9)
2109510	Instrumental Analysis	3(2-3-7)
2109516	Advanced Topics in Physical Metallurgy	3(3-0-9)
2109517	Composite Materials I	3(3-0-9)
2109518	Surface Technology	3(3-0-9)
2109519	Solidification of Casting	3(3-0-9)
2109525	Welding Engineering	3(3-0-9)
2109527	High Temperature Materials	3(3-0-9)
2109533	Powder Metallurgy	3(3-0-9)
2109535	Cellular Metal	3(3-0-9)
2109536	Advanced Topics in Production Metallurgy	3(3-0-9)
2109537	Tribology of Materials	3(3-0-9)

2.3.5) Computer Engineering for Defense — 15 credits

2108532	Satellite Surveying and Modern Techniques	3(2-3-7)
2108556	Online Spatial Information Technologies	3(2-3-7)
2108557	Spatial Data Structure and Models	3(3-0-9)
2108558	Spatial Data Handling and Analysis	3(2-3-7)
2108627	Geoimage Processing	3(2-3-7)
2108628	Radar Remote Sensing	3(2-3-7)
2108632	Advanced GNSS Surveying	3(2-3-7)
2110622	Data Management	3(3-0-9)
2110639	Computer System Security	3(3-0-9)
2110661	Computer Network	3(3-0-9)
2110678	Mobile Computing	3(3-0-9)
2110681	Computer Algorithm	3(3-0-9)
2110682	Embedded and Real-time Systems	3(3-0-9)
2110741	Robotics	3(3-0-9)
2110743	Machine learning	3(3-0-9)
2110745	Cryptography	3(3-0-9)

Other Free Elective Courses

2120602	Advanced Topics in Defense Engineering and Technology	3(3-0-9)

In addition, students may take other additional course which the curriculum allows or which is opened in graduate program in Chulalongkorn University. The course must be corresponding to the thesis and consented by the academic advisor.

3) Thesis

Pattern 1(1)

2120816	Thesis	36 credits

Pattern 1(2)

2120813	Thesis	18 credits

STUDY PROGRAM

Pattern 1(1)

The First Semester

2120601	Defense Engineering and Technology Principles	S/U
2120603	Defense Engineering and Technology Seminar I	S/U
2120816	Thesis	9
		9

The Second Semester

2120604	Defense Engineering and Technology Seminar II	S/U
2100829	Thesis	9
		9

The Third Semester

2120816	Thesis	9
		9

The Fourth Semester

2120816	Thesis	9
		9

Remarks:
* No credit will be granted, Evaluation will be only S/U

Pattern 1(2)

The First Semester

2120601	Defense Engineering and Technology Principles	3
2120603	Defense Engineering and Technology Seminar I	S/U
210XXXX	Approve Elective and/or Free Elective	6
		9

The Second Semester

2120604	Defense Engineering and Technology Seminar II	S/U
210XXXX	Approve Elective and/or Free Elective	9
		9

The Third Semester

2120813	Thesis	9
		9

The Fourth Semester

2120813	Thesis	9
		9

COURSE DESCRIPTIONS IN DEFENSE ENGINEERING AND TECHNOLOGY ENGINEERING (M.Eng.)

2120601 Defense Engineering and Technology Principles 3(3-0-9)

Principles of defense and military development; national security and national strategy; organization, responsibilities, management and work operation of the Royal Thai Armed Forces; military standards, and national disaster relief and prevention.

2120602 Advanced Topics in Defense Engineering and Technology 3(3-0-9)

Recent interesting topics and technology development in various field of defense and engineering technology.

2120603 Defense Engineering and Technology Seminar I 1(1-0-3)

Analysis of research products or quality research papers; presentation of research papers or research findings of individual researchers, and discussions.

2120604 Defense Engineering and Technology Seminar II 1(1-0-3)

Analysis of research products or quality research papers; presentation of research papers or research findings which are parts of students' thesis, and discussions.

2121670 Explosive Handling and Safety 3(3-0-9)

Basic handling and safety of explosives; laboratory handling; testing; manufacturing and storage of explosive instruments and weapons used in both the civil and the military sectors.

2121671 Blasting Design and Technology 3(2-3-7)

Advanced theory and application of explosives in excavation; detailed underground blast design; specialization in blasting, including blast casting, construction and pre-spliting; introduction to blasting research and examination of applications in other fields.

2121672 Demolition of Building and Structures 3(2-3-7)

Basic knowledge about the equipment, techniques and processes required for the demolition and remediation of mine plants and mining equipment sites and non-mining structures.

2121673 Scientific Instrumentation for Explosives Testing and Blasting 3(2-3-7)

Application of scientific principles, details of the equipment and the use of instruments for explosives including blasting; related topics: blast chamber design, equipment set up, high-speed photography, motion detection and measurement, explosives sensitivity testing, explosives properties testing, vibration measurement and analysis, destruction in both the civil and the military sectors.

2121674 Theory of High Explosive 3(3-0-9)

Applications of chemical thermodynamics and the hydrodynamics theory to determine properties of high explosives; kinetics and reaction rate; application of the above theory to the blasting of explosives.

2121675 Advanced Explosives Engineering 3(3-0-9)

Detonation of non-ideal explosives; equation of the state of porous media; explosively driven mechanical systems; shock compaction of powders and desensitization and experimental methods used in the evaluation of explosives and their applications.

2121676 Exterior Ballistics 3(3-0-9)

Benefits and uses of exterior ballistics; related background theories; trajectory; forces and moments acted on the projectile; projectile coefficients; various trajectory models; wind effect; mass asymmetries and swerve motion.

2121677 Fundamental Principles of Explosive Engineering 3(2-3-7)

Theory and application of explosives in the mining industry: explosives, initiating systems, characteristics of explosive reactions and rock breakage, fundamentals of blast design, drilling and blasting, regulatory and safety considerations.

2101535 Tunnel Engineering 3(3-0-9)

History of tunneling; soil tunneling methods; types of linings and face support; stand-up times and tunnel man's

ground classification; groundwater control and soil modification methods; lining behavior and design; ground movements and changes of pore water pressure caused by tunnel construction; field observations, monitoring, and instrumentation; building distortion/damage and relation to ground movements; fundamentals of tunnel engineering related to soil types and construction techniques; design of tunnel lining in various subsoil conditions; applications and techniques of tunnel construction for infrastructure system.

2101566   Dynamics of Structures   3(3-0-9)
Condition: Consent of Faculty

Analysis of structural systems with single and multi-degree of freedom; equations of motions; free and forced vibrations; vibration natural frequencies and mode shapes of systems; numerical evaluation of dynamic response; response spectrum; modal response history and response spectrum analysis; response of inelastic SDF system; building codes on seismic design of structures.

2101567   Rail Transport System   3(3-0-9)

This course covers the following topics: History of Rail Transport Development, Fundamental and Characteristics of Rail Operation, Rules of Safety, Composition of Rail System: Infrastructure, Rolling Stocks, Signaling and Communication, Case Studies of Rail Transport Development in Thailand and Neighboring Countries.

2101607   Advanced Mechanics of Materials   3(3-0-9)

Stress, strain, and displacement relationship; energy theorems; equilibrium and compatibility conditions; plane stress and plane strain problems; beams on elastic foundation; beam-columns, flexure of curve members; torsion of non-circular and thin-walled members; shear center; shear flow; introduction to theorems of limit analysis.

**2101615   Advanced Prestressed Concrete   3(3-0-9)
             Structures**

Prestressing systems; behavior of prestressed concrete beams; moment curvature relationship; load deflection curves, ductility and fatigue, analysis and design of composite members, continuous flexural members, prestressed frames and segmental bridges.

2101617   Structural Building Components   3(3-0-9)

Analysis and design of structural components for buildings considering various types of construction materials: timber, metal, concrete and synthetics; the components include floor systems, roof member, tilt-up walls, sandwich panels, precast, precast member, bearing walls, shear walls and light-gauge steel members.

2101619   Seismic Design of Structures   3(3-0-9)

Elementary engineering seismology; seismic waves; intensity and magnitude; response spectrum and design earthquakes; earthquake codes and analysis; response

spectrum analysis; random vibrations; artificial generation of earthquake records; structural design and detailing for earthquake resistance; special structures: bridges, dams, nuclear power plants.

**2102505   Introduction to Optimization   3(3-0-9)
             Techniques**
*Condition: PRER 2102205 or Consent of
            Faculty*

Review of linear algebra; solution of nonlinear equations; optimality conditions for unconstrained optimization; numerical methods for unconstrained optimization: steepest descent, Newton's, variable metric and conjugate gradient methods; optimality conditions for constrained optimization; numerical methods for constrained optimization: penalty and barrier function, and sequential quadratic; solutions of linear programming by the simplex method.

2102531   System Identification   3(3-0-9)
*Condition: PRER 2102332 or Consent of
            Faculty*

Models for linear time-invariant and time-varying system; nonparametric time- and frequency-domain methods; parameter estimation methods; convergence and consistency; asymptotic distribution of parameter estimates; computing the estimate; recursive identification methods; experiment design; choice of dentification criterion; model structure selection and model validation.

2102544   Advanced Embedded Systems   3(3-0-9)
Condition: Consent of Faculty

Hardware and software platforms for embedded systems; devices and buses; embedded programming; real time operating system; hardware-software co-design in an embedded system; testing.

2102571   Multimedia Communication   3(3-0-9)
Condition: Consent of Faculty

Introduction to multimedia communication; image coding standards; video coding standards; audio coding standards; speech coding standards; IP networks; wireless networks; multimedia communication protocols; multimedia communication applications.

**2102601   Power and Energy Technology in   3(3-0-9)
             Smart Grids**
Condition: Consent of Faculty

Introduction to Smart Grids; fundamentals of power system operation and control; distributed generation, microgrid and active networks; introduction to wide area monitoring and wide area protection systems; renewable energy generation; grid connection codes; renewable energy policy and regulation; energy storage; electric vehicle.

**2102602   Information and communication   3(3-0-9)
             technologies in Smart Grids**

Substation operation and related communication within substation; equipment in distribution system; communication between control center Architecture and components of AMI/AMR including phasor measurement unit, digital fault recorder and interoperability. Energy efficiency within home, building and factory. Communication channels in smart grid: wire, wireless, optical fiber, including network layer, sensing/control and control protocol. Database management and cyber security.

2102620   Electromagnetic Theory   3(3-0-9)

Maxwell's equations; theorem of electromagnetic energy and power; properties of materials in electromagnetic fields; boundary conditions; theorems of electromagnetic fields, duality principle, uniqueness, image theory, equivalence principle, induction theorem, reciprocity; potential functions; electromagnetic wave equations, plane wave functions, cylindrical wave functions, spherical wave functions mathematical tools for electromagnetic fields, separation of variables technique, transverse resonance method, perturbation and variational techniques, Green's functions, geometric algebra; solution methods for electrostatic, magnetostatic, for electrostatic, magnetostatic, and quasi-static fields problems; plane wave propagation problems, propagation in unbounded medium, multilayered medium, and anisotropic medium; wave guidance problems, field analysis in typical waveguides, modal expansion method; resonators and filters; radiation problems, radiation from current sources and apertures; scattering problems, scattering by cylinder, wedge, and sphere; optical waves, optical waveguides, optical wave propagation in photonic crystal.

2102623   Antennas and Radar Systems   3(3-0-9)
Condition: Consent of Faculty

Introduction and fundamental parameters of antennas; Transmitting and receiving antennas; Friis transmission equation; Basic antenna types; Phased array antennas; Smart antennas and multiple-input/multiple-output (MIMO) systems; Introduction and basic principle of radar systems; Radar cross section; Radar equation; Continuous wave radar; Pulsed radar; Target tracking radar.

**2102627   Reliability and Survivability of   3(3-0-9)
          Communication Networks and Systems**
Condition: Consent of Faculty

Fundamental probability; network reliability; approaches to calculating network reliability; generic reliability and maintainability concepts; network survivability; fiber transport system components and signals; APS; dual homing; self healing rings; SONET andlysis; DCS networks; survivable network design; IP and ATM network survivability.

2102631   Optimal Control Systems   3(3-0-9)
Condition: PRER 2102505 or Consent of Faculty

Discrete-time linear quadratic; calculus of variations; continuous-time linear quadratic regulator; time-optimal control; constrained control input problem; the Pontryagin's maximum principle; singular control; dynamic programming; optimal controller design; computational methods in optimal controller synthesis.

2102635   Control System Theory   3(3-0-9)
Condition: Consent of Faculty

Review of linear algebra; least-squares methods and minimum norm methods; mathematical descriptions of dynamic systems; solutions of linear dynamic equations; stability, observability; internal stability of interconnected systems; state feedback; linear quadratic regulation; observers and observer-based compensation; introduction to nonlinear systems.

**2102642   Computer Vision and Video   3(3-0-9)
          Electronics**
Condition: Consent of Faculty

Human vision; geometric camera models; image segmentation; object recognition; video signals and standards; video input and output circuits; computer vision and digital video applications.

2102645   Embedded System Design   3(3-0-9)
Condition: Consent of Faculty

Practical examples; performance evaluation; complex system designs: automotive, multimedia, biomedical instrumentation, measurement instrumentation, and robot.

2102668   Biosensors   3(3-0-9)
Condition: Consent of Faculty

Necessary concepts relevant to the principle of measuring chemical and biological phenomena with emphasis on integrating these concepts of develop to apply and to construct novel instruments for observing, examing, and controlling various phenomena in the field of biotechnology, medical science, chemical engineering for both fundamental research and process development in industrial production.

2102675   Pattern Recognition   3(3-0-9)
*Condition: PRER 2102282 or Consent of
          Faculty*

Statistical pattern recognition: linear discriminant functions, Bayesian decision theory, maximum-likelihood and Bayesian parameter estimation.

2102676   Digital Image Processing   3(3-0-9)

Image perception; image digitization; image enhancement; image restoration; image segmentation; image compression; morphological image processing; image representation and description.

**2103511   Introduction to Continuum   3(3-0-9)
          Mechanics**

Introduction to continuum mechanics; essential mathematics: notations, tensor and operations,

transformation, equation and symbol presentation; Kinematics of motion and small deformation; engineering stress; governing equations; constitutive equations; applications: setting and interpretation of heat conduction, solid mechanics and fluid mechanics.

2103510   Mechanics of Composite Materials   3(3-0-9)

Basic concepts of fiber reinforced composite materials and their application, stress and strain analysis of continuous fiber composite materials; Hooke' law and hygrothermal behavior of orthotropic lamina; classical lamination theory, failure criterion, and design concepts, as applied to composite structures; analysis of composite beams and plates; introduction to material fabrication and testing.

2103532   Computer Aided Design and   3(2-3-7)
Computer Aided Manufacturing

Introduction to CAD/CAM; Basic Concept of CAD/CAM/CAE; Product Design and Strategy; 3D Modeling Concept; Techniques for Geometry Modeling; Surface Design, Design Analysis; Mechanism Design and Animation; Computer Aided Manufacturing Concept; The Design and Manufacturing Interface; The Total Approach to Product Development; NC Programming.

2103535   Mechatronics   3(3-0-9)

Introduction to mechanical system interfacing; combinational digital logic; industrial electronic components; industrial sensors; simple computer structure; low level programming technique; embedded control computers; microcontroller; stepping motors; DC motors; Analog/Digital conversion; position and velocity measurement; amplifiers; project related to mechatronics.

2103540   Failure Analysis and Nondestructive 3(2-3-7)
Testing

Stress at crack tip and related parameters; failure phenomena; crack propagation creep; corrosion; failure surface; life assessment; case studies; nondestructive testing; practice in NDT techniques.

2103566   Compressible Fluid Dynamics   3(3-0-9)

Thermodynamics of motion; physical acoustics; wave equation; speed of sound; quasi-one dimensional flow with friction and heat addition; shock dimensional steady flow; method of characteristics; nozzle design; linearized flow visualization using optical techniques.

2103571   Micro and Nano Electromechanical   3(3-0-9)
Systems

Overview of MENS-NEMS, review of engineering mechanics and thermo-fluid engineering, electromechanics and light phenomena, micro system design, scaling of micromechanical devices, MEMS materials, review of micro fabrication, applications of MEMS, and future trends in technology development.

2103601   Advanced Engineering Mathematics 3(3-0-9)

Numerical and graphical methods of approximate solution; finite difference methods; calculus of variations,

solution of classical partial differential equations of mathematical physics including application of conformal mapping and the Laplace transformation.

2103625   Advanced Finite Element Method   3(3-0-9)

Procedures of the finite element method for structural, thermal and fluid differential equations; nonlinear structural static and dynamic problems with discrete and continuum structures; transient nonlinear heat transfer problems with conduction, and radiation; and radiation; steady and unsteady nonlinear heat transfer problems with conduction, and radiation; steady and unsteady nonlinear incompressible and compressible fluid flow problems.

2103631   Control of Dynamic Systems   3(3-0-9)

Introduction; Mathematical Representation of Dynamic Systems; Response of Linear Systems; Stability of Linear Systems; System Theory, Control of Linear Systems: Root-Locus Design, Frequency Response analysis and design, State Variable Feedback, Observer Design; Multivariable Control Systems.

2103664   Design of Thermal Systems   3(3-0-9)

Engineering design, design of a workable system, consideration; Equation fitting and mathematical modeling, system simulation, optimization, Lagrange multipliers search methods, dynamic programming, linear programming.

2103665   Advanced Computational Fluid   3(3-0-9)
Dynamics

Mathematical and numerical aspects of heat transfer and fluid mechanics, finite difference and finite volume methods for solving basic governing equations of fluid flow and heat transfer: continuity, momentum and energy, discretization methods for two and three dimensional problems, boundary conditions, numerical schemes and solvers, consistency stability and convergence, advanced numerical techniques for CFD, application of the methods to some engineering problems.

2107607   Environmental Analysis   3(3-0-9)

Procedures and details of environmental sample analysis; methods of sample collection, sample handling; analytical method selection; details of analysis and data presentation.

2107616   Air Quality Management   3(3-0-9)

Interaction among air, water and land pollutions, effects of air pollutants, standards and regulations, technical aspects of air pollution control programs, the organization and management of control programs in governmental and private sectors.

2107630   Treatment and Disposal of   3(2-3-7)
Industrial Wastes

Industrial waste problems; categories of waste; nature and characteristics of liquid waste; effect of waste on environment; laws for disposal of waste in Thailand and

other countries; method of treatment of various kinds of waste; preventive measures.

2107641 Air Pollution Control Technology 3(3-0-9)

Overview of air pollution control methods. Control of particulates and gaseous emissions by settling chambers, cyclones, scrubbers, filters and electrostatic precipitators. Design of equipment, maintenance and evaluation of control efficiency.

**2107642 Engineering Practices for Solid 3(3-0-9)
Wastes Disposal**

Municipal and industrial solid wasters, their volume and characteristics; heat value, methods of handling, storage and disposal. Size and volume reduction. Separation of components. Landfill and leachate effects. Ocean disposal. Incineration.

2107657 Energy and Environment 3(3-0-9)

Energy resources and utilization in the global context and a case studies in Thailand; fossil-based energy, environmental impact of mining and fuel processing; air pollution, greenhouse gas, and global warming from fuel utilization; energy conservation and renewable energy technologies; hydro energy harnessing and its environmental impact and mitigation; other non-fossil fuel options: biomass, solar, and wind energy; synthetic fuel conversion technology including pyrolysis and gasification; biogas from fermentation; prospect of hydrogen economy.

**2107658 Theory and Design of 4(3-3-10)
Advanced Water Treatment Processes**

Water sources; water chemistry and quality, aeration, coagulation, sedimentation, filtration, ion exchange, membrane processes, disinfection absorption, neutralization and stabilization; water conditioning for boiler and cooling system; design criteria for water sources, lines distribution and storage facilities, water treatment and softening, engineering design of water distribution system, functional and hydraulic design of complete water treatment.

**2107659 Theory and Design of Advanced 4(3-3-10)
Wastewater Treatment Processes**

Development of wastewater technology; wastewater collection and transportation; design of sewers and appurtenances; advanced wastewater treatment by microbial and biological control techniques, law related to effluent disposal; wastewater law relating to effluent disposal, wastewater treatment plant organization and management; combined and separate system pumping stations; functional and hydraulic design of complete wastewater treatment system.

**2107661 Fundamental Chemistry for 3(2-3-7)
Environmental Engineering**

Chemical and physical characteristics of water and wastewater, general considerations, methods for determination and application of date to environmental engineering practice; instrumentation; sample collection and preservation; laboratory analysis of water; interpretation of water analysis results as related to their treatment; neutralization, precipitation, coagulation, water softening, ion exchange, corrosion, absorption, chlorination; determinations of solids, Do, BOD, COD, nitrogen (in all forms related to environmental engineering practice), phosphorus and phosphates, grease and oil, volatile acids, sulfides and gas analysis.

2127675 Military Waste Management 3(3-0-9)

Management of solid and hazardous wastes from military activities; waste reuse and recycling; characteristics of wastes from military activities; site remediation; site remediation; environmental impact assessment.

**2107676 Management of Environmental 3(3-0-9)
Emergencies**

Classification and identification of susceptible sites for environmental emergencies; protection of important infrastructures in industries, in industrial estates, in fuel distribution and storage and in water supply from terrorist activities in the form chemical or biological threats; planning for emergency handling; public handling; coordinating with various work units, and training related people.

**2108532 Satellite Surveying and Modern 3(2-3-7)
Techniques**

Satellite datum, coordinate systems, concept of satellite positioning, global positioning system, observable in GPS, errors in GPS measurements, survey planning, field procedures, data processing, principles of inertial navigation system (INS), practical applications of GPS, principles of electronics, electronic surveying systems and basic components, geometry of electronic surveying, instrumentation and modern surveying technology.

**2108556 Online Spatial Information 3(2-3-7)
Technologies**

Introduction to GIS; and internet GIS; fundamental of computer networking; client/server computing; technology evolutions of web GIS; standards for distributed geospatial services (ISO & OGC), XML, GML and SVG, mobile GIS case studies and web GIS applications.

2108557 Spatial Data Structure and Models 3(3-0-9)

Conceptual model of space: entities and fields; vector data model, raster data model; data organization in raster: chain, block, run length, quadtrees, binary; data organization in vector: point, line, network, polygon, topology; comparisons of vector and raster data; database structure; file and data access; hierarchical structure; network structure, relational structure, object-oriented structure; introduction to geo-spatial relational database system, graph theory; optimal path.

2108558 Spatial Data Handling and Analysis 3(2-3-7)

Data capture techniques, coordinate systems, data quality; intersections of lines and curves, calculation of length and area, coordinate adjustment, geometric

searching; range searching; proximity searching; buffering; rubber sheeting, edge matching, image warping, conflation, feature editing; feature alignment; generalization; densification; topology construction; surface modeling; viewsheds; intervisibility; contouring.

2108627 Geoimage Processing 3(2-3-7)

Concepts of digital image: air borne, space borne; electromagnetic wave; optical and microwave sensor; digital image processing; classification; image coordinate and photo coordinate; sensor orientation; stereo-photogrammetry; photogrammetric triangulation; orthorectification.

2108628 Radar Remote Sensing 3(2-3-7)

Characteristics of microwave, microwave interaction with atmosphere and target, radar equation and radar section, principles of imaging radar, measureable phase/amplitude/polarization in radar imagery, geometric and radiometric properties of radar imagery, synthetic Aperture Radar, airborne/spaceborne SAR systems, interferometric SAR, processing stages in inteferogram generation, differential interferometric SAR, In SAR/DInSAR as measurement tools, geodetic and geophysical applications of InSAR/DInSAR, polarimetric SAR, classification and analysis of polarimetric SAR, landuse/landcover mapping applications using polarimetric SAR.

2108632 Advanced GNSS Surveying 3(2-3-7)

GPS system, coordinate and reference system, GPS observations and equations, GPS error mitigation techniques, computation of GPS satellite positions, principles of least-squares estimation, mathematical models for GPS positioning, standard format of GPS data, GPS data processing by least-squares method, interpretation of baseline results, GPS network adjustment, quality control for GPS surveying, GPS heighting, trends and applications of GNSS technology.

2109509 Stainless Steel Technology 3(3-0-9)

Stainless steel development; stainless steel grades; phase equilibrium diagram; microstructure and metallography; passive film; martensitic, ferritic, austenitic, duplex and precipitation hardening stainless steels; production technology; improvement of mechanical and corrosion properties and selection.

2109510 Instrumental Analysis 3(2-3-7)

Operation principles of transmission electron microscopy and scanning electron microscopy, Xray diffraction, X-ray fluorescence, atomic absorption and spectro analysis, ESCA and Auger electron spectrometer; interpretation of instrumental results in terms of mechanical properties.

2109516 Advanced Topics in Physical 3(3-0-9)
Metallurgy

Advanced topics of current research interests in physical metallurgy.

2109517 Composite Materials I 3(3-0-9)

Properties of engineering composite materials; types of composite materials; fiber and their interfaces; geometrical properties; elasticity; case studies.

2109518 Surface Technology 3(3-0-9)

Carburizing, nitriding, flame hardening, diffusion hardening; chemical vapor deposition and physical vapor deposition; electro-plating; hot dip coating; metal spraying and ion implantation.

2109519 Solidification of Casting 3(3-0-9)

Study of solidification of metal in molds; characteristics of liquid-solid phase transformations; Sand and metal thermal behavior; macroscopic structures; mechanical properties, and casting defects.

2109525 Welding Engineering 3(3-0-9)

Type and process of welding; mass and heat flow during welding; metallurgical effects of heat thermal cycle; solid-phase welding and joining of ceramic; welding of ferrous and non-ferrous metals; behavior of welds in service.

2109527 High Temperature Materials 3(3-0-9)

Theory of alloying and relationship among temperature, structure, and mechanical properties in nickel, cobalt, and iron base alloys; effect of thermomechanical processing; analysis of microstructures by transmission electron microscopy, scanning electron microscopy, X-ray diffraction, and X-ray microprobe.

2109533 Powder Metallurgy 3(3-0-9)

Preparation and fabrication of metal powder; engineering properties and industrial uses; theory of compaction and sintering.

2109535 Cellular Metal 3(3-0-9)

The structure, manufacturing methods, characterization techniques, mechanics. Physical and mechanical properties of cellular metals; energy absorption; sandwich structures and case studies.

2109536 Advanced Topics in Production 3(3-0-9)
Metallurgy

Advanced topics of current research interests in production metallurgy.

2109537 Tribology of Materials 3(3-0-9)

Solid lubrication and surface treatment; fundamentals of contacts between solids; abrasive, erosive, and cavitation wear; adhesion and adhesive wear, corrosive

and oxidative wear; fatigue wear; fretting and minor wear mechanism; wear of non-metallic materials; case study.

2110622   Data Management   3(3-0-9)

List structures: list, stacks, queues; table and hash in tree structures: binary search trees, AVL trees, B-trees, heaps; searching and sorting; fundamental of file structures.

2110639   Computer System Security   3(3-0-9)

Security system planning and administration; access control; data encryption; computer crime protection; disaster recovery planning; security models; including Orange book, and RACF.

2110661   Computer Network   3(3-0-9)

Introduction to network and network components; transmission links and protocols; design and analysis of network; WAN; IMP; to pology; network protocols; flow control and routing techniques.

2110678   Mobile Computing   3(3-0-9)

Principles, technologies and applications of mobile computing and wireless networks; mobile and wireless environment; protocols and architecture of mobile computing; mobile device technology; mobile computing security; application of distributed system in mobile computing; mobile middleware; mobile information and database access; mobile platforms; Web-based mobile application development.

2110681   Computer Algorithm   3(3-0-9)

Analysis and design of efficient algorithms; divide and conquer, recursion, dynamic programming and greedy algorithm; selection of appropriate data abstraction; analysis and correctness of algorithms; algebraic algorithms; combination problems; providing techniques for complexity analysis.

2110682   Embedded and Real-Time Systems 3(3-0-9)

Microcontroller architecture (RAM, ROM, CPU), I/O, and peripheral devices, I/O interfacing, real-time operating systems, real-time constraints, scheduling theory, real-time system design methodology, case studies.

2110741   Robotics   3(3-0-9)

A broad view of robotics: robot control, sensors and interfacing, robot intelligence and programming; a broad spectrum of disciplines: mechanical, electrical, industrial, and computer engineering; current topics: planning, subsumption architecture, reactive systems.

2110743   Machine Learning   3(3-0-9)

Computing with logic; using logic set theory, number theory, algebras, graph theory, automata; language of first

order logic, model theory and logic programming; problems of inductive inference in the framework of first-order predicate calculus and the probability calculus; introduction of computational learning theory.

2110745   Cryptography   3(3-0-9)

Introduction; symmetric encryption; block ciphers; block ciphers; pseudorandom permutations and pseudorandom functions; one-way functions; pseudorandom generators; hash functions; message authentication; authenticated encryption; asymmetric encryption; digital signatures; authenticated key exchange; interactive proofs and zero knowledge.

2131501   Nuclear Technology for Military   3(3-0-9)

Radioactive and nuclear materials; measurement of nuclear radiation; principles of radiation safety, detection of radioactive and nuclear materials; radiation imaging; elemental analysis using nuclear techniques, nuclear techniques for explosive detection; other uses of radioactive and nuclear materials; nuclear non-proliferation.

2111610   Nuclear Security   3(3-0-9)

Nuclear security; overview of related legal framework; interrelationships between nuclear safety, security and safeguards; nuclear and radiation threat by non-State actors; counterterrorism; chemical biological, radiological and nuclear (CBRN) weapons; basic elements of nuclear security; planning nuclear security at the state level; planning nuclear security of nuclear and radiological facility; introduction to detection of and response to, crimes and unauthorized acts involving nuclear material and other radioactive material outside regulatory control; information security; security culture.

2111613   Radiation Safety and shielding   3(3-0-9)

Definition and basic concepts in radiation safety; biological effects of radiation; basic radiation protection, dose limits; regulation concerning radioactive materials; transportation of radioactive materials; accidents and emergency procedure; gamma radiation and x-ray shielding; radiation shielding from nuclear reactor.

2111642   Nuclear Reactor Engineering   3(3-0-9)

Production and characteristics of neutrons; the fission process; neutron diffusion theory; slowing-down theory; Fermi theory of the bare thermal reactor; one-and multi-group diffusion methods; basic principles of nuclear reactor reactor kinetics and nuclear reactor control.

2111646   Radioactive Waste Management   3(3-0-9)

Nature of radioactive wastes; origin of low-high radioactive wastes; characteristics, forms and quantity of radioactive wastes; storage and transportation; waste

management technologies; radioactive waste management plans in various countries.

2111651 Weapon Mass Destruction 3(3-0-9)
Nonproliferation

Issues concerning the proliferation of nuclear, chemical, and biological weapons; introduction to nuclear and radiological terrorism; international nuclear nonproliferation framework; weapon technologies of mass destruction; nuclear proliferation issues in South Asia.

2111653 Nuclear Safeguards 3(3-0-9)

Safeguarding nuclear material and facilities; monitoring principles and technologies; safeguards issues; international framework of nuclear material safeguard; nuclear material safeguard; nuclear proliferation threat; radiological threat; detecting nuclear and other radioactive materials; roles of intelligence; A Q. Khan's network; counter-proliferation of nuclear weapons; nuclear material safeguard in various countries.

2111654 Nuclear Fuel Cycle and Environmental 3(3-0-9)
Impacts

Technology of nuclear fuel cycle; technologies used in manufacturing, safety handling, and disposing of nuclear materials and by-products; social environmental, and health impacts of materials used in each major step in the fuel cycle; potential of nuclear proliferation.

2111656 Physical Protection of Nuclear 3(3-0-9)
Materials and Facilities I

Principles of physical protection of nuclear materials and facilities: detection, delay, response; threat identification and analysis; vital area analysis; international physical safeguard framework; internal threats.

2111657 Advanced Detection Technologies 3(3-0-9)
For Radioactive and Nuclear Material

Detection and identification of the types of nuclear materials; chemical and radiological characteristics of nuclear materials from raw materials to various finished products; detection technologies; nuclear forensics.

2111658 Method and Instrumentation for 3(3-0-9)
Nuclear Security and Safeguards

Counting statistics; radiation detectors; gamma detection; neutron detection; detection of charged particles; gamma spectroscopy; activation analysis; destructive analysis; non-destructive analysis; quantitative nuclear material measurements; survey devices; use of detectors at port.

2111678 Nuclear Materials Engineering 3(3-0-9)

Nuclear fuel cycle; materials and thermal aspects of nuclear reactors; crystal structures of solids; point defects; diffusion in solids; elastic behavior of solids; dislocations in solid and creep deformation; grain and grain boundaries; cavities in solids; fission product behavior in nuclear fuel; radiation damage and fast-neutron irradiation effects in metals; introduction to the High-Temperature Gas-Cooled Reactor Technology.

2120602 Advanced Topics in Defense 3(3-0-9)
Engineering Technology

Study of recent topic and technology development in various fields of defense and engineering technology.

FOUNDATION ENGLISH COURSES

5500111 Experiential English I   3(2-2-5)
Practice in the four language skills for everyday communication; comparing, analyzing, and synthesizing information from different sources; giving oral and/or written presentations.

5500112 Experiential English II   3(2-2-5)
Condition : Prerequisite 5500111
Further practice in the four language skills for everyday communication; analyzing, synthesizing, summarizing, and evaluating information from different sources; giving oral and/or written presentations.

5500208 Communication and Presentation   3(2-2-5)
           skills
Condition : Prerequisite 5500112
Practice using English for social communication and giving oral presentation on engineering-related topics.

5500308 Technical Writing for Engineering   3(2-2-5)
Condition : Prerequisite 5500208
Practice in writing summaries, composing different types and styles of writing in the field of engineering, and writing reports of studies and experiments.

BASIC SCIENCES AND MATHEMATICES

2301107 Calculus I   3(3-0-6)
Limit, continuity, differentiation and integration of real-valued functions of a real variable and their applications; techniques of integration; improper integrals.

2301108 Calculus II   3(3-0-6)
Condition : Prerequisite 2301107
Mathematical induction; sequences and series of real numbers; Taylor series expansion and approximation of elementary functions; numerical integration; vectors, lines and planes in three dimensional space; calculus of vector valued functions of one variable; calculus of real valued functions of two variables; introduction to differential equations and their applications.

2301207 Calculus III   3(3-0-6)
Condition : Prerequisite 2301108
Lines; planes; quadric surfaces; normal lines and tangent planes to a surface, are length; calculus of real-valued functions of several veriables; Taylor's formula and its applications.

2301208   Calculus IV   3(3-0-6)
Condition : Prerequisite 2301207
Sequences and series of functions; uniform convergence; improper integrals; multiple integration; line integrals; surface integrals and integral theorems.

2301276   Engineering Mathematics I   3(3-0-6)
Condition : Prerequisite 2301108
Linear algebra; surfaces in three dimensional spaces; polar coordinate system; real-valued functions of several variables; multiple integrals.

2301277   Engineering Mathematics II   3(3-0-6)
Condition : Prerequisite 2301276
Differential vector calculus; integral vector calculus; tensors; functions of complex variables; improper integrals.

2301312   Differential Equations   3(3-0-6)
Condition : Prerequisite 2301102 or 2301108 or 2301106 or 2301118 or 2301241
Existence and uniqueness theorems for first-order equations, numerical methods, general linear equations, solution in series form, linear partial differential equations, boundary value problems.

2301366   Numerical Analysis   3(3-0-6)
Condition : Consent of Faculty
Numerical solutions of systems of linear equations, interpolation, approximation functions, least square approximation, numerical differentiation and integration; numerical solutions of algebraic and transcendental equations; numerical solutions of ordinary differential equations.

2301374   Applied Mathematical Methods   3(3-0-6)
Condition : Prerequisite 2301207
Linear algebral; introduction to the theory of approximations; solution of algebraic and transcendental equations; solutions of linear systems; first and second order differential equations; Fourier transforms and Lap lace transforms; vector calculus.

2302127   General Chemistry   3(3-0-6)
Stoichiometry and basis of the atomic theory. Properties of gas, liquid, solid and solution. Chemical equilibrium. Ionic equilibrium   Chemical kinetic. Electronic structures of atoms. Chemical bonds. Periodic properties. Representative elements, nonmetal and transition metals. Basic organic chemistry.

2302163   General Chemistry Laboratory   1(0-3-0)
Qualitative analysis techniques, Graham's law of gas diffusion, structure of metals and crystals, chemical equilibrium, indicators, acidbase titration, pH of solution and hydrolysis.

2304103   General PhysicsI   3(3-0-6)
Basic mathematics for general physics; mechanics and its applications; gases and kinetic theory; thermodynamics; transport phenomena and heat transfer; physical properties of matter.

2304104   General Physics II   3(3-0-6)
Electrostatic; direct current; alternating current;
electrical circuits; electromagnetism and magnetic
materials; mechanical and electromagnetic waves; modern
physics; nuclear physics; relativity.

2304183   General Physics Laboratory I   1(0-3-0)
Measurement and precision; statistical analysis and
accuracy; experiments on simple harmonic motion and
physical pendulum, elasticity of springs and rubber bands,
module of metals, rolling and radius of gyration, dynamics
of rotation, velocity of sound and Meld's experiment,
viscosity of fluids.

2304184   General Physics Laboratory II   1(0-3-0)
Resistance and electromotive force measurements;
experiments on ammeter, voltmeter,oscilloscope, AC
circuit, transistor,lenses and mirrors, polarization,
interference, diffraction, and radioactivity.

2307207   Physical Geology   3(3-0-6)
Basic principles and geological concepts; origin,
evolution, and history of the Earth; geological processes;
geological materials; earth's features and structures and
their relationships in space and time.

2603284   Statistics for Physical Science   3(3-0-6)
The scope and uses of statistics in physical science;
elementary principles of probability theory; random
variables and some probability distributions;
introduction to statistical inference; introduction to
analysis of variance; regression and correlation; statistical
quality control

BASIC ENGINEERING PRACTICE

2100301   Engineering Practice   2(0-35-0)
Engineering practice in related areas under
supervision of experience experienced engineers in
private   sectors or government agencies.

GENERAL EDUCATION, SPECIAL

2100111   Exploring Engineering World   3(3-0-6)

Engineering topics related to daily life: Energy,
Resources, Environment, industrial, automotive,
manufacturing, infrastructure, process, material,
Information System and bio engineering.

2100311   Engineering Essentials   3(3-0-6)
Topics related to engineering: management, ethics,
good governance, public responsibility, intellectual
property, finance, investment, economics, and green
technology.

Elective Courses

2100303   Creative Design for Community 3(2-3-4)
Creative design for community, creating concepts in
design processes by taking need users and community into
consideration; design for sustainability; prototyping,
testing and refining of the prototype, project management;
case studies.

2100310   Global Aware Tech   3(3-0-6)
Global awareness: Current mainstream technologies:
Understanding of a variety of cultures, traditions, laws &
regulations, bellefs, concepts, practices, values:
Technology implementation in various societies: Success
factora for technology implementation.

Group of courses for outbound exchange student

2100324   Study Abroad I   2(2-0-4)
Study of a course offered by a university abroad
according to the requirement of the program.

2100325   Study Abroad II   2(2-0-4)
Study of a course offered by a university abroad
according to the requirement of the program.

2100326   Study Abroad I   3(3-0-6)
Study of a course offered by a university abroad
according to the requirement of the program.

2100327   Study Abroad II   3(3-0-6)
Study of a course offered by a university abroad
according to the requirement of the program.

DESCRIPTION OF GENERAL EDUCATION COURSES

in 5 fundamental areas

Humanities I Science and Maths I Interdisciplinary I Social Sciences I 21st Gened (S/U)

1. **Humanities**

Course Number	English Abbreviation of Course Title	Credit	Course Number	English Abbreviation of Course Title	Credit
0123101	PARAGRAPH WRITING	3(1-4-4)	2207387	PHILOS WOMEN	3(3-0-6)
0123104	UNIV THAI READING	3(1-4-4)	2207467	PHILOS LANG	3(3-0-6)
0123105	THAI WRIT WORK	3(1-4-4)	2207472	JAPANESE PHILOS	3(3-0-6)
0201105	CU SMART BUD GRAD	3(3-0-6)	2207474	CHINESE PHILOS	3(3-0-6)
0201211	MEDITAT LIFE DEV	3(2-2-5)	2207478	PS TOP ETHICS	3(3-0-6)
0296110	HU ECO GLOBAL	3(3-0-6)	2209212	HUMAN LANG	3(3-0-6)
2200183	THAI CIV	3(3-0-6)	2209373	LANG CULTURE	3(3-0-6)
2200185	SURV ART ARCH THAI	3(2-4-3)	2209375	LANG ASEAN PLUS	3(3-0-6)
2200201	ACAD REPORT WRI (inter)	3(2-2-5)	2210214	LIT/ENVIRON	3(3-0-6)
2200222	VERN ARCH TH SOC	3(3-0-6)	2210215	LIT/WOMEN	3(3-0-6)
2200223	PNTG TH SOC	3(3-0-6)	2210216	MAG REAL LIT	3(3-0-6)
2200226	FOLK MUS TH SOC	3(3-0-6)	2210217	CONTEM FICT	3(3-0-6)
2200227	TH CL MUS DRAM	3(3-0-6)	2210218	REL/SPIRIT LIT	3(3-0-6)
2200330	TIPITAKA LIFE	3(3-0-6)	2210219	MYSTERY FICTION	3(3-0-6)
2200387	ARCHAEO THAI	3(2-3-4)	2210221	CRIME FICT/FILM	3(3-0-6)
2200389	ICONOGRAPHY	3(3-0-6)	2210235	LITERATURE AND FILM ADAPTATIONS	3(3-0-6)
2200390	FOR CULT TH ART	3(3-0-6)	2210239	LIT/DISABILITY	3(3-0-6)
2200391	CONT ART TH SEA	3(3-0-6)	2210313	HUMOUR/LIT	3(3-0-6)
2200392	ANC ART SIAM SEA	3(3-0-6)	2210314	JUVILE LIT	3(3-0-6)
2200393	LANG / CULT ART	3(3-0-6)	2210315	LIT/ETHN IDENTITY	3(3-0-6)
2200394	CUST/FEST TH SOC	3(3-0-6)	2210316	LIT/SOC-POL CONS	3(3-0-6)
2200395	ROY TRAD/CERE	3(3-0-6)	2210323	LIT/HUM RIGTHS	3(3-0-6)
2200396	REL RIT TH SOC	3(3-0-6)	2210335	INTRO CULT STUD	3(3-0-6)
2204180	CIVILIZATION	3(3-0-6)	2210420	MAJOR WRITER WORK	3(3-0-6)
2206101	RES ACAD REP WRIT	3(3-0-6)	2210423	LIT/PSYCHO	3(3-0-6)
2207103	PHILOS LOGIC	3(3-0-6)	2221433	BUDDHIST TEACHING	3(3-0-6)
2207201	HIST WEST PHILOS	3(3-0-6)	2221485	BUDDHIST CIV	3(3-0-6)
2207203	PHILOS FILMS	3(3-0-6)	2223243	JAPAN TODAY	3(3-0-6)
2207341	SYMBOLIC LOGIC	3(3-0-6)	2226001	INTRO VIET CULTURE	3(3-0-6)
2207361	AESTHETICS	3(3-0-6)	2232241	GER CH JU LIT	3(3-0-6)
2207363	ETHICS	3(3-0-6)	2232253	GER-SPK CNTR TODAY	3(3-0-6)
2207365	POLITICAL PHILOS	3(3-0-6)	2234482	INTRO ITAL CINEMA (inter)	3(3-0-6)
2207371	PHILOS LITERATURE	3(3-0-6)	2235320	CONTEMP PORT BRAZ	3(3-0-6)
2207385	AMERICAN PHILOS	3(3-0-6)	2236103	RUS LANG CULT	3(3-0-6)
2244151	INTRO CAMBO CULT	3(3-0-6)	2541157	PERSPEC EU ARCH (Inter)	3(3-0-6)
2296200	HUMAN LANG	3(3-0-6)	2541158	LAND/LANDSCAPE (Inter)	3(3-0-6)
2296225	LIT FILM	3(3-0-6)	2541159	UNDST/BSC IA DSGN (Inter)	3(2-2-5)
2296313	HUM LIT	3(3-0-6)	2541162	POSTMOD PHOTO (Inter)	3(3-0-6)
2296314	JUV LIT	3(3-0-6)	2541163	FML ANAL/PRES ARCH (Inter)	3(3-0-6)
2296315	LIT/ETHN IDEN	3(3-0-6)	2541168	DSGN ASIAN PESSP (Inter)	3(3-0-6)
2501191	HIST ART ARCH	3(3-0-6)	2541169	HIST ANIMATION (Inter)	3(3-0-6)
2501292	INTRO HSE DSGN	3(3-0-6)	2542001	ART DSGN FLD (inter)	3(0-9-0)
2501295	INTRO DESIGN	3(3-0-6)	2542002	COMM DSGN PROJ (inter)	3(3-0-6)
2501296	THAI ARCH HERITAGE	3(3-0-6)	2542003	DSGN THINL INNV (inter)	3(3-0-6)
2501297	ENJOY ARCH SKETCH	3(2-2-5)	2722272	DHAMMAVIDYA	2(2-0-4)
2501298	UNDERST ARCH	3(2-3-4)	2722288	DHAMMA SELF	3(3-0-6)
2501299	BUDDHIST ART/ARCH	3(3-0-6)	2736106	ART APPRECIATION	2(2-0-4)
2502291	DESIGN EVERYDAY (inter)	3(3-0-6)	2737110	MUS APPRECIATION	2(2-0-4)
2502292	CULINARY DESIGN	3(2-2-5)	2746105	LOC TALES MYTHS	3(1-6-2)
2502330	DSGN TH CULT HER	3(3-0-6)	3500111	INTRO FINE APP ART	3(3-0-6)

2502378	JWL APPRECIAT	3(3-0-6)	3501120	HIST WEST ART I (inter)	3(3-0-6)
2502379	APPRE CER	3(3-0-6)	3501214	THAI ARTS I	3(2-2-5)
2502393	CONT JP DSGN	3(3-0-6)	3501217	EAR MOD ART	3(3-0-6)
2502430	DSGN ENTREPRN	3(3-0-6)	3501222	HIST ORNTAL ART I	3(3-0-6)
2504102	HEALG ART/LDSCP	3(3-0-6)	3501224	HIST THAI ARTS	3(3-0-9)
2541151	SPARK CREAT (Inter)	3(1-4-4)	3502222	HIST CREAT ART	3(3-0-9)
2541152	C/C PROB SOLV (Inter)	3(1-4-4)	3502271	HIST FASHION	3(3-0-6)
2541154	COLOR AESTHETICS (Inter)	3(1-4-4)	3502272	HIST GRAPH DSGN	3(3-0-6)
2541155	VIS CULT (Inter)	3(2-2-5)	3503111	INTRO CLASSIC (inter)	3(3-0-6)
2541156	ARCH ENV FILM (Inter)	3(3-0-6)			

2. Science and Maths

Course Number	English Abbreviation of Course Title	Credit	Course Number	English Abbreviation of Course Title	Credit
0201152	PROD PROMOTION SCI	3(3-0-6)	2111201	GEN RAD NUCLEAR	3(3-0-6)
0298111	IN PRO COMMUNITY	3(3-0-6)	2111330	MOD MAP PROT RAD	3(3-0-6)
2100111	EXPL ENG WORLD	3(3-0-6)	2112210	WATER / SOC	3(3-0-6)
2100311	ENG ESSENTIALS	3(3-0-6)	2142109	AUTO STUDIES (Inter)	3(3-0-6)
2101251	CE PROF CONDUCT	3(3-0-6)	2140145	HOME IMPROVEMENT	3(3-0-5)
2101256	C E PROFESSION	3(3-0-6)	2300150	NATURAL SCIENCE	3(3-0-6)
2102041	ICT TELECOM MGT	3(3-0-6)	2300152	SCIENCE TODAY	3(3-0-6)
2102209	ELECT ENG ESSENT	3(3-0-6)	2300200	SCI TECH SOC	3(3-0-6)
2105261	CHEM PROD IND	3(3-0-6)	2301170	COMP PROG	3(3-0-6)
2107219	URBAN ENVIRONMENTS	3(3-0-6)	2302190	CHEMISTRY FOR MODERN LIFE (inter)	3(3-0-6)
2107220	ENV DAILY LIFE	3(3-0-6)	2303150	BIRDWATCH CONSERV	3(3-0-6)
2107221	ENV STUD	3(3-0-6)	2303165	MAN & ENVIRONMENT	3(3-0-6)
2110191	INNOV THINK	3(3-0-6)	2304274	PHYS BIO SYS	3(3-0-6)
2110221	COMP ENG ESS	3(3-0-6)	2305103	PL BETTER LIFE	3(3-0-6)
2305107	PLANT WORLD	3(3-0-6)	3309101	LIFE/HEALTH	3(3-0-6)
2305108	BIOTECH DAILY LIFE	3(3-0-6)	3309102	OUR BODY	3(3-0-6)
2305109	PL GROW TECH	3(3-0-6)	3310101	MAN & TOXIC SUBS	3(3-0-6)
2305151	ORGANIC GARDENING (inter)	3(3-0-6)	3600202	NUTRITION	2(2-0-4)
2305161	GENETICS FOR LIFE	3(3-0-6)	3600204	HLTH SEXUALITY	3(3-0-6)
2306416	MGT SYS TECH	3(3-0-6)	3600205	FAM HLTH CARE	3(3-0-6)
2307205	INTRO GEM SCI	3(3-0-6)	3600206	COM HLTH DEV	3(3-0-6)
2307206	EARTH SCIENCES	3(3-0-6)	3600207	HLTH LIVING	3(3-0-6)
2308200	SCI LOGIST SYS	3(3-0-6)	3600208	TOB ALC HLTH	3(3-0-6)
2308303	HISTORY OF SCI (inter)	3(3-0-6)	3600209	EMER DISAS CARE	3(2-2-5)
2308354	STRATEGY OF LIFE (inter)	3(3-0-6)	3640203	MTRNL CHILD HEALTH	2(2-0-4)
2309201	GEN OCEANOLOGY	2(2-0-4)	3700104	INI HC NEW GEN	3(3-0-6)
2310201	HEALTH/BEAUTY	3(3-0-6)	3700105	FOOD SCI ART	3(3-0-6)
2310202	SMT BUY CONS PROD	3(3-0-6)	3700107	SEXUAL DEVELOPMENT	3(3-0-6)
2311132	NEW TECH MAT SCI	3(3-0-6)	3700108	HLTH PREV INFC DIS	3(3-0-6)
2312100	MICROB FRIEND	3(3-0-6)	3700109	IMMUNTY OF LIFE	3(3-0-6)
2313210	VISUAL MEDIA TECH	3(3-0-6)	3700110	GOOD HEALTH	3(3-0-6)
2313213	DIGITAL PHOTO (inter)	3(3-0-6)	3700113	BLOOD ESS LIFE	3(3-0-6)
2313221	PHOTO SCI	3(3-0-6)	3700114	INTRO ENVI TOX	3(3-0-6)
2313226	PRINS MEDIA TECH	3(3-0-6)	3700210	MOD TECH HLTH	3(3-0-6)
2314255	ELEMENT FOOD TECH (inter)	3(3-0-6)	3705102	RADIA DAILY LIFE	3(3-0-6)
2314257	INTRO PACK TECH	3(3-0-6)	3705103	PREP DIAG RAD PROC	3(3-0-6)
2398130	MUGGLE MECHANICS	3(3-0-6)	3741101	COMP HLTH SCI	2(1-3-2)
2398131	PHYS IN FILMS	3(3-0-6)	3741102	LIVE SMART HLTHY	2(2-0-4)
3010101	DRUG DAILY LIFE (inter)	3(3-0-6)	3741207	MOD TECH	2(2-0-4)
3102216	ANIMAL BEHAVIOR	2(2-0-4)	3741208	LIFE LEARN SKILLS	2(1-2-3)
3101101	COMP APP PROF	1(0-3-0)	3741329	PATIENT SAFETY	1(1-0-2)
3107201	BIOSTATISTICS	3(3-0-6)	3741426	START-UP BUSIN MT	1(1-0-2)
3200106	FUN ORAL BIO HLTH	3(3-0-6)	3742100	PHY THR DAILY LIFE	3(3-0-6)
3200109	CALCIUM HLTH	3(3-0-6)	3742102	EXERCISE THERAPY	3(3-0-6)
3301102	COSMETICS DLY LIFE	3(3-0-6)	3742106	BLC BODY MIND QOL	3(3-0-6)

Course Number	English Abbreviation of Course Title	Credit	Course Number	English Abbreviation of Course Title	Credit
3304102	DRUG EDUCATION	3(3-0-6)	3742107	LIFE KNOWLEDGE	3(3-0-6)
3306101	USEFUL PLANTS	3(3-0-6)	3743422	WEIGHT CONTROL	3(3-0-6)
3307101	BASIC AROMATHERAPY	3(3-0-6)	3900200	EX/PS HLTH (inter)	3(2-2-5)
3308100	MICRO ORGAN/LIFE	3(3-0-6)	4000205	ORG AGR	3(3-0-6)
3308101	HYG ENV MICROBIO	3(3-0-6)	4000210	QUAN ANAL AGRI BUS	3(3-0-6)

3. Interdisciplinary

| Course Number	English Abbreviation of Course Title	Credit	Course Number	English Abbreviation of Course Title	Credit
0201102	THAI WISDOM	3(1-12-0)	0201252	ALT ENGY CONS	3(3-0-6)
0201103	OUR CU	3(2-3-4)	0201254	GLOB WARM ADAP	3(3-0-6)
0201106	ART SCI FIND HAP	3(3-0-6)	0201255	ICT STRATEGIC MGT	3(3-0-6)
0201107	LRN STUD ACT	3(1-6-2)	0201256	LIV DIGI WORLD (inter)	3(3-0-6)
0201108	FAMILY RELATIONS	3(3-0-6)	0201270	NAT SECURITY DEV	3(3-0-6)
0201109	INTRO EU INTEGRAT	3(3-0-6)	0201281	TEAM/ORG DEV	3(3-0-6)
0201110	SICHANG STUDY	3(2-2-5)	0201282	NAT SKB JOUR	3(3-0-6)
0201111	WISDOM LIVING	3(3-0-6)	0201283	BEAUTIFUL DEATH	3(3-0-9)
0201117	ART RATANAKOSIN	3(2-3-4)	0201284	JWL DES ENTRE (inter)	3(3-0-6)
0201121	LIFE REFL FILM	3(3-0-6)	0201285	SCON SOG PLANT	3(3-0-6)
0201122	MGT PUB DISASTER	3(3-0-6)	0295100	EXPL BME WORLD	3(3-0-6)
0201123	CULT TRAD TH LIFE	3(2-2-5)	0295101	INTRO DATA SCI	3(3-0-6)
0201125	MGT DIFF CULT (inter)	3(3-0-6)	0295102	AGRO WASTES MONEY	3(3-0-6)
0201127	QUAL WORK MGT (inter)	3(3-0-6)	0295125	DESIGN THINK INNO	3(3-0-6)
0201129	UNDERWATER WORLD	3(2-2-5)	2104181	HF ERGO DAILY LIFE	3(3-0-6)
0201130	IND BUS MGT	3(3-0-6)	2305100	NATIONAL RESOURCES	3(3-0-6)
0201131	THAI COAST COM DEV	3(2-3-4)	2305104	MAN/NATURE	3(3-0-6)
0201141	COAST ENV	3(2-3-4)	2305106	PLANS/HUMANITY	3(3-0-6)
0201151	OUR ENVIRONMENT (inter)	3(3-0-6)	2502390	INTRO PACK DESIGN	3(3-0-6)
0201153	WASTE MANAGEMENT	3(3-0-6)	2503216	AMPHAWA STUDIES	3(2-2-5)
0201154	URB GLOB WRMG	3(3-0-6)	2504101	LA APPRECIATION	3(3-0-6)
0201200	STUD PROC THAI SOC	3(2-3-4)	2506504	TRAD TAI SET HSG	3(2-3-4)
0201201	IDEAL GRADUATE 1	3(3-0-6)	2750178	LLL	3(1-4-4)
0201202	IDEAL GRADUATE 2	3(3-0-6)	3000106	DOCTOR AND SOCIETY	2(1-2-3)
0201203	IDEAL GRADUATE 3	3(3-0-6)	3000257	CRIT THK ETH/LAW	2(1-2-3)
0201204	IDEAL GRADUATE 4	3(3-0-6)	3000281	HUMAN LIFE	1(1-0-2)
0201205	IDEAL GRADUATE 5	3(3-0-6)	3000396	HLTH PROM	1(0-3-0)
0201206	THAI IDEAL GRAD	3(3-0-6)	3300100	HEALTH CONS PROT	3(3-0-6)
0201209	VALUE URB ENV	3(2-3-4)	3303100	Q LIFE	3(3-0-6)
0201210	MAT MGT GREEN	2(2-0-6)	3303191	CHEM DRUG DAILY	3(3-0-6)
0201230	MAN/PEACE	3(3-0-6)	3305101	FOOD FOR HEALTH	3(3-0-6)
0201231	URB COMM STUD	3(2-3-4)	3800252	LEADER PER DEV	3(3-0-6)
0201232	MULTI STUD RUR DEV	3(3-0-6)	3800309	PSY CONSERV NATURE	3(3-0-6)
0201234	LOCAL GLOB ISS (inter)	3(2-3-4)	3914101	REC QUAL LIFE DEV (inter)	3(3-0-6)
0201251	P2 CONTROL (inter)	3(3-0-6)	4000101	AGR PROD DEV CONS	3(3-0-6)

4. Social Sciences

Course Number	English Abbreviation of Course Title	Credit	Course Number	English Abbreviation of Course Title	Credit
0201170	MILITARY SCIENCE	3(3-0-6)	2900151	FOUNDATION ECON	3(3-0-6)
0201171	EFFECT CAREER MGT (inter)	3(3-0-6)	2900152	INTRO THAI ECON	3(3-0-6)
0201172	SELF/CAREER MGT (inter)	3(3-0-6)	3401124	INTRO IP LAW	3(3-0-6)
0294555	PROF PRESENTATION	3(3-0-6)	3401501	TAX LAW DLY LIFE	3(3-0-6)
2400104	GOVT POL THAI	3(3-0-6)	3402103	INTRO CRIM LAW	3(3-0-6)
2403183	SOCIETY & CULTURE	3(3-0-6)	3404103	LAW LAND MGT	3(3-0-9)
2403184	SOC DIVER JUS THAI (inter)	3(3-0-6)	3404109	LAW COMP TECH	3(3-0-6)
2403185	JUV DEL	3(3-0-6)	3404113	INTRO WTO LAW	3(3-0-6)
2403284	CROSS CULT MGT (inter)	3(3-0-6)	3404115	INTRO PUBLIC LAW	3(3-0-6)
2403471	ANTH RSRCH METH	3(3-0-6)	3404117	INTRO TO LAW	3(3-0-6)

2404300	IT/SOC (inter)	3(3-0-6)	3404122	LEGAL LOGICS	2(2-0-4)
2404301	SEL TOP PAX DIGI	3(3-0-6)	3404123	LEGAL HISTORY	2(2-0-4)
2541160	CREAT URB LIVING (inter)	3(3-0-6)	3404124	LAW AND SOCIETY	2(2-0-4)
2601111	BUS ACCTG	3(3-0-6)	3404201	LAW ACCTG	2(2-0-4)
2602121	INTRO BUSINESS	3(3-0-2)	3404202	LAW ECON ANAL	2(2-0-4)
2602171	BUS CPTS/ETHICS (inter)	3(3-0-6)	3404405	LEGAL ETHICS	2(2-0-4)
2602241	INTRO IT/IS (inter)	3(3-0-6)	3404500	ENV LAW SOC	3(3-0-6)
2603244	GEN PRIN INSURANCE	3(3-0-6)	3405102	INTRO INTL LAW	3(3-0-6)
2604362	PERSONAL FINANCE	3(3-0-6)	3800101	GENERAL PSYCHOLOGY	3(2-2-5)
2605311	PRINC MKTG	3(3-0-6)	3800105	INTRO PSY (inter)	3(3-0-6)
2722178	THAI CULTURE	2(2-0-4)	3800202	PSY LIFE WORK (inter)	3(3-0-6)
2722221	TH CULT GLOB	3(3-0-6)	3800250	HUMAN RELATIONS	3(3-0-6)
2746104	KHAM PHOR SORN	3(1-6-2)	3800251	MENTAL HEALTH	3(3-0-6)
2800210	ART APPRE COMM (inter)	2(2-0-4)	3800351	PSY THINK CREAT	3(3-0-6)
2800211	THAI CULT/COMM (inter)	3(3-0-6)	4000203	INTRO SUFF ECON	3(3-0-6)
2800212	HUMAN COMM (inter)	3(3-0-6)	4000204	INTRO AGRO FOOD CH (inter)	3(3-0-6)
2800218	VIS MED STUDIES (inter)	3(3-0-6)	4000206	HIST THAI AGR	3(3-0-6)
2800219	CROSS CULT COMM (inter)	3(3-0-6)	4000208	INTRO AGR ECON (inter)	3(3-0-6)
2800221	INTER COMM ETI PRO (inter)	3(3-0-6)	4000209	INTRO AGR RES MGT	3(3-0-6)
2800314	ART PUB SPKG (inter)	3(3-0-6)	5100101	POP/DEV	3(3-0-6)
2801321	NEWS INFO/SOC	3(3-0-6)			

5. 21st GENED (S/U)

Course Number	English Abbreviation of Course Title	Credit	Subject matter
0294455	PROF PRESENTATION	3(3-0-6)	Social Sciences
0295100	EXPL BME WORLD	3(3-0-6)	Interdisciplinary
0295101	INTRO DATA SCI	3(3-0-6)	Interdisciplinary
0295102	AGRO WASTES MONEY	3(3-0-6)	Interdisciplinary
0295125	DESIGN THINK INNO	3(3-0-6)	Interdisciplinary
0296110	HU ECO GLOBAL	3(3-0-6)	Humanities
0298111	IN PRO COMMUNITY	3(3-0-6)	Science and Maths
2296200	HUMAN LANG	3(3-0-6)	Humanities
2296225	LIT FILM	3(3-0-6)	Humanities
2296313	HUM LIT	3(3-0-6)	Humanities
2296314	JUV LIT	3(3-0-6)	Humanities
2296315	LIT/ETHN IDEN	3(3-0-6)	Humanities
2398130	MUGGLE MECHANICS	3(3-0-6)	Science and Maths
2398131	PHYS IN FILMS	3(3-0-6)	Science and Maths

Chulalongkorn University Map

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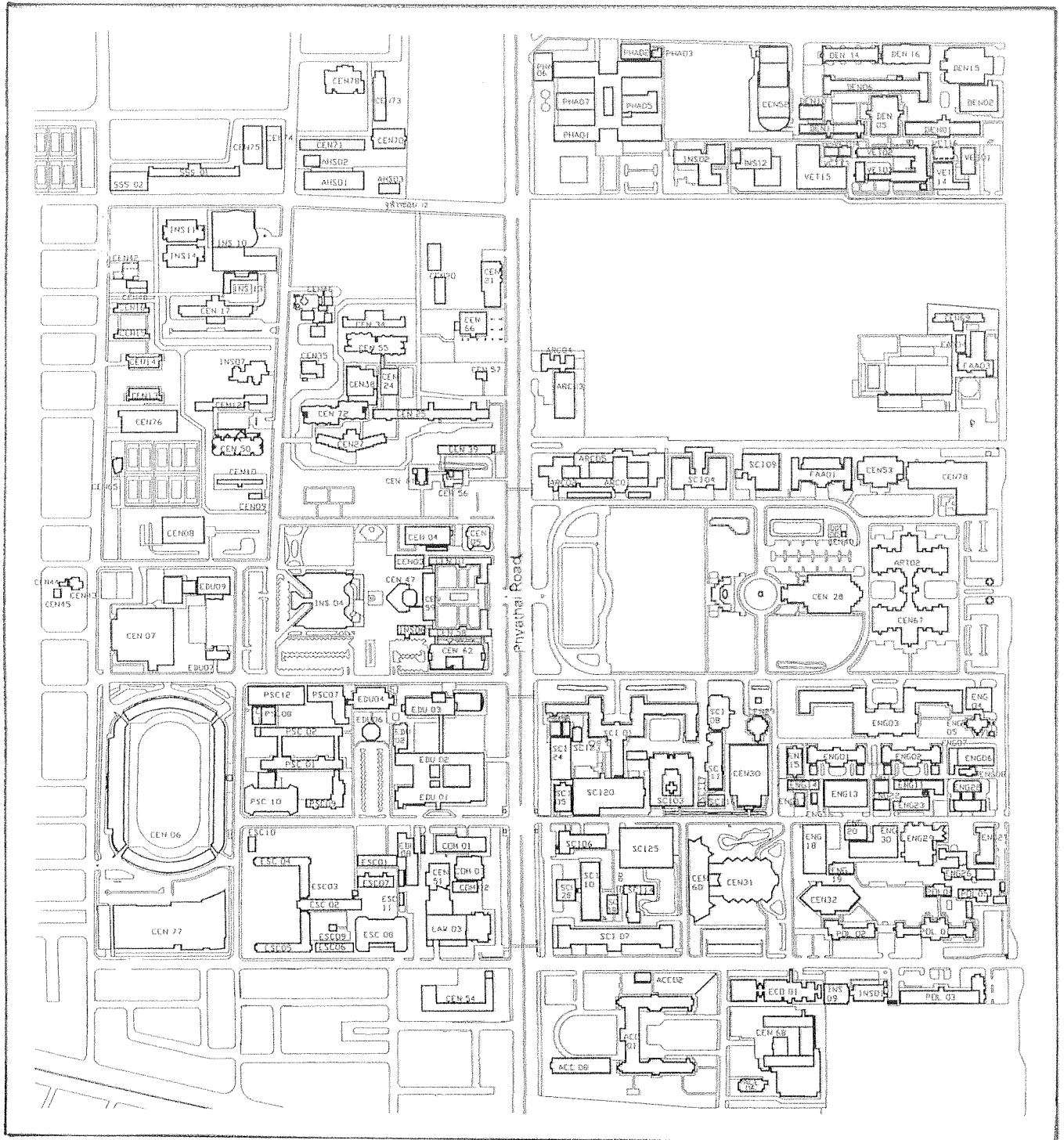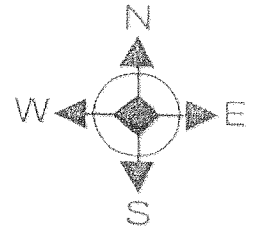
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