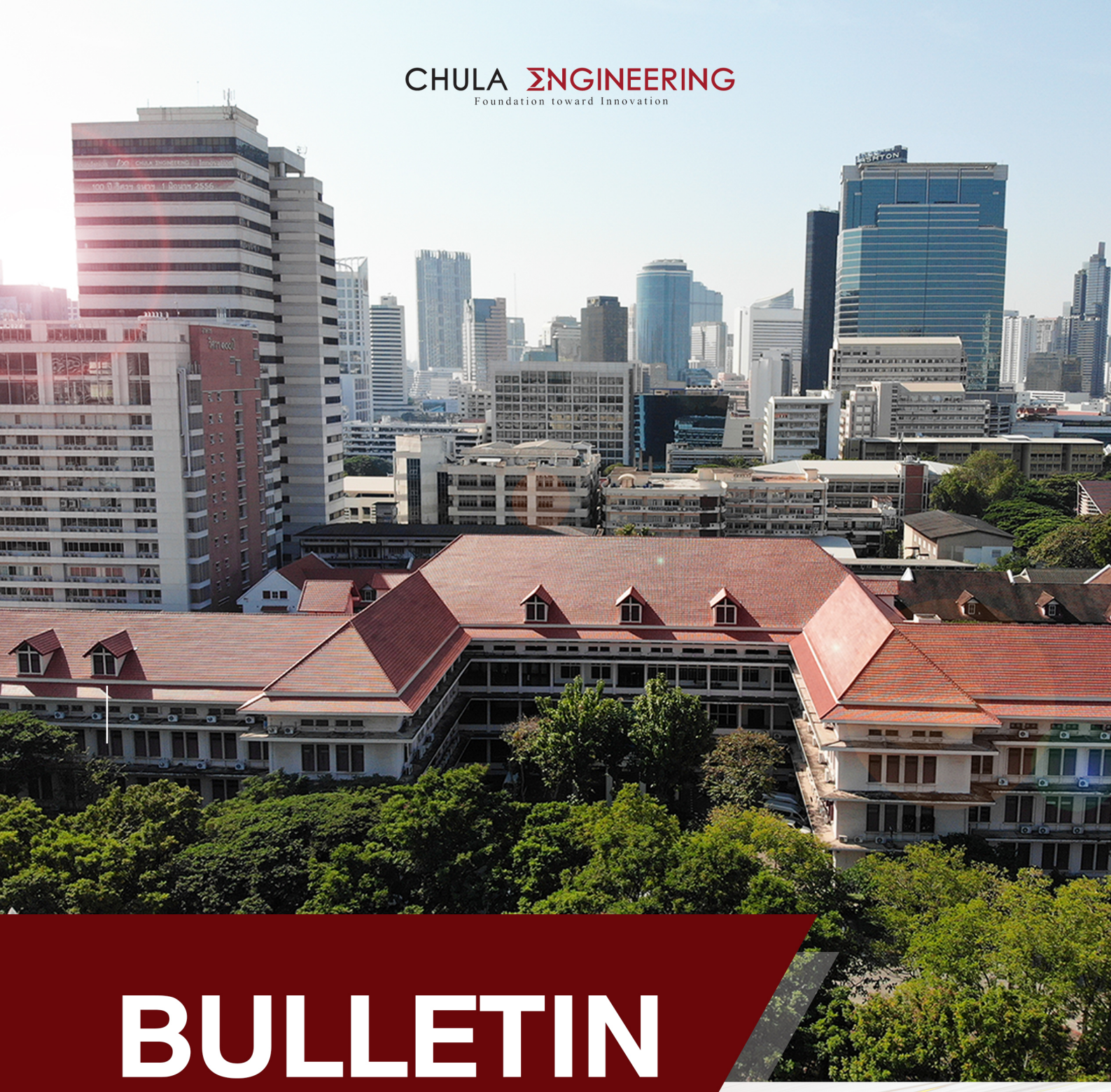
CHULA ENGINEERING
Foundation toward Innovation



BULLETIN

2019

Faculty of Engineering
Chulalongkorn University

FOR USE BY
ENGINEERING STUDENTS
HAVING ID NO. 62X XXXXX XX
UNTIL THEIR GRADUATION

UNIVERSITY CALENDAR
ACADEMIC YEAR 2019

First Semester

First day of classes	Tuesday, August 13, 2019
Midterm Examinations (if any)	Monday, October 7 – Friday, October 11, 2019
Close of first semester activities	Sunday, November 3, 2019
Last day of classes	Friday, November 29, 2019
Final Examinations	Monday, December 2– Tuesday, December 17, 2019
Close of first semester	Wednesday, December 18, 2019

Second Semester

First day of classes	Monday, January 6, 2020
Midterm Examinations (if any)	Monday, March 2 – Friday, March 6, 2020
Close of second semester activities	Sunday, April 5, 2020
Last day of classes	Friday, May 1, 2020
Final Examinations	Tuesday, May 5 – Wednesday, May 20, 2020
Close of second semester	Thursday, May 21, 2020

Summer Session

First day of classes	Monday, June 1, 2020
Last day of classes and Examinations	Friday, July 17, 2020
Close of summer session	Saturday, July 18, 2020
Last day of Academic Year	Friday, August 7, 2020

ADMINISTRATION
FACULTY BOARD

Dean of the Faculty :

Prof. Dr. Supot Techavorasinskun

Associate Dean

Prof. Dr. Kasem Choocharukul
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
Prof. Dr. Pisut Painmanakul

Assistant Dean

Assoc. Prof. Dr. Chotirat Ratanamahatana
Assoc. Prof. Dr. Athasit Surarerks
Assist. Prof. Dr. Channarong Banmongkol
Assist. Prof. Dr. Sawekchai Tangaramvong
Assist. Prof. Dr. Falan Srisuriyachai
Assist. Prof. Dr. Phannee Saengkaew
Assist. Prof. Dr. Natt Leelawat
Assist. Prof. Supattra Visessri
Dr. Surat Kwanmuang

Head of Department of Civil Engineering

Prof. Dr. Boonchai Stitmannaithum

Head of Department of Electrical Engineering

Assoc. Prof. Dr. Naebboon Hoonchareon

Head of Department of Mechanical Engineering

Assoc. Prof. Angkee Sripakagorn

Head of Department of Industrial Engineering

Assoc. Prof. Dr. Paveena Chaovalitwongse

Head of Department of Chemical Engineering

Assoc. Prof. Dr. Varong Pavarajarn

Head of Department of Mining and Petroleum Engineering

Assist. Prof. Dr. Thitisak Boonpramote

Head of Department of Environmental Engineering

Assoc. Prof. Dr. Khemarath Osathaphan

Head of Department of Survey Engineering

Prof. Dr. Chalermchon Satirapod

Head of Department of Metallurgical Engineering

Assoc. Prof. Dr. Ekasit Nisaratanaporn

Head of Department of Computer Engineering

Assist. Prof. Dr. Attawith Sudsang

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. Alongkorn Pimpin
Assoc. Prof. Thanarat Chalidabhongse
Assoc. Prof. Dr. Boonrat Lohwongwatana Assist.
Prof. Dr. Wanchalerm Pora
Assist. Prof. Dr. Somboon Rassame
Assist. Prof. Dr. Somchai Kriengkraiwasin
Assist. Prof. Dr. Piyatida Ruangrassamee
Assist. Prof. Poom Luangjarmekorn
Dr. Akawat Sirisuk

Program Director of International School of Engineering

Assoc. Prof. Dr. Witaya Wannasuphoprasit

Program Director of The Regional Centre for Manufacturing Systems Engineering

Prof. Dr. Parames Chutima

Acting Director of Biomedical Engineering Program

Assist. Prof. Dr. Juthamas Ratanavaraporn

Acting Director of Defense Engineering and Technology Program

Assoc. Prof. Dr. Pichaya Rachdawong
Col.Assist. Prof. Dr. Chuan Chuntavan

Director of Center for Engineering Research and Technical Services

Prof. Dr. Thanyawat Pothisiri

Registrar :

Assoc. Prof. Dr. Athasit Surarerks

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	25,500	baht per semester
Summer session	6,375	baht per session

Regular Graduate Programs

Regular semester	33,500	baht per semester
Summer session	8,375	baht per session

Notes : 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)

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.

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 6 are major requirement, 12 required elective courses in related fields, and 18 are thesis or theis and applied technology courses.

The major requirement consists of 6 research clusters namely: (1) Bioelectronics, (2) Energy, (3) Data Analytics, (4) Intelligent Systems, (5) Materials and Devices, and (6) Telecommunications and Networking.

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 Ph.D. student has to pass the following requirements in order to achieve his or her study:

1. The applicant who holds a Master's Degree with 3.5 grade point average or higher 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. 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 :

Naebboon	Hoonchareon,	Ph.D. (Purdue)

PROFESSORS :

Boonchai	Tacha-amnart,	D.Eng.(Kyoto)
Bundhit	Eua-arporn,	Ph.D. (London)
David	Banjerdpongchai,	Ph.D. (Stanford)
Songphol	Kanjanachuchai,	Ph.D.(Cambridge)
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)
Naebboon	Hoonchareon,	Ph.D. (Purdue)
Nisachon	Tangsangiumvisai,	Ph.D. (London)
Prasit	Teekaput,	Ph.D. (VPI & Su)
Somchai	Ratanathammaphan,	D.Eng. (Chula)
Sotdhipong	Phichaisawat,	Ph.D. (Brunel, UK)
Supavadee	Aramvith,	Ph.D. (Washington)
Supatana	Auethavekiat	Ph.D. (Tokyo)
Thavatchai	Tayjasanant,	Ph.D. (Alberta)
Wanchalerm	Pora,	Ph.D. (London)
Watcharapong	Khovidhungij,	Ph.D. (UCLA)

ASSISTANT PROFESSORS :

Apiwat	Lek-Uthai	Dr.Ing. (Karlsruhe)
Arporn	Teeramongkonrasmee,	Ph.D. (Chula)
Chaiyachet	Saivichit,	Ph.D. (London)
Chanchana	Tangwongsan,	Ph.D. (Wisconsin)
Channarong	Banmongkol,	D.Eng. (Nagoya)
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)
Panuwat	Janpugdee	Ph.D. (Ohio State)
Pasu	Kaewplang,	Ph.D. (Chula)
Somboon	Sangwongwanich,	D.Eng. (Nagoya)
Suchin	Arunsawatwong,	Ph.D. (Manchester)
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)
Weerapun	Rungseevijitprapa,	Dr.-Ing. (Hannover)
Widhyakorn	Asdornwised,	D.Eng. (Chula)

LECTURERS :

Bunchauy	Supmonchai,	M.Eng. (Chula)
Hadsakoon	Boriphonmongkol,	M.Eng. (Chula)
Jakapan	Lee,	M.Eng. (Tokyo Tech)
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 TO DIGITAL CIRCUITS	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

Compulsory Elective/Elective courses

Category	Power	Control	Communications	Electronics
Compulsory Elective (At least 14 credits)	2102356 Electrical Machines II (3) 2102446 Fundamental of Power Electronics (3) 2102458 High Voltage Engineering I (3) 2102459 High Voltage Engineering Laboratory (1) 2102461 Electrical Power Systems II (3) 2102465 Electrical Power Laboratory (1)	2102401 Random Processes for EE (3) 2102432 Linear Control Systems II (3) 2102433 Digital Control Systems (3) 2102435 Industrial Automation (3) 2102436 Control and Instrumentation Laboratory (1)	2102322 Telecommunication Transmission (3) 2102423 Digital Signal Processing (3) 2102425 Data Communications (3) 2102472 Fundamental of Digital Communication (3) 2102473 Communication Engineering Laboratory (1)	2102444 Introduction to Embedded Systems (3) 2102446 Fundamental of Power Electronics (3) 2102447 Electronics Engineering Laboratory (1) 2102488 Semiconductor Devices II (3) 2102489 Principle of Analog Circuit Design (3)
Elective (At least 6 credits)	*See the list of Elective courses from the Electrical Department announcement, in which it can be updated annually.*			

Notes

- A student must select 2 fields in the compulsory elective courses from Compulsory Elective category, with a minimum of 2 lecture subjects and one laboratory subject in each selected field.
- The total credits for Compulsory Elective category must be at least 14.
- In case, the student selects 2102446 FUNDAMENTAL of POWER ELECTRONICS he or she can declare them only in one field.
- A student must select courses from Elective category with a total of at least 6 credits.
- The Compulsory Elective/Elective courses can also be selected as free elective course(s).

Remark:
Typographical error correction (displayed here in RED) as approved for uses in academic year 2021
by the postgraduate curriculum administrative committee of Department of Electrical Engineering

NAME OF THE DEGREE

: Master of Engineering
: M. Eng.

PROFESSORS :

Boonchai	Techaumnat,	D.Eng. (Kyoto)
Bundhit	Eua-arporn,	Ph.D. (London)
David	Banjerdpongchai,	Ph.D. (Stanford)
Somsak	Panyakeow,	D.Eng. (Osaka)
Songphol	Kanjanachuchai,	Ph.D.(Cambridge)
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)
Naebboon	Hoonchareon,	Ph.D. (Purdue)
Nisachon	Tangsangiumvisai,	Ph.D. (London)
Prasit	Teekaput,	Ph.D. (VPI & Su)
Somchai	Ratanathammaphan,	D.Eng. (Chula)
Sotdhipong	Phichaisawat,	Ph.D. (Brunel, UK)
Supavadee	Aramvith,	Ph.D. (Washington)
Supatana	Auethavekiat	Ph.D. (Tokyo)
Thavatchai	Tayjasanant,	Ph.D. (Alberta)
Wanchalerm	Pora,	Ph.D. (London)
Watcharapong	Khovidhungij,	Ph.D. (UCLA)

ASSISTANT PROFESSORS :

Apiwat	Lek-Uthai	Dr.Ing. (Karlsruhe)
Arporn	Teeramongkonrasmee,	Ph.D. (Chula)
Chaiyachet	Saivichit,	Ph.D. (London)
Chanchana	Tangwongsan,	Ph.D. (Wisconsin)
Channarong	Banmongkol,	D.Eng. (Nagoya)
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)
Panuwat	Janpugdee	Ph.D. (Ohio State)
Pasu	Kaewplang,	Ph.D. (Chula)
Somboon	Sangwongwanich,	D.Eng. (Nagoya)
Suchin	Arunsawatwong,	Ph.D. (Manchester)
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)
Weerapun	Rungseevijitprapa,	Dr.-Ing. (Hannover)
Widhyakorn	Asdornwised,	D.Eng. (Chula)

LECTURERS :

Bunchauy	Supmonchai,	M.Eng. (Chula)
Hadsakoon	Boriphonmongkol,	M.Eng. (Chula)
Jakapan	Lee,	M.Eng. (Tokyo Tech)
Pisitpol	Chirapngsananurak	Ph.D. (Texas)

COURSE REQUIREMENTS

1) Required Courses

2102790	Electrical Engineering Seminar	2(2-0-6)

2) Compulsory Electives in Electrical Engineering Research Cluster 6 credits from

- **Bioelectronics**

2102547	Cognitive Engineering	3(3-0-9)
2102585	Biomaterial Science	3(3-0-9)
2102588	Biomedical Electronics	3(3-0-9)
2102668	Biosensors	3(3-0-9)
2102785	Advanced Sensor Theory	3(3-0-9)
2110675	Biomedical Information and Communication Systems	3(3-0-9)
3017767	Human Body for Biomedical Engineering	3(2-3-7)

- **Energy**

2102543	Advanced Electric Motor Drives	3(3-0-9)
2102544	Advanced Embedded Systems	3(3-0-9)
2102548	Switched-Mode Electrical Power Processing I	3(3-0-9)
2102552	Introduction to Distributed Generation	3(3-0-9)
2102553	Fundamentals of Electromagnetic Compatibility	3(3-0-9)
2102555	Fundamentals of Power Quality	3(3-0-9)
2102556	Power System Economics	3(3-0-9)
2102558	Insulation Coordination	3(3-0-9)
2102560	High Voltage Equipment Maintenance and Testing	3(3-0-9)
2102561	Power and Energy Technologies in Smart Grids	3(3-0-9)
2102562	ICT Infrastructure for EMS-WAMS Applications	3(3-0-9)
2102563	Power Electronics for Smart Grids and Renewable Energy	3(3-0-9)
2102564	Software Tools for Smart Grid Analysis and Design	3(3-0-9)

- ~~Analysis and Design~~

2102565	Economics in Energy Supply Industry	3(3-0-9)
2102566	Substation Automation Systems	3(3-0-9)
2102567	Power System Analysis	3(3-0-9)
2102650	Electrical Transients in Power Systems	3(3-0-9)
2102651	Power System Stability	3(3-0-9)
2102653	Special Topics in Power Electronics	3(3-0-9)
2102656	Power System Protection	3(3-0-9)
2102686	Switched-Mode Electrical Power Processing II	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)

- **Data Analytics**

2102502	Random Signals and Systems	3(3-0-9)
2102505	Introduction to Optimization Techniques	3(3-0-9)
2102531	System Identification	3(3-0-9)
2102571	Multimedia Communication	3(3-0-9)
2102575	Statistical Inference and Modeling	3(3-0-9)
2102576	Signal Transforms and Applications	3(3-0-9)
2102611	Medical Instrumentation	3(3-0-9)
2102642	Computer Vision and Video Electronics	3(3-0-9)
2102676	Digital Image Processing	3(3-0-9)
2102732	Convex Optimization and Engineering Applications	3(3-0-9)
2102875	Digital Video Processing	3(3-0-9)
2102876	Adaptive Signal Processing	3(3-0-9)
2110743	Machine Learning	3(3-0-9)

- **Intelligent Systems**

2102504	Introduction to Mathematical Analysis	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)
2102536	Nonlinear Control Systems I	3(3-0-9)
2102537	Glocal Control Systems	3(3-0-9)
2102541	IoT Fundamentals	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)
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)
2102642	Computer Vision and Video Electronics	3(3-0-9)
2102731	Infinite-Dimensional Control Systems	3(3-0-9)
2103530	Industrial Robots I	3(3-0-9)
2103535	Mechatronics	3(3-0-9)
2103630	Industrial Robots II	3(3-0-9)
2110634	Software Design and Development	3(3-0-9)
2110654	Artificial Intelligence	3(3-0-9)
2110743	Machine Learning	3(3-0-9)
2110746	Big Data Analytics	3(3-0-9)
2110773	Data Mining	3(3-0-9)

- **Materials and Devices**

2102506	Finite Element Analysis for Electrical Engineers	3(3-0-9)
2102582	Photonic Devices in Optical Communication Systems	3(3-0-9)
2102585	Biomaterial Science	3(3-0-9)
2102588	Biomedical Electronics	3(3-0-9)
2102589	Laser Engineering	3(3-0-9)
2102620	Electromagnetic Theory	3(3-0-9)
2102624	Microwave Photonic and Radio over Fiber Technology	3(3-0-9)
2102663	Solar Cell Technology	3(3-0-9)
2102668	Biosensors	3(3-0-9)
2102674	Optical Communication	3(3-0-9)
2102682	Solid-State Physics for Electronics Engineers	3(3-0-9)

- **Telecommunications and Networking**

2102520	Optical Fiber Transmissions and Networks	3(3-0-9)
2102522	Internet Technology and Applications	3(3-0-9)
2102526	Mobile Communications and Networking	3(3-0-9)
2102527	Traffic Engineering Analysis and Simulation	3(3-0-9)
2102541	IoT Fundamentals	3(3-0-9)
2102571	Multimedia Communication	3(3-0-9)
2102577	Telecommunication Network	3(3-0-9)
2102578	Satellite Communications	3(3-0-9)
2102620	Electromagnetic Theory	3(3-0-9)
2102624	Microwave Photonic and Radio over Fiber Technology	3(3-0-9)
2102626	Antennas and Radio Wave Propagation	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)
2102674	Optical Communication	3(3-0-9)
2102771	Advanced Wireless Communications	3(3-0-9)
2102774	Telecommunications Switching, Transmission and Signaling	3(3-0-9)
2110640	Information Security	3(3-0-9)

3) Compulsory Electives in Applied Technology Group

2102691	Industrial Experiences 1	3(0-12-0)
2102692	Industrial Experiences 2	3(0-12-0)
2102694	Internship Aboard 1	3(0-12-0)
2102695	Internship Aboard 2	3(0-12-0)

4) Elective Courses 12 ~~6~~ credits

2102591	Future technology trends in EE industry 1	3(3-0-9)
2102592	Future technology trends in EE industry 2	3(3-0-9)
2102598	Special Problems in Electrical Engineering I	3(3-0-9)
2102697	Special Problems in Electrical Engineering II	3(3-0-9)

Select 12 credits from the list of Compulsory Electives in Electrical Engineering Research Clusters or Elective Courses as given in the curriculum.

5) THESIS

2102811	THESIS	12	credits
2102813	THESIS	18	credits
2102816	THESIS	36	credits

2102811 is for students getting S from 6 credits of Compulsory Electives in Applied Technology Group. 2102816 is for students in continuous B.Eng-M.Eng program. And 2102813 is for all the other M.Eng students.

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)
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Songphol	Kanjanachuchai,	Ph.D.(Cambridge)
Watit	Benjapolakul,	D.Eng. (Tokyo)

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Cherdkul	Sopavanit,	M.Eng. (Chula)
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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)
Sotdhipong	Phichaisawat,	Ph.D. (Brunel, UK)
Supavadee	Aramvith,	Ph.D. (Washington)
Supatana	Auethavekiat	Ph.D. (Tokyo)
Thavatchai	Tayjasanant,	Ph.D. (Alberta)
Wanchalerm	Pora,	Ph.D. (London)
Watcharapong	Khovidhungij,	Ph.D. (UCLA)

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Chaiyachet	Saivichit,	Ph.D. (London)
Chanchana	Tangwongsan,	Ph.D. (Wisconsin)
Channarong	Banmongkol,	D.Eng. (Nagoya)
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)
Panuwat	Janpugdee	Ph.D. (Ohio State)
Pasu	Kaewplang,	Ph.D. (Chula)
Somboon	Sangwongwanich,	D.Eng. (Nagoya)
Suchin	Arunsawatwong,	Ph.D. (Manchester)
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)
Weerapun	Rungseevijitprapa,	Dr.-Ing. (Hannover)
Widhyakorn	Asdornwised,	D.Eng. (Chula)

LECTURERS :

Bunchauy	Supmonchai,	M.Eng. (Chula)
Hadsakoon	Boriphonmongkol,	M.Eng. (Chula)
Jakapan	Lee,	M.Eng. (Tokyo Tech)
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 Electrical Engineering Research Cluster 9 credits from**
(Required for Ph.D. students in Plan 2.2 only.)

- **Bioelectronics**

2102547	Cognitive Engineering	3(3-0-9)
2102585	Biomaterial Science	3(3-0-9)
2102588	Biomedical Electronics	3(3-0-9)
2102668	Biosensors	3(3-0-9)
2102785	Advanced Sensor Theory	3(3-0-9)
2110675	Biomedical Information and Communication Systems	3(3-0-9)
3017767	Human Body for Biomedical Engineering	3(2-3-7)

- **Energy**

2102543	Advanced Electric Motor Drives	3(3-0-9)
2102544	Advanced Embedded Systems	3(3-0-9)
2102548	Switched-Mode Electrical Power Processing I	3(3-0-9)
2102552	Introduction to Distributed Generation	3(3-0-9)
2102553	Fundamentals of Electromagnetic Compatibility	3(3-0-9)
2102555	Fundamentals of Power Quality	3(3-0-9)
2102556	Power System Economics	3(3-0-9)
2102558	Insulation Coordination	3(3-0-9)
2102560	High Voltage Equipment Maintenance and Testing	3(3-0-9)
2102561	Power and Energy Technologies in Smart Grids	3(3-0-9)
2102562	ICT Infrastructure for EMS-WAMS Applications	3(3-0-9)
2102563	Power Electronics for Smart Grids and Renewable Energy	3(3-0-9)
2102564	Software Tools for Smart Grid Analysis and Design	3(3-0-9)
2102565	Economics in Energy Supply Industry	3(3-0-9)
2102566	Substation Automation Systems	3(3-0-9)
2102567	Power System Analysis	3(3-0-9)
2102650	Electrical Transients in Power Systems	3(3-0-9)
2102651	Power System Stability	3(3-0-9)
2102653	Special Topics in Power Electronics	3(3-0-9)
2102656	Power System Protection	3(3-0-9)
2102686	Switched-Mode Electrical Power Processing II	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)

- **Data Analytics**

2102502	Random Signals and Systems	3(3-0-9)
2102505	Introduction to Optimization Techniques	3(3-0-9)
2102531	System Identification	3(3-0-9)
2102571	Multimedia Communication	3(3-0-9)
2102575	Statistical Inference and Modeling	3(3-0-9)
2102576	Signal Transforms and Applications	3(3-0-9)
2102611	Medical Instrumentation	3(3-0-9)
2102642	Computer Vision and Video Electronics	3(3-0-9)
2102676	Digital Image Processing	3(3-0-9)
2102732	Convex Optimization and Engineering Applications	3(3-0-9)
2102875	Digital Video Processing	3(3-0-9)
2102876	Adaptive Signal Processing	3(3-0-9)
2110743	Machine Learning	3(3-0-9)

- **Intelligent Systems**

2102504	Introduction to Mathematical Analysis	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)
2102536	Nonlinear Control Systems I	3(3-0-9)
2102537	Glocal Control Systems	3(3-0-9)
2102541	IoT Fundamentals	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)
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)
2102642	Computer Vision and Video Electronics	3(3-0-9)
2102731	Infinite-Dimensional Control Systems	3(3-0-9)
2103530	Industrial Robots I	3(3-0-9)
2103535	Mechatronics	3(3-0-9)
2103630	Industrial Robots II	3(3-0-9)
2110634	Software Design and Development	3(3-0-9)
2110654	Artificial Intelligence	3(3-0-9)
2110743	Machine Learning	3(3-0-9)
2110746	Big Data Analytics	3(3-0-9)
2110773	Data Mining	3(3-0-9)

- **Materials and Devices**

2102506	Finite Element Analysis for Electrical Engineers	3(3-0-9)
2102582	Photonic Devices in Optical Communication Systems	3(3-0-9)
2102585	Biomaterial Science	3(3-0-9)
2102588	Biomedical Electronics	3(3-0-9)
2102589	Laser Engineering	3(3-0-9)

2102620	Electromagnetic Theory	3(3-0-9)
2102624	Microwave Photonic and Radio over Fiber Technology	3(3-0-9)
2102663	Solar Cell Technology	3(3-0-9)
2102668	Biosensors	3(3-0-9)
2102674	Optical Communication	3(3-0-9)
2102682	Solid-State Physics for Electronics Engineers	3(3-0-9)

- **Telecommunications and Networking**

2102520	Optical Fiber Transmissions and Networks	3(3-0-9)
2102522	Internet Technology and Applications	3(3-0-9)
2102526	Mobile Communications and Networking	3(3-0-9)
2102527	Traffic Engineering Analysis and Simulation	3(3-0-9)
2102541	IoT Fundamentals	3(3-0-9)
2102571	Multimedia Communication	3(3-0-9)
2102577	Telecommunication Network	3(3-0-9)
2102578	Satellite Communications	3(3-0-9)
2102620	Electromagnetic Theory	3(3-0-9)
2102624	Microwave Photonic and Radio over Fiber Technology	3(3-0-9)
2102626	Antennas and Radio Wave Propagation	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)
2102674	Optical Communication	3(3-0-9)
2102771	Advanced Wireless Communications	3(3-0-9)
2102774	Telecommunications Switching, Transmission and Signaling	3(3-0-9)
2110640	Information Security	3(3-0-9)

3) Elective Courses **12 or 15 credits**

(12 credits are required for Ph.D. students in Plan 2.1.
15 credits are required for Ph.D. students in Plan 2.2.)

Select from any in item 2) and the following course

2102591	Future technology trends in EE industry 1	3(3-0-9)
2102592	Future technology trends in EE industry 2	3(3-0-9)
2102598	Special Problems in Electrical Engineering I	3(3-0-9)
2102697	Special Problems in Electrical Engineering II	3(3-0-9)

4) Dissertation

2102828	Dissertation	48	credits
2102829	Dissertation	60	credits
2102830	Dissertation	72	credits

2102828 is for Ph.D. students in Plan 2.1 and Plan 2.2.
2102829 is for Ph.D. students in Plan 1.1.
2102830 is for Ph.D. students in Plan 1.2.

Plans 1.1, 1.2, 2.1 and 2.2 are referenced from departmental Ph.D. admission announcement of Chulalongkorn University.

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(3-1-5)

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.

2102308 Properties of Electrical Engineering Materials 3(3-0-6)

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 Instrumentation 3(3-0-6)

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 Laboratory 4(3-3-6)

Condition: Prerequisite 2102201 for EE students, Corequisite 2102214, 2310312

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 Laboratory 3(3-1-5)
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.

2102401 Random Processes for Electrical Engineering 3(3-0-6)
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 Engineering 3(3-0-6)
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 Communication Networks 3(3-0-6)

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 Technology 3(3-0-6)

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 or 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 Laboratory 1(0-3-0)

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 Electronics 3(3-0-9)

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 Electronics 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 Laboratory I 1(0-3-0)

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)

Review of probability theory; random variables; discrete and continuous-time stationary random processes; Gaussian processes; rational spectral factorization; Bayesian estimator; discrete-time Kalman filtering; expansion of random processes.

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 2102205 or Consent of Faculty

Review of linear algebra; solution of nonlinear equations; optimality conditions for unconstrained optimization; numerical methods for unconstrained optimization; optimality conditions for constrained optimization; solution of linear programs by the simplex method; solution of convex quadratic programs by the active set method.

2102506 Finite Element Analysis for Electrical Engineers 3(3-0-9)

Condition : 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 arithmetic; 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-to-point link; dispersion compensation methods and their optimum design rules; wavelength division multiplexed (WDM) transmission systems; Dense WDM (DWDM); long-haul DWDM

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; 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 and future trends in fiber-optic transmissions and networks.

2102522* **Internet Technology and Applications** **3(3-0-9)**

Condition : Consent of Faculty

Overview of TCP/IP protocols; wireless Local Area Networks technologies; routing protocols; switching architecture; performance analysis and simulation; client and server paradigm; basic Internet services: email, ftp and world wide web; modern Internet services: social networking, banking and shopping; IoT communication protocols; IoT and connected home, industrial sector, consumer wearables; mobile and web development; cyber security fundamentals.

2102526* **Mobile Communications and Networking** **3(3-0-9)**

Condition : Consent of Faculty

Overview of future wireless systems for voice, data, video and Internet services; Radio wave propagation and modeling; cellular concept and network planning; voice codec: Linear Predictive Coding and waveform coding; techniques for combating fading: adaptive equalizer, channel coding and diversity; FDMA, TDMA, CDMA, OFDM, multiuser and multicarrier systems; multiple input/output systems (MIMO), wireless local area networks: IEEE802 standards, cellular mobile phone systems standards: 4G and 5G, smart homes and appliances, wireless sensor networks, automated motorways, Ad- Hoc networks design and applications.

2102527* **Traffic Engineering Analysis and Simulation** **3(3-0-9)**

Condition : 2102203 or Consent of Faculty

Fundamentals of traffic engineering; revision of probability theory; traffic modelling; computer simulation; fundamentals of stochastic process; Markov chain; theory of lossless system; theory of queuing system; traffic engineering application.

2102531 **System Identification** **3(3-0-9)**

Condition : Prerequisite 2102332 or Consent of Faculty

Essential elements in System Identification; Nonparametric Identification; Input selection Model parametrization (linear time-invariant discrete-time models); Least-squares Estimation and its variants; Minimum mean-squared estimation (MSE); Maximum-likelihood estimation (MLE); Maximum a posteriori estimation (MAP); Subspace Identification; Model selection and model validation; Recursive identification; Real-world Applications.

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.

2102537* **Glocal Control Systems** **3(3-0-9)**

Hierarchical networked dynamical systems, LTI system with generalized frequency variable, homogeneous networked system, heterogeneous networked system, stability analysis: Nyquist stability, Hurwitz stability, Lyapunov stabilty, robust stability, hierarchically decentralized control design, LQR optimal control design, robust control design, applications to energy management systems, smart transportation, and electric vehicles.

2102541* **IoT Fundamentals** **3(3-0-9)**

Condition : Consent of Faculty

Sensor network technology: communication architecture for low-powered sensors, energy-efficient communication protocols e.g. ZigBee, 6LowPan, LORA, NB-IoT; IoT cloud technology: resource sharing in cloud architecture, introduction to IoT and cloud platforms (e.g. NETPIE, IEEE1888, ECHONET Lite); IoT data analysis : feature extraction, prediction, and representation; IoT security: threats and security requirement for IoT, authentication, authorization, access control, confidentiality and key management.

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

Condition : Prerequisite 2102356 or Consent of Faculty

Electric motor drive principles; modeling and dynamic equations of dc motors; control principles of dc motor drives; modeling and dynamic equations of induction and synchronous motors; control principles of synchronous and induction motors; power electronic converters for dc and ac motors; modulation techniques and current control for power converters.

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 codesign 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)
Condition : Consent of Faculty

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 Processing I 3(3-0-9)
Condition : Prerequisite 2102386 or 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.

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

Introduction to Distributed Generation (DG); Technologies of DG such as wind, photovoltaics, combined heat and power, biomass/biogas/waste, small-scale hydro; DG interfaces; Distribution systems; Studies of DG impact on power systems, e.g. voltages and power losses, fault current and protection system, electrical islanding, DG impact on system reliability, etc.

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

EMI/EMC understanding; source of EMI; definition and effect of EMI; EMI 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 filters and the selectio and usage.

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

Definitions and Classification of Power Quality (PQ) Disturbances, Power System Harmonic Analysis, Voltage Sag Analysis, Voltage Fluctuation, Interharmonic and Flicker Analysis, PQ Standards, PQ Mitigation Techniques, PQ Case Studies, PQ issues in a Smart Grid.

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

Economic Dispatch Problem; Economic dispatch considering transmission system losses; Unit commitment Problem; Microeconomic theory; Power pool structure; Bilateral contract structure; Power system analysis considering market structures.

2102558 Insulation Coordination 3(3-0-9)
Condition : 2102 458 HV I

Switching overvoltage between phase to ground, between phase to 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.

2102560* High Voltage Equipment Maintenance and Testing 3(3-0-9)

High-voltage equipment in transmission and distribution systems; Condition-based and preventive maintenance; high-voltage equipment testing for condition assessment.

2102561* Power and Energy Technologies in Smart Grids 3(3-0-9)
Condition : Consent of Faculty

Electrical power system structure; fundamental principles of power system operation and control; load

frequency control; voltage regulation; basic power system analysis; load flow calculation; power system stability and reliability evaluation; introduction to smart grids; microgrids; distributed generation.

2102562* **ICT Infrastructure for EMS-WAMS Applications** **3(3-0-9)**
Condition : Consent of Faculty

ICT infrastructure in smart grids; automatic meter reading (AMR) and advanced metering infrastructure (AMI); phasor measurement unit (PMU); supervisory control and data acquisition (SCADA) system; remote terminal unit (RTU); energy management system (EMS); renewable energy forecast; demand response; wide area monitoring system (WAMS).

2102563* **Power Electronics for Smart Grids and Renewable Energy** **3(3-0-9)**
Condition : Consent of Faculty

Power electronics circuits and electrical generators for conversion of renewable energy generation; power electronics circuits for battery energy storage system, active and reactive power control of power converters; control of power converters for grid-connected and intentional islanding operations; impacts of renewable energy on electrical grids, grid-connection codes for renewable energy integration.

2102564* **Software Tools for Smart Grid Analysis and Design** **3(3-0-9)**
Condition : Consent of Faculty

Theories and techniques for power system simulation; phasor-domain analysis; time-domain analysis; quasi-static time- series simulation; electromechanical transient simulation; electromagnetic transient simulation;

2102565* **Economics in Energy Supply Industry** **3(3-0-9)**

Classical Economic Dispatch Problem; Renewable Energy Generation Model; Renewable Energy Project Feasibility Study; Feed-in Tariff; Power Development Planning; Microeconomic theory; Structure of Energy Supply Industry.

2102566* **Substation Automation Systems** **3(3-0-9)**

Primary equipment in substations and protective relays; functions and benefits of substation automation, structure and architectures; system standard IEC 61850; data communication in substation automation.

2102567* **Power System Analysis** **3(3-0-9)**
Condition : Consent of Faculty

Basic power system modeling, review of load flow calculation, sensitivity of loss and load flow, principle of power dispatch, review of fault calculation, distribution system reliability, dynamic simulation for power system analysis, basic power system controls.

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.

2102575* **Statistical Inference and Modeling** **3(3-0-9)**
Condition : Consent of Faculty

Introduction to Statistical Learning; Bias-Variance Dilemma; Bayes Decision Theory; Parametric and Nonparametric Classification Techniques; Feature Extraction and Selection; Neural Networks; Support Vector Machines; Logistic and Linear Regressions; Regularization Techniques and Equivalences; Expectation and Maximization Algorithm and Its Applications; Unsupervised Learning; Resampling Methods; Advanced Topics.

2102576* **Signal Transforms and Applications** **3(3-0-9)**
Condition : Consent of Faculty

Continuous-Time and Discrete-Time Fourier Transform; Discrete Fourier Transform; Discrete Cosine Transform; Discrete Wavelet Transform; Radon Transform; Empirical Mode Decomposition and Hilbert Huang Transform; Other Transforms; Applications.

2577 **Telecommunication Networks** **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 communications; satellite orbits; satellites; earth station; very small aperture terminal (VSAT); satellite link design; modulation and multiplexing; multiple access; error control coding; polarization; interference; various types of satellites and their operations, such as geostationary satellite, low-earth-orbit satellite, direct broadcast satellite, broadband satellite, and global positioning system.

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 Communication Systems **3(3-0-9)**
Condition : Prerequisite 2102222, 2102385 or Consent of Faculty

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

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; medical imaging systems: Ultrasound, MRI; electrical hazards and prevention; medical instrumentation.

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 sciences, precision measurement, telecommunication materiel processing, spectroscopy, display hologram. Nonlinear optics.

2102591* Future technology trends in EE industry I **3(3-0-9)**
Condition : Consent of Faculty

Technologies under current interest or future technologies related to applications to electrical engineering industry. Topcis assigned by the instructor with consent of the head of the Department.

2102592* Future technology trends in EE industry II **3(3-0-9)**
Condition : Consent of Faculty

Technologies under current interest or future technologies related to applications to electrical engineering industry. Topics assigned by the instructor with consent of the head of the Department.

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

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

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

Basic concepts of medical instrumentation; origin and characteristic of medical signal, its processing and analysis; medical imaging system; therapeutic devices and concepts of smart healthcare systems and devices.

2102620 Electromagnetic Theory **3(3-0-9)**
Condition : Consent of Faculty

Fundamentals principles of electromagnetic, including, Maxwell's Equations, properties of materials in electromagnetic field, boundary conditions, and electromagnetic potentials; Electromagnetic Theorem, Poynting's theorem, Uniqueness theorem, Reciprocity theorem, Duality principles and Equivalence principles; Applications of electromagnetic theory and theorems to find the analytical solution of electromagnetic boundary-value problems in Cartesian, cylindrical and spherical coordinates for the analysis of waveguide, cavity, antenna and scattering problems; Basic computational techniques for numerical analysis of electromagnetics problems, including the finite difference, finite element, and moment methods.

2102624* Microwave Photonic and Radio over Fiber Technology **3(3-0-9)**
Condition : Consent of Faculty

Introduction to microwave photonic and radio over fiber technology; Performance of radio over fiber optic links; Analysis of microwave photonic links; External Modulators and Modulation techniques for microwave photonic; Photodetectors for microwave photonic applications; Microwave photonic link design; Applications of microwave photonic, including of photonic based microwave signal processing, high precision radar imaging system, and photonic methods for microwave and terahertz wave signal generation.

2102626* **Antennas and Radio Wave Propagation** **3(3-0-9)**

Condition : Consent of Faculty

Fundamental parameters of antennas; antenna radiation; Friis transmission equation; basic antenna types; phased array antennas; multiple-input multiple-output (MIMO) antennas; fundamentals of radio wave propagation; ground wave propagation; Ionospheric propagation; atmospheric propagation; rain attenuation; microwave and millimeter-wave propagation.

2102627 **Reliability and Survivability of Communication Networks and Systems** **3(3-0-9)**

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 Optimization** **3(3-0-9)**

Condition : Consent of Faculty

Introduction to graph theory; concepts of paths, cycles and trees; various types of graphs; transshipment problems; shortest path problems; maximum flow problems; minimum cost flow problems; network optimization; matching; Matriods and greedy algorithms; applications.

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 and stability issues in multivariable systems; uncertainties and robustness; multivariable control system designs: frequency domain methods, LQG and LTR methods, parameter optimization methods, H_2 and $H\infty$ control, model reduction.

2102638* **Nonlinear Control Systems II** **3(3-0-9)**

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 Electronics** **3(3-0-9)**

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.

2102650 **Electrical Transient in Power Systems** **3(3-0-9)**

Condition : PRER 2102458 or Consent of Faculty

Introduction to electrical transient; switching transient: simple and abnormal switch transients; electromagnetic phenomena under transient conditions; lightning 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.

2102651 **Power System Stability** **3(3-0-9)**

Condition : PRER 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 generator models for stability study; power network model and key characteristics; excitation system control; active power and frequency control; transient stability; small-signal stability.

2102653* **Special Topics in Power Electronics** **3(3-0-9)**

Selected topics of advanced technology or applications related to power electronics engineering.

2102656 **Power System Protection** **3(3-0-9)**

Condition : Consent of Faculty

Selected topics in transducers, protective relaying, protection of primary equipment, phase measurement unit, and wide-area protection system.

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 sola; gallium arsenide solar cells; photovoltaic system design; concentrated sunlight system; photovoltaic system applications.

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 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 : PRER 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.

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.

2102682 Solid-State Physics for Electronics Engineers 3(3-0-9)
Condition : Consent of Faculty
Crystal structures and lattices; lattice vibration and thermal properties of crystals; crystalline defects; 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; optical properties of materials; magnetism and magnetic resonances; superconductivity; introduction to 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.

2102691* Industrial Experiences I 3(0-12-0)
Experience at related industrial, research, or government sectors under supervision of a mentor engineer and thesis advisor.

2102692* Industrial Experiences II 3(0-12-0)
Experience at related industrial, research, or government sectors under supervision of a mentor engineer and thesis advisor.

2102694* Internship Aboard I 3(0-12-0)
Experience at a related university or research institute in foreign country under collaborated supervision of thesis advisor and a faculty staff/researcher at the host university or institute.

2102695* Internship Aboard II 3(0-12-0)
Experience at a related university or research institute in foreign country under collaborated supervision of thesis advisor and a faculty staff/researcher at the host university or institute.

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 Systems 3(3-0-9)
Semigroup theory and infinitesimal generator; Hille-Yosida theorem; contractive semigroups; dual semigroups; Riesz-spectral operators; invariant subspaces; problem formulation: abstract Cauchy problem, perturbed systems and composite systems; boundary control; basic system properties: stability, controllability, observability, exponential stabilizability and detectability; compensator design for infinite-dimensional systems.

2102732 Convex Optimization and Engineering Applications 3(3-0-9)
Condition : PRER 2102505 or Consent of Faculty
Convex sets, functions, and optimization problems; basics of convex analysis; least-squares, linear and quadratic programs, semidefinite programming; optimality conditions, duality theory; interior-point methods; applications to engineering topics.

2102754 Electric Field Analysis in High Voltage Engineering 3(3-0-9)
Condition : Consent of Faculty
Basics of electric field analysis; Application to high-voltage insulation and other related apparatus; Introduction to numerical methods in field analysis; Charge simulation method; Finite element method; Boundary Element Method; Field calculation programs; Practical examples; advanced topics.

2102755 Power System Electromagnetic Transient Simulation 3(3-0-9)
Condition : Consent of Faculty

Using an electromagnetic transient program to analyze power system transient phenomena such as lightning surges, switching surges, temporary over voltages with modeling technique of equipment in power systems.

2102771* **Advanced Wireless Communications** **3(3-0-9)**
Condition : Consent of Faculty

Wireless channel characterization, narrowband and wideband; techniques for combating fading: adaptive equalizer, channel coding and diversity; spread spectrum, multiuser systems, mutlicarrier modulation and multiple access: OFDM, FBMC, UFMC, GFDM, NOMA, SCMA, MUSA and PDMA; smart antennas and beamformer; adaptive modulation; multiple input/output systems (MIMO), space-time coding, capacity and outage; spectrum sensing and cognitive radio.

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; 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; telecommunications transmission systems; transmission of the 64-kbps signal; PCM primary rate transmission; higher order PCM transmission; optical fiber transmission system; SDH transmission system; signaling; signalling networks; signalling system No. 7 levels.

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.

2102790 **Electrical Engineering Seminar** **2(2-0-6)**
Condition : Consent of Faculty

Analysis of PWM converters and their derivatives; phase-controlled rectifier an 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 converters and inverters; analysis of resonant inverters using fundamental frequency approximation and their applications.

2102811 **Thesis** **12 credits**

2102813 **Thesis** **18 credits**

2102816 **Thesis** **36 credits**

2102874 **Speech Processing Power** **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

Principles and characteristics of discrete-time signals and linear-time-invariant systems, properties of random process, linear optimum filter, principles of adaptive filtering and its applications, structures of adaptive filter, Least-Mean-Square (LMS) algorithm, Recursive Least Square (RLS) algorithm, block adaptive filtering, frequency-domain adaptive filtering algorithm, multi-rate systems and its applications in adaptive filtering.

2103530 **Industrial Robots I** **3(3-0-9)**

Introduction to industrial robots, review of feedback control, cartesian and joint coordinates control, motion control strategies of industrial robots, position control of a single joint industrial manipulator arm, single joint controller for conveyor application, actuator drives for industrial robots, sensor for industrial robots.

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.

2103630 **Industrial Robots II** **3(3-0-9)**

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.

2110634 Software Design and Development **3(3-0-9)**

Basic concepts of design; design quality; design principles; architectural design; architectural style detailed design; integrated development environment. converters and inverters; analysis of resonant inverters using fundamental frequency approximation and their applications.

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.

2110654 Artificial Intelligence **3(3-0-9)**

Definitions and application of artificial intelligence; Problems, problem space and search; Knowledge representation, predicate logic; Prolog programming; Natural language processing; Machine learning.

2110675 Biomedical Information and Communication Systems **3(3-0-9)**

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.

2110743 Machine Learning **3(3-0-9)**

Introduction to machine learning, concept learning, decision tree learning, linear regression, logistic regression, neural network, evaluating hypotheses, Bayesian learning, computational learning theory, instance-based learning, learning sets of rules, support vector machines.

2110746 Big Data Analytics **3(3-0-9)**

Introduction to Big Data Analytics, Hadoop, Map-reduce, Spark, Programming Languages for Big Data Analytics, Search and Indexing, Recommendation System, Regression, Classification, Clustering and Feature Selection.

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.

3017767 Human Body for Biomedical Engineering **3(3-0-9)**

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.

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.

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)**

IMPORTANT

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Chulalongkorn University

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