COLLEGE OF ENGINEERING

KOLEHIYO ng INHENYERIYA

Location: Melchor Hall, Osmeña Avenue, University of the Philippines, Diliman, Quezon City, 1101 Philippines
Telephone Number: +63-2-981-8500 locals 3101 to 3104 | +63-2-926-0703 | +63-2-928-3144 |+63-2-920-8860 (fax)
Email Address: upengg@coe.upd.edu.ph
Website: www.coe.edu.ph

The College of Engineering (CoE) was established on 13 June 1910, with the aim of providing industry, government, and academe with trained engineers in all branches of the profession. The different engineering curricula have been designed to prepare the graduates for the challenges of their chosen career and to adequately equip them with the proper theoretical background to be put into practical use. The College, thru the National Graduate School of Engineering (NGSE), also provides advanced studies in the master's and doctoral programs and opportunities for research and development work in the various fields of engineering.

PROGRAMS OFFERED

Chemical Engineering

Prepares students in the systematic analysis of engineering problems and provides training in areas such as process engineering and design, equipment design; process optimization and control; pilot plant research and scale-up; health, safety and environment considerations inplant design and operation; and biochemical engineering.

Civil Engineering

Provides graduates a balanced education in the six specialized fields of civil engineering as well as the social sciences and humanities-a recognition that technical solutions in civil engineering problems must consider the socio-economic, legal, political, and environmental aspects.

Computer Engineering

Trains students in computer hardware design, implementation, and application including computer software engineering.

Computer Science

Equips students with methods, tools, and techniques from both theoretical and systems aspect of computing in developing innovative IT solutions to problems in the physical and social sciences, and engineering.

Electrical Engineering

Trains students in the analysis, planning, design, operation, instrumentation, and control of power systems as well as electrical machines and installations.

Electronics and Communications Engineering

Prepares students in the evaluation, planning, design, and operation of electronic devices and communication systems.

Energy Engineering (Master's and Doctoral Programs)

Provides students with advanced graduate training in the field of energy, with particular emphasis on energy research subjects of special interest to the country.

Environmental Engineering (Master's and Doctoral Programs)

Provides advanced and specialized training in environmental engineering, including water quality control, waste water disposal and treatment, pollution control, solid waste management, environmental impact assessment, and related concerns.

Geodetic Engineering

Provides proficiency in the execution of control surveys, mineral surveys, hydrographic surveys, topographic surveys, photogrammetric surveys, gravimetric surveys, and astronomical observations.

Industrial Engineering

Trains students in designing, improving, installing, and sustaining integrated systems of people, materials, equipment, energy and information, and instills the discipline to create systems that are efficient, effective, and robust.

Materials Engineering

Provides specialized training in the characterization, processing, and applications of engineering materials in support of the manpower requirements of the growing engineering materials industry.

Mechanical Engineering

Provides well-rounded education in the fields of thermal engineering, conventional and renewable energy, power generation, refrigeration, air conditioning, ventilation, machine design, control systems and automation, manufacturing, vehicle engineering, and multidisciplinary fields involving Mechanical Engineering.

Metallurgical Engineering

Prepares graduates for employment in mines, mineral processing plants, smelters, steel mills, metal fabrication plants, and other factories where metals and materials are being used or processed.

Mining Engineering

Trains students on the principles of mineral exploration and surface and underground mining operations with emphasis on recovering more minerals from low-grade, marginal deposits through the application of mechanization, technology, scientific management, and mass production techniques.

UNDERGRADUATE PROGRAM

Undergraduate programs give a solid foundation of the basic sciences of mathematics, chemistry, and physics and will enable future engineers to understand the general methods of solving problems in their respective fields.

The undergraduate programs offered by the College are:

1) Bachelor of Science in Chemical Engineering (BSChE)
2) Bachelor of Science in Civil Engineering (BSCE)
3) Bachelor of Science in Computer Engineering (BSCoE)
4) Bachelor of Science in Computer Science (BSCS)
5) Bachelor of Science in Electrical Engineering (BSEE)
6) Bachelor of Science in Electronics and Communications Engineering (BSECE)
7) Bachelor of Science in Geodetic Engineering (BSGE)
8) Bachelor of Science in Industrial Engineering (BSIE)
9) Bachelor of Science in Materials Engineering (BSMatE)
10) Bachelor of Science in Mechanical Engineering (BSME)
11) Bachelor of Science in Metallurgical Engineering (BSMetE)
12) Bachelor of Science in Mining Engineering (BSEM)

All are five-year programs except for the four-year BSCS program.

GRADUATE PROGRAM

Engineering graduate programs offer advanced specialized training in the various fields of engineering and aim primarily to provide opportunities for advancement in the field of engineering. They are designed to prepare engineers for effective participation and leadership in the country's industrialization. Advanced materials are presented in the form of course work and research to develop the student's better understanding of, and greater skill in, solving new and old engineering problems

DIPLOMA PROGRAMS

Specializations in the diploma programs are available in industrial engineering and remote sensing.

MASTER'S PROGRAMS

The MS programs offered by the College are in: Chemical Engineering, Civil Engineering, Computer Science, Electrical Engineering, Energy Engineering, Environmental Engineering, Industrial Engineering, Materials Science and Engineering, Mechanical Engineering, Metallurgical Engineering, Geomatics Engineering, and Water Resources. The College also offers the Master of Engineering in Electrical Engineering (MEEE) and Industrial Engineering (MEngIE).

DOCTORAL PROGRAMS

PhD programs are available in chemical engineering, civil engineering, computer science, electrical and electronics engineering, energy engineering, environmental engineering and materials science and engineering. The Doctor of Engineering degree is also available in the fields of Chemical Engineering and Electrical and Electronics Engineering.

ADMISSION POLICIES/REQUIREMENTS

UNDERGRADUATE

Transfer, Shifting and Admission Policies

1) Transfer, shifting, and admission for a second bachelor's degree will be allowed in both the first and second semesters, subject to availability of slots.
2) Transfer applicants from other institutions must satisfy the University requirements for admission (see section on Academic Information).
3) Applicants for transfer or shifting to any engineering program:
   a) must have earned at least thirty-three (33) academic units in their respective schools/units;
   b) must not have completed their third year in their current program; and
   c) must have no grade lower than 3.00 in mathematics, physics, and chemistry courses.

   Final admission is subject to availability of slots.
4) Students of the College wishing to shift within the College and applicants with a first degree from UP may file their applications directly with the appropriate Department Chairman through the College Secretary. Priority will be given to those coming from the

College. Processing of these applications will be done one week before the start of the registration period.

A student who is thus admitted into the College must pass all his deficiencies in the mathematics, physics, and chemistry courses within three academic years of actual residence in the University. Otherwise, he will be dropped from the rolls of the College without appeal for reconsideration.

Scholastic Delinquency (College Academic Rules)

A student who, at the beginning of the first semester of the school year, has thirty-six (36) academic units or more to pass before graduation and who enrolls in two semesters or two semesters and summer in one school year must pass at least twenty-four (24) units in that school year; otherwise, he/she shall be dismissed from the College.

A student who, at the beginning of the first semester of the school year, has 36 academic units or more to pass before graduation and completes only one semester or one semester and one summer in one school year must pass at least 50% of all the units he/she has enrolled in for that school year; otherwise, he shall be dismissed from the College.

A student who, at the beginning of the first semester of the school year, has thirty-five (35) academic units or fewer to pass before graduation will be subject only to the University rules and regulations on dismissal.

Grades of Inc. must be completed and grades of 4.00 removed before the registration for the semester following one academic year in order to be credited.

For purposes of definition, an academic/school year will consist of two semesters and one summer session.

In addition to the above rules, a student must also satisfy University requirements on waiver, dropping, leave of absence, academic load, graduation with honors, substitution of courses, cross-registration, etc. as specified in the pertinent portions of this catalogue.

GRADUATE PROGRAM

Any holder of a bachelor's degree in engineering or allied fields from a duly accredited institution may, upon application, be admitted to any graduate program.

Unless otherwise specified, the rules and regulations of the University governing graduate programs apply to the master's and doctoral programs.

DIPLOMA PROGRAMS

The minimum unit requirements for the diploma programs follow:

Dip IE	18 units
DIP RS	21 units

MASTER'S PROGRAMS

Students whose academic records and/or experience indicates adequate preparation for graduate work in the field of their choice may, upon application, be admitted as degree students. Others may be admitted as non-degree students, in which case, they shall not be allowed to enroll for more than one semester except by special permission of the Dean. Non-degree students who are able to demonstrate creditable performance in graduate courses may apply for transfer to degree status subject to the approval of the head of the department/institute concerned.

Minimum Requirements

Upon completion of 12 units of graduate courses, all students shall be guided by a program of study before they can enroll. No subject in the program of study for which a student has already received a grade shall be replaced by another subject without the approval of the Dean.

A student shall be disqualified from any graduate program if he fails to meet the minimum weighted grade average corresponding to the number of units indicated below:

No. of Units	Minimum Grade Average
12	2.35
13 to 18	2.15
19 and above	2.05

A weighted average of 2.00 or better for all graduate courses passed and accepted for credit towards the degree shall be required for graduation. In case a student fails to meet the required weighted average of 2.00, he may be allowed to take additional courses to improve his average, subject to the approval of his adviser. No course previously passed shall be repeated for this purpose.

Any student who obtains a grade lower than 3.00 in six (6) or more units of graduate courses shall be dismissed from the program.

DOCTORAL PROGRAMS

The basic admission requirements for the doctoral program are a bachelor's degree in engineering or allied fields and a very high degree of intellectual capacity and aptitude for advanced study and research.

Minimum Requirements

To qualify for the PhD degree, a student must:

1) complete a minimum of 24 units of graduate courses if he/she has a master's degree, or a minimum of forty-five (45) units if he/she has a bachelor's degree.
2) maintain a cumulative weighted average of 1.75 or better in all the courses in his/her program of study;
3) pass the PhD qualifying examination after passing the core, specialty, applied mathematics, and elective courses; and

4) submit a doctoral dissertation based on an independent and original research in the chosen field and successfully defend it in a Final Doctoral Examination.

PRIVATE SCHOLARSHIP

The College of Engineering continuously receives private scholarships for students in need of financial assistance. The following are some of the available scholarships for Engineering students:

1) Concepcion Hidalgo Sandoval Memorial Scholarship
2) Flour-Metrobank Foundation College Scholarship Program
3) GMA Network Inc.
4) Kayan Chan Scholarship
5) PASAR Foundation, Inc. (PFI)
6) Pay Engg Forward Scholarship Program (Michael Gonzales Donation)
7) PETRON Scholarship Grant
8) PHILEX MINING Scholarship
9) Philippine Australia Resources Education Excellence Program (PAREEP)
10) PNOC EC
11) Robert G. Cheng-Uratex Undergraduate Scholarship
12) Tau Alpha Foundation, Inc. (TAFI)

FACILITIES

The Institute of Civil Engineering maintains the Construction Materials and Structures Laboratory (CoMSLab). CoMSLab supports the instruction, research, and extension activities of the Institute. It is the instruction laboratory for the undergraduate class in construction materials as well as for the graduate course in soil and rock testing. It also hosts the experiments of students doing their undergraduate research under the construction materials and geotechnical engineering tracks.

The Institute also maintains the Civil Engineering Computational Laboratory. Inaugurated in November 2005, this instructional laboratoy has thirty-five (35) units of desktop personal computers that are used by civil engineering students and faculty in courses requiring computations. The laboratory is located at Room 235 of Melchor Hall.

The Institute is one of the beneficiaries of the on-going ten-year multi-billion-peso program of the national government called the Engineering Research and Development for Technology (ERDT) through the construction of new classrooms, offices (Institute ffice and Classroom Wing) and laboratory facilities (Structural Engineering Laboratory and Construction Engineering and Management Laboratory, Fire Laboratory, Water Resources Engineering Laboratory and Geotechnical Engineering Laboratory, Environment and Energy Engineering Laboratory, and Transportation Engineering Laboratory) in the Engineering Complex.

Three research and extension-service Centers were also established over the years that continue to involve civil engineering faculty members and students. These are the U.P Building Research Service (UP-BRS) established in 1971; the National Hydraulic Research Center (NHRC), established in 1973; and the UP National Center for Transportation Studies (UPNCTS), established as Transport Training Center in 1976. Extension services of these Centers have been closely linked to the instruction and research activities in the various fields of civil engineering. The classroom, library, office space, computing and laboratory facilities of these Centers have been supporting academic, research and extension activities of the Institute.

The Department of Chemical Engineering has computing facilities and instructional and research laboratories. Students can do experiments in unit operations, unit processes, thermodynamics, and process control. The department also has research laboratories in biochemical engineering; fuels, energy and thermal systems; polymers and catalysis; electrochemical engineering; and environmental process engineering. Some of the major equipment of the Department are: GC-MS, GC FID, GC TCD, Ion Chromatograph, HPLC, RT-PCR, Denaturing Gradient Gel Electrophoresis Analyzer, Scanning Electron Microscope, FITR, Atomic Absorption Spectroscopy, Karl Fischer Titrator, Kjeldahl Nitrogen Analyzer, ovens, dryers, mixers, mills, screens and incubators.

The Department of Computer Science houses two large lecture halls; five computer classrooms, one equipped with Apple iMac computers; and seven research laboratories equipped with Apple iMac and Mac Pro machines, Acer, HP and IBM computers, smart phones, and tablets with both android and iOS platforms, thin clients, printers, and servers. All of these are in rooms that are fully air-conditioned with tempered glass boards and projectors.

The Electrical and Electronics Engineering Institute (EEEI) maintains the following instructional laboratories where students are trained on basic usage and handling of computers, equipment, electronic components, devices, and software:

1) Alexan Electronics Laboratory (A-Lab)
2) Basic Electronics Laboratory (B-Lab)
3) Communications Electronics and Embedded Systems Laboratory (CEESL)
4) Electrical Machines Laboratory (EML)
5) Electronics Laboratory (E-Lab)
6) Electronics Prototyping Laboratory (EPL)
7) Network Simulation and Training Laboratory (NSTL)
8) Software Applications Training Center (STC)

In addition, the EEE Institute also maintains the following research laboratories that support research and development in various areas of Electrical and Electronics Engineering:

1) Astec Power Electronics Laboratory (PEL)
2) Computer Networks Laboratory (CNL)
3) Digital Signal Processing Laboratory (DSP)
4) Electric Power Research Laboratory (EPRL)
5) Intel Microprocessors Laboratory (IML)
6) Instrumentation, Robotics, and Control Laboratory (IRC)
7) Microelectronics and Microprocessors Laboratory (MicroLab)
8) Mobile Robotics Laboratory (Mobot)
9) Power System Simulation Laboratory (PSSL)
10) Robotics and Automation Laboratory (RAL)
11) Solar Photovoltaics Laboratory (SPL)
12) Wireless Communications Engineering Laboratory (WCEL)

The Department of Geodetic Engineering and the Training Center for Applied Geodesy and Photogrammetry (TCAGP) share the following equipment: Theodolites: WILD (T-1, T-2); stereoplotters: Wild

Autograph A-8, Aviograph B-8, Kern PG 2 and 3, Kelsh plotter; SEG-V rectifier-enlarger; mirror stereoscopes; WILD electronic distance meter; Coradi Coordinatograph, Garrett process camera; photographic processing laboratory, ZEISS Ortophoto projector and contact printer KG 30; WILD PUG 4 point transfer device and film viewer; Logetronic RAP 20 film processor; spectroradiometer; SummaGraphics digitizer; Mitsubishi thermal printer; Hewlett-Packard color printer; Sun workstation; personal computers; image processing software: ERMapper, Disimp, Microbrian, BSIPP; geographic information systems software: ArcInfo , SPANS, OSUMAP, and APPL7.

An Ergonomics and Methods Engineering Laboratory, equipped with audio-visual and ergonomic instruments for instruction purposes, is maintained by the Department of Industrial Engineering and Operations Research. The Department also has a computing facility equipped with personal computers with selected statistical, modeling, and simulation software packages for use of IE students.

The Department of Mechanical Engineering has several instructional, research and develpment laboratories, shops, and fabrication facility that provide its students computational capability, hands-on training and exercises in using machine tools and equipment in mechanical engineering systems. These facilities enable students to do computational validation of designs, fabrication and building of components and systems, and research and development activities. The laboratory competencies that students learn are indispensable to their future in industry, academic and research institutions, and government.

The following are the facilities of the Department of Mechanical Engineering:

1) Instrumentation Laboratory
2) Computational Mechanics Laboratory
3) EMERSON Heating, Ventilation, Air Conditioniong and Refrigeration Laboratory
4) Power Laboratory
5) Biomechanics Laboratory
6) Machine Design Laboratory
7) Computer Integrated Manufacturing Laboratory
8) Manufacturing and Design Center
9) Vehicle Research and Testing Laboratory
10) ME Shop and Fabrication Facility

The Department of Mining, Metallurgical and Materials Engineering has batch testing and pilot scale testing facilities for mineral processing and foundry testing. It also maintains metallographic, morphological, scanning and transmission electron microscopes. The Department also has a powder X-ray diffractometer, X-ray fluorescence spectrometer, atomic absorption spectrometer and EDS/WDS-based microanalytical equipment.

The Department also has the following instructional and research laboratories: Shop Laboratory, Nanomaterials Laboratory, Joeres Laboratory, Shono Semiconductor Laboratory, Electron Microscopy Laboratory, Extractive Metallurgy Laboratory, Metallography Laboratory, Composite Materials Laboratory, Advance Alloys Laboratory, Surface Science Laboratory, Advance Ceramic Laboratory, Electrometallurgy Laboratory, Substrate Processing Laboratory, Computational Materials Laboratory, and EM Computing Laboratory.

The University of the Philippines College of Engineering Library, more commonly known as Engg lib among the UP locals, has been the forefront of library excellence within the UP System. The Library is housed in two locations: EnggLib1 is currently in Melchor Hall, servicing the ChE, GE, IEOR, and ME Departments, and ICE, while EnggLib 2 is at the UP Alumni Engineers Centennial Hall servicing the CS, EEE, and MMM students and faculty. The interior design of the new library merges the conventional or traditional library look woody and cozy, with the modern arrangement-minimalist, multifunctional and ergonomic.

Its vast collection includes print and electronic books, journals, magazines, theses, plant designs and feasibility studies on various fields of engineering and computer science but skews more online resources because of their convenience, practicability and economical quality. As of the AY 2012-2013, the library is host to three dozens of world-renowned scholarly journals and e-book database accessible via powerful workstations and eReaders. To better service these online resources, EnggLib offers the UP College of Engineering community various facilities and technologies to utilize. One is The Learning Commons, a technologically-based social learning space in the library which offers a one-stop shop for computing, reference services, and multimedia needs. The facility caters to academic group discussions, collaborative, and shared learning. These and more top-of-the-class resources, services, and facilities can be seen at the UP College of Engineering Library as it strives to achieve its mission of inculcating in the Engineering community how to “Innovate. Recreate. Collaborate.”

BACHELOR OF SCIENCE IN CHEMICAL ENGINEERING
184 units

APPROVAL
135th UPD UC: 24 June 2016 | President AEPascual : 26 January 2016

FIRST YEAR

1st Semester (19 units)		2nd Semester (19 units)	
GE (AH 1) Eng 10	3	GE (AH 2) Comm 3	3
GE (SSP 1) Philo 1	3	Chem 17	5
GE (MST 1)	3	Physics 71	4
Chem 16	5	Physics 71.1	1
Math 17	5	ChE 100	1
PE	(2)	Math 53	5
		PE	(2)

SECOND YEAR

1st Semester (18 units)		2nd Semester (17 units)	
Math 54	5	Math 55	3
Chem 28	3	Chem 31	3
Chem 28.1	2	Chem 31.1	2
Physics 72	4	Physics 73	4
Physics 72.1	1	Physics 73.1	1
ChE 26	3	ChE 101	4
PE	(2)	PE	(2)
NSTP	(3)	NSTP	(3)

THIRD YEAR

1st Semester (17 units)		2nd Semester (19 units)	
ChE 122	3	GE (SSP 2) Kas 1	3
ES 1	2	ChE 123	3
ES 11	3	ChE 125	3
ChE 106	3	ChE 131	3
MatE 10	3	EEE 1	4
IE 3	3	ES 12	3

FOURTH YEAR

1st Semester (18 units)		2nd Semester (19 units)	
GE (AH 3) Fil 40	3	GE (AH 4) Free Choice	3
ChE 132	3	GE (MST 2) Free Choice	3
ChE 133	3	ChE 135	2
ChE 134	3	ChE 140	3
ES 13	3	ChE 150	3
Chem 154	3	ChE 124	2
		ChE 126	3

FIFTH YEAR

1st Semester (18 units)		2nd Semester (20 units)	
GE (SSP 3) Free Choice	3	GE (MST 3) STS	3
ChE 143	2	GE (AH 5) Free Choice	3
ChE 190	1	GE (SSP 4) Free Choice	3
ChE 182	3	GE (SSP 5) Free Choice	3
ChE 141	3	ChE 142	3
PI 100	3	ChE 144	2
Qualified Elective	3	Qualified Elective	3

Qualified Electives: ChE 153, ChE 171, ChE 174, ChE 197, ChE 198, EgyE 101
1. Six (6) units of RGEP courses must be in the Philippine Studies domain
2. Minimum of nine (9) units of English/Communication courses must be taken
*3. **Except for Math 1, RGEP courses in the MST domain must NOT be under Physics, Chemistry or Mathematics***
As a requirement for graduation, all students are required to take one (1) year program in one of the following components: (a) Military Training Service (ROTC); (b) Civic Welfare Training Service (CWTS); (c) Literacy Training Service.

BACHELOR OF SCIENCE IN CIVIL ENGINEERING
182 units

APPROVAL
135th UPD UC: 24 June 2016 | President AEPascual : 26 January 2016

FIRST YEAR

1st Semester (20 units)		2nd Semester (19 units)	
GE (MST 1) Free Choice	3	GE (AH 3) Fil 40	3
GE (AH 1) Free Choice	3	GE (SSP 3) Philo 1	3
GE (SSP 1) Kas 1	3	GE (MST 2) Free Choice	3
GE (SSP 2) Free Choice	3	Math 53	5
GE (AH 2) Eng 10	3	Chem 16	5
Math 17	5	PE	(2)
PE	(2)	NSTP	(3)
NSTP	(3)		

SECOND YEAR

1st Semester (18 units)		2nd Semester (17 units)	
GE (AH 4) Comm 3	3	Math 55	3
Geol 11	3	Physics 72	4
Math 54	5	Physics 72.1	1
Physics 71	4	GE 10	3
Physics 71.1	1	ES 11	3
ES 1	2	CE 26	3
PE	(2)	PE	(2)

THIRD YEAR

1st Semester (17 units)		2nd Semester (19 units)	
Physics 73	4	EEE 3	3
Physics 73.1	1	GE 12	4
ES 12	3	CE 14	3
ES 13	3	CE 15	3
CE 21	3	CE 28	3
CE 27	3	CE 131	3

FOURTH YEAR

1st Semester (17 units)		2nd Semester (18 units)	
CE 16	2	CE 111	3
CE 22	3	CE 123	3
CE 110	3	CE 132	3
CE 121	3	CE 141	3
CE 155	3	CE 156	3
CE 162	3	CE 163	3

FIFTH YEAR

1st Semester (19 units)		2nd Semester (18 units)	
GE (SSP 4) Free Choice	3	GE (AH 5) Free Choice	3
CE 112	3	GE (SSP 5) Free Choice	3
CE 124	3	GE (MST 3) STS	3
CE 142	3	PI 100	3
CE 157	3	CE 199	3
CE 190	1	Elective 2	3
Elective 1	3		

1. Kas 1 & Fil 40 satisfy the 6-unit Philippine Studies requirement
2. Minimum of nine (9) units of English/Communication courses must be taken
*3. **Except for Math 1, RGEP courses in the MST domain must NOT be under Physics, Chemistry or Mathematics***
As a requirement for graduation, all students are required to take one (1) year program in one of the following components: (a) Military Training Service (ROTC); Civic Welfare Training Service (CWTS); (c) Literacy Training Service.

BACHELOR OF SCIENCE IN COMPUTER SCIENCE
146 units

APPROVAL
135th UPD UC: 24 June 2016 | President AEPascual : 26 January 2016

FIRST YEAR

1st Semester (17 units)		2nd Semester (17 units)	
GE (AH 1) Comm in English	3	GE (SSP 2) Free Choice	3
GE (SSP 1) Philo 1	3	GE (AH 2) Free Choice	3
GE (MST 1) Free Choice	3	CS 30	3
Math 17	5	Math 53	5
CS 11	3	CS 12	3
PE	(2)	PE	(2)

SECOND YEAR

1st Semester (18 units)		2nd Semester (19 units)	
GE (AH 3) Eng 10	3	GE (AH 4) Fil 40	3
Math 54	5	CS 135	3
CS 32	3	Math 55	3
CS 133	3	Physics 71	4
CS 21	4	CS 140	3
PE	(2)	CS 150	3
NSTP	(3)	PE	(2)
		NSTP	(3)

THIRD YEAR

1st Semester (18 units)		2nd Semester (19 units)	
GE (AH 5) Comm 3	3	GE (SSP 3) Kas 1	3
CS 130	3	CS 131	3
Stat 130	3	CS Elective	3
CS 145	3	CS 180	3
CS 165	3	CS 192	3
CS 191	3	CS 153	3
		CS 194	1

SUMMER

3 units

CS 195 (Practicum)	3

FOURTH YEAR

1st Semester (19 units)		2nd Semester (16 units)	
GE (SSP 4) Free Choice	3	GE (SSP 5) Free Choice	3
GE (MST 2) STS	3	CS 196	1
GE (MST 3) Free Choice	3	CS 199	3
CS 198	3	CS 200	
Physics 72	4	GE (MST 4) Free Choice	3
Math, Science or Engg Elective	3	PI 100	3
		Free Elective	3

1. Six (6) units of RGEP courses must be in the Philippine Studies domain
2. Minimum of nine (9) units of English/Communication courses must be taken
3. As a requirement for graduation, all students are required to take one (1) year program in one of the following components: (a) Military Training Service (ROTC); (b) Civic Welfare Training Service (CWTS); (c) Literacy Training Service.

BACHELOR OF SCIENCE IN COMPUTER ENGINEERING
181 units

APPROVAL
135th UPD UC: 24 June 2016 | President AEPascual : 26 January 2016

FIRST YEAR

1st Semester (19 units)		2nd Semester (18 units)	
GE (AH 1) ENG 10	3	GE (AH 2) Comm 3	3
GE (SSP 1) Philo 1	3	EEE 11	3
GE (SSP 2) Kas 1	3	EEE 31	3
Chem 16	5	Physics 71	4
Math 17	5	Math 53	5
PE	(2)	PE	(2)

SECOND YEAR

1st Semester (20 units)		2nd Semester (19 units)	
EEE 21	3	EEE 23	4
EEE 13	3	EEE 35	4
EEE 33	4	ES 11	3
EEE 34	1	Math 55	3
Physics 72	4	Math 114	3
Math 54	5	ES 1	2
PE	(2)	PE	(2)
NSTP	(3)	NSTP	(3)

THIRD YEAR

1st Semester (19 units)		2nd Semester (18 units)	
GE (MST 1) STS	3	GE (AH 3) Fil 40	3
EEE 25	3	EEE 105	4
EEE 41	3	EEE 51	3
EEE 42	1	EEE 52	1
EEE 43	3	EEE 100	1
CoE 23	3	EEE 101	3
ES 12	3	EEE 53	3

FOURTH YEAR

1st Semester (18 units)		2nd Semester (16 units)	
GE (MST 2) Free Choice	3	GE (SSP 3) Free Choice	3
CoE 111	3	CoE 113	4
CoE 135	3	CoE 115	3
CoE 133	2	CoE 134	2
EEE 107	3	CoE 151	4
EEE 54	1		
Elective	3		

FIFTH YEAR

1st Semester (17 units)		2nd Semester (17 units)	
GE (SSP 4) Free Choice	3	GE (SSP 5) Free Choice	3
GE (AH 4) Free Choice	3	GE (AH 5) Free Choice	3
PI 100	3	GE (MST 3) Free Choice	3
CE 22	3	CoE 198	5
EEE 190	2	Elective	3
Elective	3		

1. Kas 1 & Fil 40 satisfy the 6-unit Philippine Studies requirement
2. Minimum of nine (9) units of English/Communication courses must be taken
*3. **Except for Math 1, RGEP courses in the MST domain must NOT be under Physics, Chemistry or Mathematics***
4. As a requirement for graduation, all students are required to take one (1) year program in one of the following components: (a) Military Training Service (ROTC); Civic Welfare Training Service (CWTS); (c) Literacy Training Service.

BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING
184 units

APPROVAL
135th UPD UC: 24 June 2016 | President AEPascual : 26 January 2016

FIRST YEAR

1st Semester (19 units)		2nd Semester (18 units)	
GE (AH 1) Eng 10	3	GE (AH 2) Comm 3	3
GE (SSP 1) Philo 1	3	EEE 11	3
GE (SSP 2) Kas 1	3	EEE 31	3
Chem 16	5	Physics 71	4
Math 17	5	Math 53	5
PE	(2)	PE	(2)

SECOND YEAR

1st Semester (20 units)		2nd Semester (19 units)	
EEE 21	3	EEE 23	4
EEE 13	3	EEE 35	4
EEE 33	4	ES 11	3
EEE 34	1	Math 55	3
Physics 72	4	Math 114	3
Math 54	5	ES 1	2
PE	(2)	PE	(2)
NSTP	(3)	NSTP	(3)

THIRD YEAR

1st Semester (19 units)		2nd Semester (18 units)	
GE (MST 1) STS	3	GE (AH 3) Fil 40	3
GE (SSP 3) Free Choice	3	EE 143	3
EEE 25	3	EEE 44	1
EEE 41	3	EEE 53	3
EEE 42	1	EEE 54	1
EEE 43	3	EEE 100	1
ES 12	3	EEE 101	3
		EEE 103	3

FOURTH YEAR

1st Semester (19 units)		2nd Semester (17 units)	
GE (AH 4) Free Choice	3	EE 121	3
EE 145	3	EE 153	3
EE 146	1	EEE 51	3
EE 152	3	EEE 52	1
EE 158	3	EEE 105	4
EEE 107	3	ME 63	3
Elective	3		

FIFTH YEAR

1st Semester (18 units)		2nd Semester (17 units)	
GE (SSP 4) Free Choice	3	GE (AH 5) Free Choice	3
GE (MST 2) Free Choice	3	GE (SSP 5) Free Choice	3
CE 22	3	GE (MST 3) Free Choice	3
Physics 73	4	EE 198	5
EEE 190	2	PI 100	3
Elective	3		

1. Kas 1 & Fil 40 satisfy the 6-unit Philippine Studies requirement
2. Minimum of nine (9) units of English/Communication courses must be taken
*3. **Except for Math 1, RGEP courses in the MST domain must NOT be under Physics, Chemistry or Mathematics***
4. As a requirement for graduation, all students are required to take one (1) year program in one of the following components: (a) Military Training Service (ROTC); Civic Welfare Training Service (CWTS); (c) Literacy Training Service.

BACHELOR OF SCIENCE IN ELECTRONICS AND COMMUNICATIONS ENGINEERING
183 units

APPROVAL
135th UPD UC: 24 June 2016 | President AEPascual : 26 January 2016

FIRST YEAR

1st Semester (19 units)		2nd Semester (18 units)	
GE (AH 1) Eng 10	3	GE (AH 2) Comm 3	3
GE (SSP 1) Philo 1	3	EEE 11	3
GE (SSP 2) Kas 1	3	EEE 31	3
Chem 16	5	Physics 71	4
Math 17	5	Math 53	5
PE	(2)	PE	(2)

SECOND YEAR

1st Semester (20 units)		2nd Semester (18 units)	
GE (MST 1) STS	3	EEE 23	4
EEE 13	3	EEE 35	4
EEE 33	4	ES 11	3
EEE 34	1	Math 55	3
Physics 72	4	Physics 73	4
Math 54	5	PE	(2)
PE	(2)	NSTP	(3)
NSTP	(3)		

THIRD YEAR

1st Semester (17 units)		2nd Semester (18 units)	
EEE 21	3	GE (AH 3) Fil 40	3
EEE 25	3	EEE 51	3
EEE 41	3	EEE 52	1
EEE 42	1	EEE 107	3
EEE 43	3	Math 114	3
EEE 44	1	ES 1	2
ES 12	3	ME 63	3

FOURTH YEAR

1st Semester (18 units)		2nd Semester (18 units)	
ECE 141	3	GE (SSP 3) Free Choice	3
EEE 53	3	ECE 113	3
EEE 54	1	CoE 115	3
EEE 100	1	ECE 117	3
EEE 105	4	ECE 151	3
EEE 101	3	EEE 103	3
Elective	3		

FIFTH YEAR

1st Semester (20 units)		2nd Semester (17 units)	
GE (SSP 4) Free Choice	3	GE (SSP 5) Free Choice	3
GE (AH 4) Free Choice	3	GE (AH 5) Free Choice	3
GE (MST 2) Free Choice	3	GE (MST 3) Free Choice	3
CE 22	3	ECE 198	5
EEE 190	2	PI 100	3
Elective	3		
Elective	3		

1. Kas 1 & Fil 40 satisfy the 6-unit Philippine Studies requirement
2. Minimum of nine (9) units of English/Communication courses must be taken
*3. **Except for Math 1, RGEP courses in the MST domain must NOT be under Physics, Chemistry or Mathematics***
4. As a requirement for graduation, all students are required to take one (1) year program in one of the following components: (a) Military Training Service (ROTC); Civic Welfare Training Service (CWTS); (c) Literacy Training Service.

BACHELOR OF SCIENCE IN INDUSTRIAL ENGINEERING
180 units

APPROVAL
135th UPD UC : 24 June 2016 | President AEPascual : 26 January 2016

FIRST YEAR

1st Semester (18 units)		2nd Semester (18 units)	
Math 17	5	Math 53	5
IE 10	1	Chem 16	5
GE (AH 1) Eng 10	3	Physics 71	4
GE (AH 2) Fil 40	3	Pysics 71.1	1
GE (SSP 1) Philo 1	3	GE (AH 3) Comm 3	3
GE (SSP 2) Kas 1	3	PE	(2)
PE	(2)		

SECOND YEAR

1st Semester (18 units)		2nd Semester (18 units)	
Math 54	5	Math 55	3
Physics 72	4	ES 11	3
Physics 72.1	1	ES 21	3
ES 1	2	ES 26	3
GE (AH 4) Free Choice	3	GE (AH 5) Free Choice	3
GE (MST 1) Free Choice	3	Acctg. 1	3
PE	(2)	PE	(2)
NSTP	(3)	NSTP	(3)

THIRD YEAR

1st Semester (19 units)		2nd Semester (17 units)	
IE 21	3	IE 28	3
IE 27	3	IE 32	3
IE 31	3	IE 33	2
Shop 7	1	IE 41	3
ES 12	3	IE 50	3
ES 13	3	Econ 100.1	3
GE (MST 2) STS	3		

FOURTH YEAR

1st Semester (18 units)		2nd Semester (18 units)	
IE 135	3	IE 122	3
IE 142	3	IE 144	3
IE 143	3	IE 151	3
IE 160	3	ChE 2	3
BA 115	3	EEE 3	3
GE (SSP 3) Free Choice	3	GE (SSP 4) Free Choice	3

FIFTH YEAR

1st Semester (18 units)		2nd Semester (18 units)	
IE 152	3	IE 155	3
IE 153	3	IE 156	3
IE 154	3	IE 198	3
ME 63	3	PI 100	3
IE Elective	3	Elective	3
GE (SSP 5)	3	GE (MST 3) Free Choice	3

1. Kas 1 & Fil 40 satisfy the 6-unit Philippine Studies requirement
2. Minimum of nine (9) units of English/Communication courses must be taken
*3. **Except for Math 1, RGEP courses in the MST domain must NOT be under Physics, Chemistry or Mathematics***
4. As a requirement for graduation, all students are required to take one (1) year program in one of the following components: (a) Military Training Service (ROTC); Civic Welfare Training Service (CWTS); (c) Literacy Training Service.

BACHELOR OF SCIENCE IN MATERIALS ENGINEERING
186 units

APPROVAL
135th UPD UC: 24 June 2016 | President AEPascual : 26 January 2016

FIRST YEAR

1st Semester (19 units)		2nd Semester (18 units)	
GE (AH 1) Eng 10	3	GE (SSP 2) Philo 1	3
GE (SSP 1) Kas 1	3	Physics 71	4
GE (MST 1) Free Choice	3	Physics 71.1	1
Math 17	5	Chem 17	5
Chem 16	5	Math 53	5
PE	(2)	PE	(2)

SECOND YEAR

1st Semester (18 units)		2nd Semester (19 units)	
GE (AH 2) Comm 3	3	Math 55	3
Physics 72	4	Physics 73	4
Physics 72.1	1	Physics 73.1	1
Chem 28	3	Chem 31	3
Chem 28.1	2	Chem 31.1	2
Math 54	5	MatE 10	3
PE	(2)	ES 11	3
NSTP	(3)	PE	(2)
		NSTP	(3)

THIRD YEAR

1st Semester (19 units)		2nd Semester (18 units)	
ES 1	2	MatE 103	3
ES 13	3	MatE 104	2
ES 21	3	MatE 111	3
MatE 11	3	MatE 100	3
MatE 101	3	MatE 100.1	1
MatE 14	3	EEE 5	3
MatE 180	2	ES 26	3

FOURTH YEAR

1st Semester (18 units)		2nd Semester (19 units)	
GE (AH 3) Fil 40	3	GE (AH 4) Free Choice	3
MatE 105	3	GE (SSP 3) Free Choice	3
MatE 105.1	1	MatE 121.1	1
MatE 131	3	MatE 123	2
MatE 131.1	1	MatE 151	3
MatE 141	3	MatE 151.1	1
MatE 141.1	1	MatE 161	3
ES 12	3	MatE 121	3

FIFTH YEAR

1st Semester (20 units)		2nd Semester (18 units)	
GE (SSP 4) Free Choice	3	GE (AH 5) Free Choice	3
GE (MST 2) STS	3	GE (SSP 5) Free Choice	3
MatE 195/MatE 190	2	GE (MST 3) Free Choice	3
MatE Elective	3	MatE 196/MatE 199	3
MatE 171	3	MatE Elective	3
MatE 173	3	PI 100	3
ES 15	3		

1. Kas 1 & Fil 40 satisfy the 6-unit Philippine Studies requirement
2. Minimum of nine (9) units of English/Communication courses must be taken
*3. **Except for Math 1, RGEP courses in the MST domain must NOT be under Physics, Chemistry or Mathematics***
4. As a requirement for graduation, all students are required to take one (1) year program in one of the following components: (a) Military Training Service (ROTC); Civic Welfare Training Service (CWTS); (c) Literacy Training Service.

BACHELOR OF SCIENCE IN GEODETIC ENGINEERING
183 units

APPROVAL
135th UPD UC: 24 June 2016 | President AEPascual : 26 January 2016

FIRST YEAR

1st Semester (17 units)		2nd Semester (19 units)	
GE (SSP 1) Kas 1	3	GE (AH 2) Free Choice	3
GE (SSP 2) Free Choice	3	GE (SSP 3) Philo 1	3
GE (AH 1) Free Choice	3	Geol 11	3
GE (MST 1) Free Choice	3	Chem 16	5
Math 17	5	Math 53	5
PE	(2)	PE	(2)

SECOND YEAR

1st Semester (18 units)		2nd Semester (18 units)	
GE (AH 3) Eng 10	3	GE (AH 4) Fil 40	3
ES 1	2	Physics 72	4
Physics 71	4	Physics 72.1	1
Physics 71.1	1	Math 55	3
Math 54	5	GE 12	4
GE 10	3	GE 120	3
PE	(2)	PE	(2)
NSTP	(3)	NSTP	(3)

THIRD YEAR

1st Semester (17 units)		2nd Semester (19 units)	
Physics 73	4	GE (AH 5) Comm 3	3
Physics 73.1	1	GE 118	3
ES 11	3	GE 152	4
GE 122	3	GE 153	3
GE 151	3	GE 128	3
GE 117	3	EEE 3	3

BACHELOR OF SCIENCE IN GEODETIC ENGINEERING
183 units

APPROVAL
135th UPD UC: 24 June 2016 | President AEPascual : 26 January 2016

FOURTH YEAR

1st Semester (17 units)		2nd Semester (18 units)	
GE (SSP 4) Free Choice	3	GE (MST 2) Free Choice	3
ES 12	3	ES 13	3
GE 154	3	GE 191	1
GE 119	4	GE 149	2
GE 129	4	GE 173	3
		GE 155	2
		GE 155.1	1
		PI 100	3

SUMMER

2 units

GE 192	2

FIFTH YEAR

1st Semester (18 units)		2nd Semester (20 units)	
ES 15	3	GE (MST 3) STS	3
GE 190	1	GE 199	4
GsE 188	4	GsE 189	4
GIM 175	3	GIM 177	3
GE 155.2	1	GE 148	3
GE 143	3	Elective	3
GE (SSP 5) Free Choice	3		

1. Kas 1 & Fil 40 satisfy the 6-unit Philippine Studies requirement
2. Minimum of nine (9) units of English/Communication courses must be taken
*3. **Except for Math 1, RGEP courses in the MST domain must NOT be under Physics, Chemistry or Mathematics***
4. As a requirement for graduation, all students are required to take one (1) year program in one of the following components: (a) Military Training Service (ROTC); Civic Welfare Training Service (CWTS); (c) Literacy Training Service.

BACHELOR OF SCIENCE IN METALLURGICAL ENGINEERING
184 units

APPROVAL
140th UPD UC: 05 September 2016 | President AEPascual : 26 September 2016

FIRST YEAR

1st Semester (17 units)		2nd Semester (18 units)	
GE (AH 1) Eng 10	3	GE (AH 2) Fil 40	3
GE (SSP 1) Philo 1	3	Chem 16	5
GE (SSP 2) Kas 1	3	Math 53	5
GE (MST 1) Free Choice	3	Physics 71	4
Math 17	5	Physics 71.1	1
PE	(2)	PE	(2)

SECOND YEAR

1st Semester (18 units)		2nd Semester (19 units)	
GE (AH 3)Comm 3	3	GE (SSP 3) Free Choice	3
Chem 17	5	Math 55	3
Math 54	5	Geol 11	3
Physics 72	4	Chem 28	3
Physics 72.1	1	Chem 28.1	2
PE	(2)	MetE 11	3
NSTP	(1.5)	MetE 15	2
		PE	(2)
		NSTP	(1.5)

THIRD YEAR

1st Semester (18 units)		2nd Semester (19 units)	
GE (SSP 4) Free Choice	3	GE (AH 4) Free Choice	3
GE (MST 2) Free Choice	3	ES 13	3
Geol 11.1	1	Geol 40	4
ES 1	2	MetE 17	3
ES 11	3	MetE 143	3
MetE 13	2	GE (SSP 5) Free Choice	3
MetE 12	1		
MetE 14	3		

BACHELOR OF SCIENCE IN METALLURGICAL ENGINEERING
184 units

APPROVAL
140th UPD UC: 05 September 2016 | President AEPascual : 26 September 2016

FOURTH YEAR

1st Semester (18 units)		2nd Semester (20 units)	
ES 12	3	EEE 3 or EEE 5	3
EM 10	3	MetE 127	3
MetE 19	3	MetE 128	2
MetE 121	3	MetE 132	3
MetE 146	3	MetE 147	3
Elective	3	Elective	3
		ES 15	3

SUMMER

Summer Plant Practice

FIFTH YEAR

1st Semester (20 units)		2nd Semester (17 units)	
GE (MST 3) STS	3	GE (AH 5) Free Choice	3
PI 100	3	ES 26	3
ES 21	3	MetE 135	2
MetE 134	3	MetE 136	3
MetE 148	2	Elective	3
MetE 149	3	MetE 150	1
MetE 198	3	MetE 199	2

1. Kas 1 & Fil 40 satisfy the 6-unit Philippine Studies requirement
2. Minimum of nine (9) units of English/Communication courses must be taken
*3. **Except for Math 1, RGEP courses in the MST domain must NOT be under Physics, Chemistry or Mathematics***
4. As a requirement for graduation, all students are required to take one (1) year program in one of the following components: (a) Military Training Service (ROTC); Civic Welfare Training Service (CWTS); (c) Literacy Training Service.

BACHELOR OF SCIENCE IN MINING ENGINEERING
182 units

APPROVAL
135th UPD UC: 24 June 2016 | President AEPascual : 26 January 2016

FIRST YEAR

1st Semester 19 units		2nd Semester 18 units	
GE (AH 1) Eng 10	3	GE (AH 2) Fil 40	3
GE (SSP 1) Kas 1	3	Chem 17	5
GE (SSP 2) Free Choice	3	Physics 71	4
Chem 16	5	Physics 71.1	1
Math 17	5	Math 53	5
PE	(2)	PE	(2)

SECOND YEAR

1st Semester 19 units		2nd Semester 17 units	
GE (AH 3) Comm 3	3	GE (SSP 4) Free Choice	3
GE (MST 1) Free Choice	3	ES 1	2
GE (SSP 3) Philo 1	3	Physics 73	4
Physics 72	4	Physics 73.1	1
Physics 72.1	1	Math 55	3
Math 54	5	Geol 11	3
PE	(2)	Geol 11.1	1
NSTP	(3)	PE	(2)
		NSTP	(3)

THIRD YEAR

1st Semester 19 units		2nd Semester 17 units	
GE (AH 4) Free Choice	3	GE (AH 5) Free Choice	3
Geol 40	4	Geol 50	4
GE 10	3	GE 12	4
MetE 11	3	EM 36	3
EM 10	3	ES 13	3
ES 11	3		

BACHELOR OF SCIENCE IN MINING ENGINEERING
182 units

APPROVAL
135th UPD UC: 24 June 2016 | President AEPascual : 26 January 2016

FOURTH YEAR

1st Semester 19 units		2nd Semester 19 units	
Geol 112	4	GE (SSP 5) Free Choice	3
PI 100	3	EEE 3	3
Stat 101	3	MetE 13	2
EM 45	3	EM 146	3
ES 26	3	Geol 194	5
ES 12	3	ES 15	3

SUMMER

Summer Plant Practice	0

FIFTH YEAR

1st Semester 18 units		2nd Semester 17 units	
GE (MST 2) STS	3	GE (MST 3) Free Choice	3
MetE 120	3	MetE 128	2
EM 152	3	EM 156	3
EM 154	3	Elective	3
Elective	3	EM 157	3
EM 198	3	EM 191	3

1. Kas 1 & Fil 40 satisfy the 6-unit Philippine Studies requirement
2. Minimum of nine (9) units of English/Communication courses must be taken
3. ***Except for Math 1, RGEP courses in the MST domain must NOT be under Physics, Chemistry or Mathematics***
4. As a requirement for graduation, all students are required to take one (1) year program in one of the following components: (a) Military Training Service (ROTC); Civic Welfare Training Service (CWTS); (c) Literacy Training Service.

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING
179 units

APPROVAL
135th UPD UC: 24 June 2016 | President AEPascual : 26 January 2016

FIRST YEAR

1st Semester (17 units)		2nd Semester (18 units)	
GE (AH 1) Eng 10	3	GE (AH 2) Comm 3	3
GE (SSP 1) Philo 1	3	Math 53	5
GE (SSP 2) Kas 1	3	Physics 71	4
GE (MST 1) Free Choice	3	Physics 71.1	1
Math 17	5	Chem 16	5
PE	(2)	PE	(2)

SECOND YEAR

1st Semester (18 units)		2nd Semester (17 units)	
GE (AH 3) Free Choice	3	GE (AH 5) Free Choice	3
GE (AH 4) Fil 40	3	GE (SSP 3) Free Choice	3
Math 54	5	Math 55	3
Physics 72	4	Physics 73	4
Physics 72.1	1	Physics 73.1	1
ES 1	2	ES 11	3
PE	(2)	PE	(2)
NSTP	(3)	NSTP	(3)

THIRD YEAR

1st Semester (18 units)		2nd Semester (18 units)	
GE (SSP 4) Free Choice	3	GE (MST 2) STS	3
GE (SSP 5) Free Choice	3	ES 13	3
ES 12	3	ES 15	3
ES 21	3	ME 41	3
ES 26	3	ME 73	3
ME 63	3	ME 91	3

FOURTH YEAR

1st Semester (19 units)		2nd Semester (18 units)	
GE (MST 3) Free Choice	3	IE 3	3
MetE 143	3	ME 122	3
ME 131	4	ME 136	3
ME 142	3	ME 143	3
ME 153	3	ME 154	3
ME 165	3	ME 164	3

FIFTH YEAR

1st Semester (19 units)		2nd Semester (17 units)	
CE 22	3	PI 100	3
EEE 1	4	ME 177	2
ME 155	2	ME 180	2
ME 176	3	ME 188	4
ME 183	4	ME 192	3
Elective	3	Elective	3

1. Kas 1 & Fil 40 satisfy the 6-unit Philippine Studies requirement
2. Minimum of nine (9) units of English/Communication courses must be taken
*3. **Except for Math 1, RGEP courses in the MST domain must NOT be under Physics, Chemistry or Mathematics***
4. As a requirement for graduation, all students are required to take one (1) year program in one of the following components: (a) Military Training Service (ROTC); Civic Welfare Training Service (CWTS); (c) Literacy Training Service.

MASTER OF SCIENCE IN CHEMICAL ENGINEERING
Thesis 32 units

APPROVAL
126th UPD UC : 24 April 2013 | President AEPascual : 14 August 2013

FIRST YEAR

1st Semester (13 units)		2nd Semester (13 units)	
ChE 220[1]	3	ChE 241[1]	3
ChE 229 or ChE 231[1]	3	ChE Major Subject[2]	3
ChE Major Subject[2]	3	Applied Math/Statistics[3]	3
Applied Math/Statistics[3]	3	Elective[4]	3
ChE 296.1	1	ChE 296.2	1

SECOND YEAR

1st Semester (3 units)		2nd Semester (3 units)	
ChE 300	3	ChE 300	3

[1] ChE Core Courses: ChE 220, ChE 229 or ChE 231, ChE 241
[2] ChE Major Subjects: ChE 202, ChE 205, ChE 211, ChE 221, ChE 224, ChE 233, ChE 237, ChE 242, ChE 244, ChE 245, ChE 246, ChE 247, ChE 248, ChE 250, ChE 251, ChE 261, ChE 266, ChE 291, ChE 292, ChE 293, ChE 294, ChE 297, ChE 298
[3]Any graduate course in applied mathematics and/or statistics as recommended by the program/thesis adviser and approved by the Graduate Program Committee of the Department.
[4] ChE 297, ChE 298, or any 3-unit graduate course outside the Department as recommended by the program/thesis adviser and approved by the Graduate Program Committee of the Department.

MASTER OF SCIENCE IN CHEMICAL ENGINEERING
Non-Thesis 37 units

APPROVAL
126th UPD UC : 24 April 2013 | President AEPascual : 14 August 2013

FIRST YEAR

1st Semester (13 units)		2nd Semester (12 units)	
ChE 220[1]	3	ChE 241[1]	3
ChE 229 or ChE 231[1]	3	ChE Major Subject[2]	3
ChE Major Subject[2]	3	ChE Major Subject[2]	3
Applied Math/Statistics[3]	3	Applied Math/Statistics[3]	3
ChE 296.1	1		

SECOND YEAR

1st Semester (6 units)		2nd Semester (6 units)	
ChE Major Subject[1]	3	Elective[4]	3
Elective[4]	3	Elective[4]	3

THIRD YEAR

1st Semester
Comprehensive Examination

[1] ChE Core Courses: ChE 220, ChE 229 or ChE 231, ChE 241
[2] ChE Major Subjects: ChE 202, ChE 205, ChE 211, ChE 221, ChE 224, ChE 233, ChE 237, ChE 242, ChE 244, ChE 245, ChE 246, ChE 247, ChE 248, ChE 250, ChE 251, ChE 261, ChE 266, ChE 291, ChE 292, ChE 293, ChE 294, ChE 297, ChE 298
[3]Any graduate course in applied mathematics and/or statistics as recommended by the program/thesis adviser and approved by the Graduate Program Committee of the Department.
[4] ChE 297, ChE 298, or any 3-unit graduate course outside the Department as recommended by the program/thesis adviser and approved by the Graduate Program Committee of the Department.

Checklists for Undergraduate and Graduate programs are for guidance of students only and are based on approved Program of Study (POS)

MASTER OF SCIENCE IN CIVIL ENGINEERING
Field of Study: Geotechnical Engineering 30-36 units

APPROVAL
103rd UPD UC: 23 April 2008 | President ERRoman: 25 April 2008

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
CE 260	3	CE 262	3
CE 261	3	CE 264	3
ES 201	3	ES 204	3
CE 297[1]	3	CE Elective Major[1]	3

SECOND YEAR

1st Semester 3 units		2nd Semester 3 units	
CE Elective Major[1]	3	CE Elective Major[1]	3
CE Elective[2]	3	CE Elective[2]	3

THIRD YEAR

1st Semester	
Comprehensive Examination or CE 300	6

* For the Thesis Option: Minimum of 3u Elective Major/Specialization Course and minimum of 3u Elective

[1] Elective Major/Specialization Courses: CE 263, CE 265, CE 266, CE 268, CE 269, CE 297, CE 298
[2] Elective Courses: CE 206, CE 216, CE 219, CE 220, CE 225, CE 236, CE 251, CE 296, ES 202, ES 230, ES 231
With Institute approval, courses to be credited as Elective may be chosen from the list of elective courses below and among major/specialization courses from other MSCE Fields of Study. The Institute may, from time to time, add or delete courses from the list of elective courses.

MASTER OF SCIENCE IN CIVIL ENGINEERING
Field of Study: Transportation Engineering 30 units

APPROVAL
103rd UPD UC: 23 April 2008 | President ERRoman: 25 April 2008

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
CE 240	3	CE 242[1]	3
CE 246	3	CE 249	3
CE 248	3	ES 204	3
ES 201	3	CE Elective[2]	3

SECOND YEAR

1st Semester 3 units		2nd Semester 3 units	
CE 300	3	CE 300	3

[1] Elective Major/Specialization Courses: CE 241, CE 242, CE 243, CE 244, CE 245, CE 247, CE 297, CE 298
[2] Elective Courses: CE 206, CE 216, CE 219, CE 220, CE 225, CE 236, CE 251, CE 296, ES 202, ES 230, ES 231
With Institute approval, courses to be credited as Elective may be chosen from the list of elective courses below and among major/specialization courses from other MSCE Fields of Study. The Institute may, from time to time add or delete courses from the list of elective courses.

MASTER OF SCIENCE IN CIVIL ENGINEERING
Field of Study: Structural Engineering 30/36 units

APPROVAL
103rd UPD UC: 23 April 2008 | President ERRoman: 25 April 2008

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
CE 201[1]	3	ES 230	3
ES 204	3	CE Elective Major[1]	3
ES 201	3	CE Elective[2]	3
CE 226	3	CE Elective Major[1]	3

SECOND YEAR

1st Semester 3 units		2nd Semester 6 units	
CE 257	3	CE Elective[2]	3
CE 253[1]	3	CE Elective[2]	3
CE Elective Major[1]	3		

THIRD YEAR * *

1st Semester	
Comprehensive Examination or CE 300	6

*For the Thesis Option: Minimum of 6u of Elective Major/Specialization Course and minimum of 3u Elective

[1] Elective Major/Specialization Courses: CE 201, CE 222, CE 250, CE 252, CE 253, CE 255, CE 256, CE 258, CE 259, CE 291, CE 297, CE 298
[2] Elective Courses: CE 206, CE 216, CE 219, CE 220, CE 225, CE 236, CE 251, CE 296, ES 202, ES 230, ES 231*
With Institute approval, courses to be credited as Elective may be chosen from the list of elective courses below and among major/specialization courses from other MSCE Fields of Study. The Institute may, from time to time add or delete courses from the list of elective courses.
Note: CE 201 is required for Non-UP BS graduates who have not taken the undergraduate course in Matrix Theory of Structures. Additional three (3) units are required over the minimum. The grade is included in computing the comulative weighted average grade.

Checklists for Undergraduate and Graduate programs are for guidance of students only and are based on approved Program of Study (POS)

MASTER OF SCIENCE IN CIVIL ENGINEERING

Field of Study: Water Resources Engineering (Thesis) 30 units

APPROVAL
103rd UPD UC: 23 April 2008 | President ERRoman: 25 April 2008

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
CE 212	3	CE 215	3
CE 214	3	CE Elective[1]	3
ES 201	3	ES 204	3
ES 251	3	CE Elective[2]	3

SECOND YEAR

1st Semester 3 units		2nd Semester 3 units	
CE 300	3	CE 300	3

[1] Elective Major/Specialization Courses: CE 211, CE 213, CE 217, CE 270, CE 273, CE 297, CE 298, EnE 210
[2] Elective Courses: CE 206, CE 216, CE 219, CE 220, CE 225, CE 236, CE 251, CE 296, ES 202, ES 230, ES 231
With Institute approval, courses to be credited as Elective may be chosen from the list of elective courses and among major/specialization courses from other MSCE Fields of Study. The Institute may, from time to time, add or delete courses from the list of elective courses.

MASTER OF SCIENCE IN CIVIL ENGINEERING

Field of Study: Water Resources Engineering (Non-Thesis) 36 units

APPROVAL
103rd UPD UC: 23 April 2008 | President ERRoman: 25 April 2008

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
CE 212	3	CE 211	3
CE 214	3	CE 213	3
ES 201	3	CE 215	3
ES 251	3	ES 204	3

SECOND YEAR

1st Semester 12 units		2nd Semester	
CE Elective Major[1]	3	Comprehensive Examination	
CE Elective[1,2]	3		
CE Elective[1,2]	3		
CE Elective[1,2]	3		

[1] Elective Major/Specialization Courses: CE 217, CE 270, CE 273, CE 297, CE 298, EnE 210
[2] Elective Courses: CE 206, CE 216, CE 219, CE 220, CE 225, CE 236, CE 251, CE 296, ES 202, ES 230, ES 231
With Institute approval, courses to be credited as Elective may be chosen from the list of elective courses below and among major/specialization courses from other MSCE Fields of Study. The Institute may, from time to time, add or delete courses from the list of elective courses.

MASTER OF SCIENCE IN COMPUTER SCIENCE

Non-Thesis 37 units

APPROVAL
106th UPD UC : 15 December 2008 | President ERRoman: 06 February 2009

FIRST YEAR

1st Semester 12 units		2nd Semester 13 units	
CS Theory Course[1]	3	CS 296	1
CS Systems Course[1]	3	CS Specialization Course[2]	3
CS Theory or Systems Course[1]	3	CS Specialization Course[2]	3
CS Specialization Course[2]	3	CS Specialization Course[2]	3

SECOND YEAR

1st Semester 12 units		2nd Semester 3 units	
CS 298	3	Elective	3
CS Elective	3	Comprehensive Examination	
Elective	3		
Elective	3		

[1] Core Courses:
Theory Courses: CS 204, CS 210
Systems Courses: CS 250, CS 255, CS 270, CS 260, CS 280
[2] Specialization Courses:
Theory Courses: CS 204, CS 208, CS 210, CS 211, CS 213, CS 214, CS 216, CS 222, CS 225, CS 231, CS 236, CS 237, CS 271, CS 290, CS 294, ES 201, ES 202
Systems Courses: CS 220, CS 237, CS 239, CS 240, CS 242, CS 250, CS 253, CS 255, CS 256, CS 257, CS 258, CS 259, CS 260, CS 262, CS 265, CS 266, CS 267, CS 268, CS 270, CS 280, CS 281, CS 282, CS 283, CS 284, CS 286, CS 291, CS 292, CS 293, CS 295, CS 297, CS 298, EE 227, EE 267, EE 270, EE 274, EE 264, GE 203, GE 213, IE 253, IE 254

MASTER OF SCIENCE IN COMPUTER SCIENCE

Thesis 31 units

APPROVAL
106th UPD UC : 15 December 2008 | President ERRoman: 06 February 2009

FIRST YEAR

1st Semester 9 units		2nd Semester 10 units	
CS Theory Course[1]	3	CS 296	1
CS Systems Course[1]	3	CS Specialization Course[2]	3
CS Theory or Systems Course[1]	3	CS Specialization Course[2]	3
		Elective	3

SECOND YEAR

1st Semester 6 units		2nd Semester 6 units	
CS 298	3	CS 300	6
CS Specialization Course[2]	3		

[1] Core Courses:
Theory Courses: CS 204, CS 210
Systems Courses: CS 250, CS 255, CS 270, CS 260, CS 280
[2] Specialization Courses:
Theory Courses: CS 204, CS 208, CS 210, CS 211, CS 213, CS 214, CS 216, CS 222, CS 225, CS 231, CS 236, CS 237, CS 271, CS 290, CS 294, ES 201, ES 202
Systems Courses: CS 220, CS 237, CS 239, CS 240, CS 242, CS 250, CS 253, CS 255, CS 256, CS 257, CS 258, CS 259, CS 260, CS 262, CS 265, CS 266, CS 267, CS 268, CS 270, CS 280, CS 281, CS 282, CS 283, CS 284, CS 286, CS 291, CS 292, CS 293, CS 295, CS 297, CS 298, EE 227, EE 267, EE 270, EE 274, EE 264, GE 203, GE 213, IE 253, IE 254

Checklists for Undergraduate and Graduate programs are for guidance of students only and are based on approved Program of Study (POS)

MASTER OF SCIENCE IN ELECTRICAL ENGINEERING
30 units

APPROVAL
126th UPD UC : 24 April 2013 | President AEPascual : 13 August 2013

FIRST YEAR

1st Semester 12 units		2nd Semester 10 units	
Major Subject[1]	3	Major Subject[1]	3
Major Subject[1]	3	Major Subject[1]	3
Elective[2]	3	Elective[2]	3
Elective[2]	3	EE 296	1

SECOND YEAR

1st Semester 5 units		2nd Semester 3 units	
Major Subject[1]	3	EE 300	3
EE 300	3		

[1] Major Subject:
Any creditable graduate-level EE course offered by the EEE Institute that is relevant to the area of specialization.
[2] Elective:
Any creditable graduate-level course that has been recommended for approval by the adviser and the Institute graduate program committee; provided that all prerequisites of the course have been satisfied.

MASTER OF SCIENCE IN ENERGY ENGINEERING
Thesis 32 units

APPROVAL
126th UPD UC: 24 April 2013 | President AEPascual: 14 August 2013

FIRST YEAR

1st Semester 13 units		2nd Semester 13 units	
Applied Math*	3	Applied Math*	3
EgyE 201	3	Major Subject	3
EgyE 211	3	Major Subject	3
EgyE 231	3	Elective**	3
EgyE 205	1	EgyE 296	1

SECOND YEAR

1st Semester 3 units		2nd Semester 3 units	
EgyE 300	3	EgyE 300	3

**Student may choose from Applied Mathematics Courses offered by the College Engineering such as but not limited to: ES 201, ES 202, ES 204, IE 211, IE 214, EE 214, IE 230 or any graduate course in mathematics as recommended by the program/thesis adviser and approved by the Program Committee of the energy program.*
***Electives approved by the program adviser may be taken from among graduate courses offered by the College of Engineering, upon the consent of the instructor or department offering the course, such as but not limited to: EgyE 290, EgyE 297, EgyE 298, ChE 229, ChE 231, EE 355, EE 357, EE 358, GE 202, GE 203, GE 204, IE 241, IE 242, ME 224, ME 286, ME 287*
Electives may also be taken from among graduate courses offered by the National Center of Public Administration and Governance, Technology Management Center, School of Economics, College of Science, School of Urban and Regional Planning upon approval by the program adviser and subject to the consent of the instructor or the department offering the course.

MASTER OF SCIENCE IN ENVIRONMENTAL ENGINEERING
32 units

APPROVAL
141st UPD UC: 20 February 2017 | Executive Vice President TJ Herbosa: 10 April 2017

FIRST YEAR

1st Semester 13 units		2nd Semester 12 units	
EnE 203	4	ES 204	3
EnE 202	3	EnE 205/Major Course*	3
EnE 205/Major Course*	3	Major Course*	3
ES 201	3	Elective**	3

SECOND YEAR

1st Semester 4 units		2nd Semester 3 units	
EnE 296	1	EnE 300	3
EnE 300	3		

**List of Major Courses*
Water Quality Management: EnE 210, 213, 214, 215, 216, 218
Air Quality Management: EnE 253, 254, 252, Meteo 283
Geoenvironmental Quality Management: EnE 260, 261, 272
Solid Waste and Hazardous Materials Management: EnE 270, 272, ChE 266, MSE 268
Environmental Systems Engineering: EnE 280, 281, 282, 283, GmE 203

*** List of Elective Courses: Select from the list of major courses or any course as advised by the program adviser*

MASTER OF SCIENCE IN ENERGY ENGINEERING
Non-Thesis 38 units

APPROVAL
126th UPD UC: 24 April 2013 | President AEPascual: 14 August 2013

FIRST YEAR

1st Semester 6 units		2nd Semester 6 units	
Applied Math*	3	Applied Math*	3
EgyE 201	3	EgyE 211	3

SECOND YEAR

1st Semester 7 units		2nd Semester 7 units	
EgyE 231	3	Major Subject	3
EgyE 205	1	EgyE 296	1
Major Subject	3	Elective**	3

THIRD YEAR

1st Semester 6 units		2nd Semester 6 units	
Major Subject	3	Elective**	3
Major Subject	3	Elective**	3

**See footnotes for Thesis option*
***See footnotes for Thesis option*

Checklists for Undergraduate and Graduate programs are for guidance of students only and are based on approved Program of Study (POS)

MASTER OF SCIENCE IN GEOMATICS ENGINEERING
30 units

APPROVAL
112th UPD UC : 26 March 2010 | President ERRoman : 19 April 2010

FIRST YEAR

1st Semester (12 units)		2nd Semester (12 units)	
GmE 202	3	GmE Common Course[1]	3
GmE 203	3	GmE Specialization Course[2]	3
GmE 205	3	GmE Specialization Course[2]	3
GmE Common Course[1]	3	Elective[3]	2

SECOND YEAR

1st Semester (3 units)		2nd Semester (3 units)	
GmE 300	3	GmE 300	3

[1] Common Courses (6 units):
For all fields of specialization: ES 201, ES 202, ES 204, IE 230
For Geoinformatics and Remote Sensing: Stat 276, Stat 277
For Remote Sensing and Applied Geodesy: GmE 211, GmE 216
For Geoinformatics and Applied Geodesy: GmE 210, GmE 217
[2] Specialized Courses (6 units):
For Geoinformatics: GmE 220, GmE 221, GmE 222, GmE 223
For Remote Sensing: GmE 230, GmE 231, GmE 232, GmE 233
For Applied Geodesy: GE 152 (Back Subject), GmE 241, GmE 242, GmE 243
[3] Electives:
LA 255, EgyE 201, EnE 210, EnE 211, EnE 212, EnE 250, EnE 280, EnE 298, CE 212, CE 213, CE 215, CE 218, CE 220, CE 243, CE 261, EE 264, EE 274, EE 277, IE 221, IE 230, IE 251, IE 253, Bio 222, Bio 260, Bio 262, Bio 263, Bio 265, GE 205, GE 212, Geol 297, MS 210, PA 213, PA 224, PA 227, PA 241, PA 242.1, PA 242.2, PA 273, PA 274, PA 278, Planning 202, Planning 203, Planning 222, Planning 210, Stat 280, Geog 209, Geog 241, Geog 242, Geog 291, other courses recommended by the adviser/s

MASTER OF SCIENCE IN INDUSTRIAL ENGINEERING
31 units

APPROVAL
89th UPD UC : 20 April 2005 | President FNemenzo : 28 April 2005

FIRST YEAR

1st Semester (9 units)		2nd Semester (9 units)	
IE 230	3	IE 251	3
IE 231	3	IE Specialization Course[1]	3
IE 241	3	Non-IE Elective [2](PS/HFE/IS/ Tracks or IE 181 (OR Track)	3

SECOND YEAR

1st Semester (6 units)		2nd Semester (7 units)	
IE Specialization Course[1]	3	IE 296	1
Non-IE Elective[2]	3	IE 300	6

[1]Specialization Courses:
Production Systems: IE 245, IE 255
Operations Research: IE 242, IE 252, IE 281
Information Systems: IE 253, IE 254
Human Factors and Ergonomics: IE 243, IE 256
Students are required to take 6 units of IE Specialization Courses
[2] Qualified Non-IE Electives: ME 211, EnE 201, EnE 280, EgyE 201, EgyE 211, TM 201, TM 202, Econ 201, Econ 202, IR 201, IR 205, IR 212, IR 213

MASTER OF SCIENCE (MATERIALS SCIENCE AND ENGINEERING)
37/43 units

APPROVAL
28th UPD UC : 21 April 1992

FIRST YEAR

1st Semester (12 units)		2nd Semester (13 units)	
MSE 201*	3	MSE 225[1]	3
MSE 231	3	MSE 233[1]	3
MSE 241	3	MSE 251[1]	3
ES 201	3	MSE Laboratory Course[1]	1
		ES 204	3

SECOND YEAR

1st Semester (12 units)		2nd Semester (12 units)	
MSE Laboratory Course[1]	1	MSE 300[3]	3
MSE Laboratory Course[1]	1	MSE Specialization Course[2]	3
MSE Laboratory Course[1]	1	MSE Specialization Course[2]	3
MSE Laboratory Course[1]	1	MSE Specialization Course[2]	3
MSE Laboratory Course[1]	1		
MSE Specialization Course[2]	3		
MSE 300[3]	3		
MSE 296	1		

THIRD YEAR

1st Semester	
Comprehensive Exam[4]	

** Student with Metallurgical or Materials Engineering background must take a 3-unit specialization course instead of MSE 201.*

[1] Laboratory Core Courses: MSE 201, MSE 225, MSE 231, MSE 233, MSE 241, MSE 251, MSE 211, MSE 212, MSE 213, MSE 214, MSE 215, MSE 216, MSE 217, MSE 218, MSE 219
[2] Specialization Courses (12 units required for non-thesis option): MSE 243, MSE 243.1, MSE 245, MSE 245.1, MSE 253, MSE 255, MSE 265, MSE 266, MSE 267, MSE 268, MSE 271, MSE 271.1, MSE 271.2, MSE 275, MSE 276, MSE 281, MSE 282, MSE 283, MSE 283.1, MSE 285, MSE 286, MSE 287, MSE 287.1, MSE 298
[3] Required for students in thesis option only
[4] Required for students in non-thesis option only

Checklists for Undergraduate and Graduate programs are for guidance of students only and are based on approved Program of Study (POS)

MASTER OF SCIENCE IN MECHANICAL ENGINEERING
30 units

APPROVAL
106th UPD UC : 15 December 2008 | President ERRoman: 06 February 2009

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
Core Course[1]	3	ES 204	3
Core Course[1]	3	ME Elective[2]	3
ES 201	3	ME Elective[2]	3
ME Elective[2]	3	ME Elective[2]	3

SECOND YEAR

1st Semester 3 units		2nd Semester 3 units	
ME 300	3	ME 300	3

[1]Core Courses (6 units): ME 258, ME 267, ME 260, ME 242
[2]Electives (12 units): CE 201, CE 226, ES 231, ES 233, ES 250, ES 251, ES 252, ES 253, EgyE 231, EgyE 232, ME 222, ME 224, ME 226, ME 231, ME 236, ME 242, ME 243, ME 258, ME 259, ME 260, ME 264, ME 267, ME 268, ME 281, MW 282, ME 287, ME 296, ME 298, MSE 251, MSE 255, Cognate (other Engineering courses with Department Approval)

MASTER OF SCIENCE IN METALLURGICAL ENGINEERING
30 units

APPROVAL
8th UPD UC: 26 July 1986

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
MetE 210[1]	3	ES 204 or 202	3
MetE 213[1]	3	MetE Core Course[1]	3
ES 201	3	MetE Core Course[1]	3
MetE Core Course[1]	3	MetE Elective	3

SECOND YEAR

1st Semester 3 units		1st Semester 3 units	
MetE 300	3	MetE 300	3

[1]Core Courses:
Extractive Metallurgy (15 units): MetE 210, MetE 213, Met E 221, MetE 231, MetE 232, MetE 235
*Physical Metallurgy (12 units): MetE 210, MetE 213, MetE 241, MetE 243, MetE 251, MetE 257, MetE 298**

**any of the following MSE courses can be substituted for MetE 298 to be credited as part of core course requirement: MSE 225, MSE 285, MSE 268, MSE 267, MSE 281, MSE 282, MSE 286*

[2] Electives:
Extractive Metallurgy: MetE 217, MetE 218, MetE 241, MetE 243, MetE 251, MetE 257, MetE 298, or one (1) elective from other fields may be given with the approval of the adviser
Physical Metallurgy: Any of the core courses listed above can be credited under electives if not being applied for credit as core course. Other MetE graduate courses can be credited under electives. Any of the MSE course except MSE 201 can be credited under electives as long as they are not considered equivalent of MetE core courses already applied for credit as a core course.

MASTER OF ENGINEERING IN ELECTRICAL ENGINEERING
30 units

APPROVAL
126th UPD UC : 24 April 2013 | President AEPAscual : 13 August 2013

FIRST YEAR

1st Semester 12 units		2nd Semester 10 units	
Major Subject[1]	3	Major Subject[1]	3
Major Subject[1]	3	Major Subject[1]	3
Elective[2]	3	Elective[2]	3
Elective[2]	3	EE 296	1

SECOND YEAR

1st Semester 8 units		2nd Semester
Major Subject[1]	3	Comprehensive Examination
Elective[2]	3	
Elective[2]	2	

[1] Major Subject:
Any creditable graduate-level EE course offered by the EEE Institute that is relevant to the area of specialization.
[2] Elective:
Any creditable graduate-level course that has been recommended for approval by the adviser and the Institute graduate program committee; provided that all prerequisites of the course have been satisfied.

MASTER OF ENGINEERING IN INDUSTRIAL ENGINEERING
31 units

APPROVAL
122nd UPD UC: 09 July 2012 | President AEPascual: 01 August 2012

FIRST YEAR

1st Semester 9 units		2nd Semester 9 units	
IE 230	3	IE 251	3
IE 231	3	IE Specialization Course[1]	3
IE 241	3	IE Elective[2]	3

SECOND YEAR

1st Semester 9 units		2nd Semester 4 units	
IE Specialization Course[1]	3	IE 296	1
IE Elective[2]	3	IE 299	3
Non-IE Elective[3]	3	Comprehensive Examination	

[1]Specialization Courses:
Production Systems: IE 245, IE 255
Operations Research: IE 242, IE 252,
Information Systems: IE 253, IE 254
Human Factors and Ergonomics: IE 243, IE 256
Students are required to take 6 units of IE Specialization Courses, 6 units of IE Electives and 3 units of Non-IE Elective
[2] IE Electives may be taken from among the following (each has 3 units credit): IE 242, IE 243, IE 245, IE 253, IE 281, IE 298
[3] Non-IE Electives may be taken from among the following (each has 3 units credit): DE 201, DE 202, EgyE 201, EgyE 211, EnE 201, EnE 280, IR 201, IR 205, IR 212, IR 213, ME 211, TM 201, TM 202 or Any Graduate-Level Course Acceptable to the Degree Program Sponsor

Checklists for Undergraduate and Graduate programs are for guidance of students only and are based on approved Program of Study (POS)

DOCTOR OF PHILOSOPHY (CIVIL ENGINEERING)
Area of Study: Geotechnical Engineering 36 units*

APPROVAL
85th UPD UC : 19 April 2004 | BOR : 27 May 2004

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
CE Course in Major Field[1]	3	CE Course in Major Field[1]	3
CE Core Course[2]	3	CE Core Course[2]	3
CE Course in Major Field[1]	3	CE Course in Major Field[1]	3
CE Elective[3]	3	CE Elective[3]	3

SECOND YEAR

1st Semester 12 units	
CE 400	12

** For MS degree holders*
[1]Courses in Major Field (12 units): CE 260, CE 261, CE 262, CE 263, CE 264, CE 265, CE 266, CE 268, CE 269, CE 360, CE 361
[2]Core Courses: CE 301, CE 304, CE 306, CE 400
[3]Electives: CE 225, CE 297, CE 298, ES 201, ES 202, ES 204, ES 230, ES 231, ES 233, ES 241, ES 250, ES 251, ES 252, ES 253, ES 257, EnE 210
New Courses to be Offered: CE 397, CE 398, CE 206, CE 236, CE 307, CE 308

DOCTOR OF PHILOSOPHY (CIVIL ENGINEERING)
Area of Study: Structural Engineering 36 units*

APPROVAL
85th UPD UC : 19 April 2004 | BOR : 27 May 2004

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
CE Course in Major Field[1]	3	CE Course in Major Field[1]	3
CE Core Course[2]	3	CE Core Course	3
CE Course in Major Field[1]	3	CE Course in Major Field[1]	3
CE Elective[3]	3	CE Elective[3]	3

SECOND YEAR

1st Semester 12 units	
CE 400	12

** For MS degree holders*
[1]Courses in Major Field (12 units): CE 201, CE 216, CE 226, CE 250, CE 251, CE 252, CE 253, CE 255, CE 256, CE 257, CE 258, CE 222, CE 259, CE 291, CE 322, CE 350, CE 351, CE 352, CE 353, CE 356, CE 358
[2]Core Courses: CE 301, CE 304, CE 306, CE 400
[3]Electives: CE 225, CE 297, CE 298, ES 201, ES 202, EWS 204, ES 230, ES 231, ES 233, ES 241, ES 250, ES 251, ES 252, ES 253, ES 257, EnE 210
New Courses to be Offered: CE 397, CE 398, CE 206, CE 236, CE 307, CE 308

DOCTOR OF PHILOSOPHY (CIVIL ENGINEERING)
Field of Study: Transportation Engineering 36 units*

APPROVAL
85th UPD UC : 19 April 2004 | BOR : 7 May 2004

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
CE Course in Major Field[1]	3	CE Course in Major Field[1]	3
CE Core Course[2]	3	CE Core Course[2]	3
CE Course in Major Field[1]	3	CE Course in Major Field[1]	3
CE Elective[3]	3	CE Elective[3]	3

SECOND YEAR

1st Semester 12 units	
CE 400	12

** For MS degree holders*
[1]Courses in Major Field (12 units): CE 240, CE 241, CE 242, CE 243, CE 244, CE 245, CE 246, CE 247, CE 248, CE 249, CE 340, CE 341, CE 342
[2]Core Courses: CE 301, CE 304, CE 306, CE 400
[3]Electives: CE 225, CE 297, CE 298, ES 201, ES 202, EWS 204, ES 230, ES 231, ES 233, ES 241, ES 250, ES 251, ES 252, ES 253, ES 257, EnE 210
New Courses to be Offered: CE 397, CE 398, CE 206, CE 236, CE 307, CE 308

DOCTOR OF PHILOSOPHY (CIVIL ENGINEERING)
Field of Study : Water Resources 36 units*

APPROVAL
85th UPD UC : 19 April 2004 | BOR : 27 May 2004

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
CE Course in Major Field[1]	3	CE Course in Major Field[1]	3
CE Core Course[2]	3	CE Core Course[2]	3
CE Course in Major Field[1]	3	CE Course in Major Field[1]	3
CE Elective[3]	3	CE Elective[3]	3

SECOND YEAR

1st Semester 12 units	
CE 400	12

** For MS degree holders*
[1]Courses in Major Field (12 units): CE 211, CE 212 CE 213, CE 214, CE 215, CE 217, CE 219, CE 270, CE 273, CE 311, CE 313, CE 315, CE 316, CE 318
[2]Core Courses: CE 301, CE 304, CE 306, CE 400
[3]Electives: CE 225, CE 297, CE 298, ES 201, ES 202, EWS 204, ES 230, ES 231, ES 233, ES 241, ES 250, ES 251, ES 252, ES 253, ES 257, EnE 210
New Courses to be Offered: CE 397, CE 398, CE 206, CE 236, CE 307, CE 308

DOCTOR OF PHILOSOPHY IN COMPUTER SCIENCE
37 units

APPROVAL
116th UPD UC : 13 December 2010 | President ERRoman : 04 January 2011

FIRST YEAR

1st Semester 12 units		2nd Semester 13 units	
CS Course in Theory[1]	3	Course in Theory or Systems[1]	3
CS Course in Systems[1]	3	Specialization Course[2]	3
Specialization Course[2]	3	Specialization Course[2]	3
Graduate Elective	3	Graduate Elective	3
		CS 296 Graduate Seminar	1

SECOND YEAR

1st Semester 6 units		2nd Semester 6 units	
CS 400	6	CS 400	6

[1]Core Courses:
Theory Courses: CS 204, CS 210, CS 214, CS 231, CS 360
Systems Courses: CS 250, CS 253, CS 255, CS 260, CS 268, CS 270, CS 280, CS 351, CS 369
[2] Specialization Courses:
Theory Courses: CS 204, CS 208, CS 210, CS 211, CS 213, CS 214, CS 216, CS 222, CS 231, CS 236, CS 237, CS 239, CS 240, CS 242, CS 247, CS 271, CS 290, CS 294, CS 301, CS 315, CS 318, CS 334, CS 338, CS 360, CS 390, ES 201, ES 202
Systems Courses: CS 220, CS 250, CS 253, CS 255, CS 256, CS 257, CS 258, CS 259, CS 260, CS 262, CS 265, CS 266, CS 267, CS 268, CS 270, CS 280, CS 281, CS 282, CS 283, CS 284, CS 286, CS 291, CS 292, CS 295, CS 341, CS 351, CS 369, CS 371, CS 381, CS 385, CS 389, CS 390, CS 397

DOCTOR OF PHILOSOPHY (ELECTRICAL AND ELECTRONICS ENGINEERING)
36 units

APPROVAL
30th UPD UC 12 December 1992 | BOR : 25 January 1993

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
Major[1] or Specialization[2] Course	3	Major[1] or Specialization[2] Course	3
Major[1] or Specialization[2] Course	3	Major[1] or Specialization[2] Course	3
Major[1] or Specialization[2] Course	3	Major[1] or Specialization[2] Course	3
Major[1] or Specialization[2] Course	3	Major[1] or Specialization[2] Course	3

SECOND YEAR

1st Semester 3 units		2nd Semester 3 units	
EE 400[3]	3	EE 400[3]	3

THIRD YEAR

1st Semester 3 units		2nd Semester 3 units	
EE 400[3]	3	EE 400[3]	3

**For MS/ME degree holders*
[1] Major Course: Any creditable Electrical & Electronics Engineering (EE) graduate course relevant to the field/area of specialization.
[2] Specialization Course: Any creditable graduate course relevant to the field/area of specialization, pre-approved by the adviser and for which all prerequisites have been satisfied.
[3] The student must submit a 12-unit dissertation where s/he makes an original contribution to the fundamental knowledge in the field.

DOCTOR OF ENGINEERING (ELECTRICAL AND ELECTRONICS ENGINEERING)
36 units

APPROVAL
30th UPD UC 12 December 1992 | BOR : 25 January 1993

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
Major[1] or Specialization[2] Course	3	Major[1] or Specialization[2] Course	3
Major[1] or Specialization[2] Course	3	Major[1] or Specialization[2] Course	3
Major[1] or Specialization[2] Course	3	Major[1] or Specialization[2] Course	3
Major[1] or Specialization[2] Course	3	Major[1] or Specialization[2] Course	3

SECOND YEAR

1st Semester 3 units		2nd Semester 3 units	
EE 400[3]	3	EE 400[3]	3

THIRD YEAR

1st Semester 3 units		2nd Semester 3 units	
EE 400[3]	3	EE 400[3]	3

**For MS/ME degree holders*
[1] Major Course: Any creditable Electrical & Electronics Engineering (EE) graduate course relevant to the field/area of specialization.
[2] Specialization Course: Any creditable graduate course relevant to the field/area of specialization, pre-approved by the adviser and for which all prerequisites have been satisfied.
[3] The student must submit a 12-unit dissertation where s/he addresses an engineering problem of substance and develops a solution in a creative and distinguished manner.

DOCTOR OF PHILOSOPHY (ENVIRONMENTAL ENGINEERING)
For MS Degree Holder **36 units**

APPROVAL
95th UPD UC : 19 April 2006 | BOR : 27 April 2006

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
Core Course[1]	3	Core Course[1]	3
Course in Field of Specialization[2]	3	Course in Field of Specialization[2]	3
Course in Field of Specialization[2]	3	Course in Field of Specialization[2]	3
Core Course[1]	3	Core Course[1]	3

SECOND YEAR

1st Semester 3 units		2nd Semester 3 units	
EnE 400	3	CE 400	3

THIRD YEAR

1st Semester 3 units		2nd Semester 3 units	
EnE 400	3	EnE 400	3

For MS/ME degree holders
[1] Core Courses (12 units): EnE 302, EnE 303, EnE 304, EnE 305
[2]Courses in the Field of Specialization (12 units): Air Pollution: EnE 251, ME 286, ME 287, MSE 267; Solid and Hazardous Waste: EnE 372, EnE 382, CE 318, CE 264; Water and Wastewater: EnE 210, EnE 213, EnE 214, EnE 215

DOCTOR OF PHILOSOPHY (ENVIRONMENTAL ENGINEERING)
For BS Degree Holder **57 units**

APPROVAL
95th UPD UC : 19 April 2006 | BOR : 27 April 2006

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
Core Course[1]	3	Core Course[1]	3
Core Course[1]	3	Core Course[1]	3
Core Course[1]	3	Core Course[1]	3
Course in Field of Specialization[2]	3	Course in Field of Specialization[2]	3

SECOND YEAR

1st Semester 12 units		2nd Semester 12 units	
Core Course[1]	3	Core Course[1]	3
Core Course[1]	3	Course in Field of Specialization[2]	3
Course in Field of Specialization[2]	3	EnE Elective[3]	3
EnE Elective[3]	3	EnE 400	3

THIRD YEAR

1st Semester 6 units		2nd Semester 3 units	
EnE 400	6	EnE 400	3

For BS degree holders
[1] Core Courses (27 units): EnE 205, EnE 212, EnE 250, EnE 270, EnE 280, EnE 302, EnE 303, EnE 304, EnE 305
[2]Courses in the Field of Specialization (12 units): Air Pollution: EnE 251, ME 286, ME 287, MSE 267; Solid and Hazardous Waste: EnE 372, EnE 382, CE 318, CE 264; Water and Wastewater: EnE 210, EnE 213, EnE 214, EnE 215
[3]Electives: EnE 220, ChE 233, EnE 298, CE 236, CE 298, CE 315, CE 316, GE 202, GE 203, IE 230, Geology 205, Geology 274

Checklists for Undergraduate and Graduate programs are for guidance of students only and are based on approved Program of Study (POS)

DOCTOR OF PHILOSOPHY IN ENERGY ENGINEERING
38 units*

APPROVAL
126th UPD UC: 24 April 2013 | President AEPascual: 14 August 2013

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
EgyE 236	3	EgyE 332	3
EgyE 320	1	Specialty Course[1]	3
Specialty Course[1]	3	Applied Math[2]	3
Elective	3	EgyE Special Project	3

SECOND YEAR

1st Semester 4 units		2nd Semester 4 units	
EgyE 296	1	EgyE 296	1
EgyE 400	3	EgyE 400	3

THIRD YEAR

1st Semester 3 units		2nd Semester 3 units	
EgyE 400	3	EgyE 400	3

**For MS EgyE degree holders*

[1] Specialty Courses: EgyE 220, EgyE 221, EgyE 222, EgyE 223, EgyE 235, EgyE 251, EgyE 272, EgyE 273, EgyE 321, EgyE 322, EgyE 323, EgyE 324, EgyE 331
Other Specialty courses that may be taken subject to the consent of instructor or department offering the course: An advanced Course in Thermodynamics, An Advanced Course in Heat, Mass &/or Momentum Transfer, ChE 229, ChE 231, EE 355, CE 211, CE 212, EE 357, EE 358, GE 202, GE 203, GE 204, IE 241, IE 242, ME 224, ME 286, ME 287
Other graduate courses more suited to the student's research interest and background may be taken from the College of Engineering, or from other colleges upon consent of the instructor or department offering the course.

[2] Applied Mathematics: Student may choose from Applied Mathematics Courses offered by the College of Engineering such as but not limited to: ES 201, ES 202, ES 204, IE 211, IE 214, EE 214, IE 230 or any graduate course in mathematics as recommended by the program/thesis adviser and approved by the Program Committee of the energy program.
Applied Mathematics courses may also be taken from the College of Science and the School of Statistics upon the consent of the instructor or department offering the course.

DOCTOR OF PHILOSOPHY IN ENERGY ENGINEERING
39 units*

APPROVAL
126th UPD UC: 24 April 2013 | President AEPascual: 14 August 2013

FIRST YEAR

1st Semester 10 units		2nd Semester 9 units	
EgyE 201	3	EgyE 211	3
EgyE 205	1	EgyE 231	3
Specialty Course[1]	3	Applied Math[2]	3
EgyE 320	3		

SECOND YEAR

1st Semester 7 units		2nd Semester 4 units	
Elective	3	EgyE 296	1
EgyE Special Project	3	EgyE 400	3
EgyE 296	1		

THIRD YEAR

1st Semester 3 units		2nd Semester 6 units	
EgyE 400	3	EgyE 400	6

**For MS Allied Field*

[1] Specialty Courses: EgyE 220, EgyE 221, EgyE 222, EgyE 223, EgyE 235, EgyE 251, EgyE 272, EgyE 273, EgyE 321, EgyE 322, EgyE 323, EgyE 324, EgyE 331
Other Specialty courses that may be taken subject to the consent of instructor or department offering the course: An advanced Course in Thermodynamics, An Advanced Course in Heat, Mass &/or Momentum Transfer, ChE 229, ChE 231, EE 355, CE 211, CE 212, EE 357, EE 358, GE 202, GE 203, GE 204, IE 241, IE 242, ME 224, ME 286, ME 287
Other graduate courses more suited to the student's research interest and background may be taken from the College of Engineering, or from other colleges upon consent of the instructor or department offering the course.

[2] Applied Mathematics: Student may choose from Applied Mathematics Courses offered by the College of Engineering such as but not limited to: ES 201, ES 202, ES 204, IE 211, IE 214, EE 214, IE 230 or any graduate course in mathematics as recommended by the program/thesis adviser and approved by the Program Committee of the energy program.
Applied Mathematics courses may also be taken from the College of Science and the School of Statistics upon the consent of the instructor or department offering the course.

DOCTOR OF PHILOSOPHY IN ENERGY ENGINEERING
60 units*

APPROVAL
126th UPD UC: 24 April 2013 | President AEPascual: 14 August 2013

FIRST YEAR

1st Semester 12 units		2nd Semester 11 units	
EgyE 201	3	EgyE 205	1
EgyE 211	3	EgyE 320	3
EgyE 231	3	EgyE 332	3
EgyE 236	3	Applied Math[2]	3
		EgyE 296	1

SECOND YEAR

1st Semester 12 units		2nd Semester 12 units	
Applied Math[2]	3	Specialty Course[1]	3
Applied Math[2]	3	Elective	3
Specialty Course[1]	3	Elective	3
Specialty Course[1]	3	EgyE Special Project	3

THIRD YEAR

1st Semester 4 units		2nd Semester 3 units	
EgyE 296	1	EgyE 400	3
EgyE 400	3		

FOURTH YEAR

1st Semester 3 units		1st Semester 3 units	
EgyE 400	3	EgyE 400	3

**For BS Allied Field*

[1] Specialty Courses: EgyE 220, EgyE 221, EgyE 222, EgyE 223, EgyE 235, EgyE 251, EgyE 272, EgyE 273, EgyE 321, EgyE 322, EgyE 323, EgyE 324, EgyE 331
Other Specialty courses that may be taken subject to the consent of instructor or department offering the course: An advanced Course in Thermodynamics, An Advanced Course in Heat, Mass &/or Momentum Transfer, ChE 229, ChE 231, EE 355, CE 211, CE 212, EE 357, EE 358, GE 202, GE 203, GE 204, IE 241, IE 242, ME 224, ME 286, ME 287
Other graduate courses more suited to the student's research interest and background may be taken from the College of Engineering, or from other colleges upon consent of the instructor or department offering the course.

[2] Applied Mathematics: Student may choose from Applied Mathematics Courses offered by the College of Engineering such as but not limited to: ES 201, ES 202, ES 204, IE 211, IE 214, EE 214, IE 230 or any graduate course in mathematics as recommended by the program/thesis adviser and approved by the Program Committee of the energy program.
Applied Mathematics courses may also be taken from the College of Science and the School of Statistics upon the consent of the instructor or department offering the course.

DOCTOR OF PHILOSOPHY (MATERIALS SCIENCE AND ENGINEERING)
For MSE Degree Holders 36 units

APPROVAL
28th UPD UC : 21 April 1992

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
MSE Specialization Course[1]	3	MSE Specialization Course[1]	3
MSE Specialization Course[1]	3	MSE Specialization Course[1]	3
MSE Specialization Course[1]	3	MSE Specialization Course[1]	3
MSE Specialization Course[1]	3	MSE Specialization Course[1]	3

SECOND YEAR

1st Semester 3 units		2nd Semester 3 units	
Comprehensive Examination		Candidacy Examination	0
MSE 296	(1)	MSE 400	3
MSE 400	3		

THIRD YEAR

1st Semester 3 units		2nd Semester 3 units	
MSE 400	3	MSE 400	3

Specialization Courses: MSE 243, MSE 243.1, MSE 245, MSE 245.1, MSE 253, MSE 255, MSE 265, MSE 266, MSE 267, MSE 268, MSE 271, MSE 271.1, MSE 271.2, MSE 275, MSE 276, MSE 281, MSE 282, MSE 283, MSE 283.1, MSE 285, MSE 286, MSE 287, MSE 287.1, MSE 298

DOCTOR OF PHILOSOPHY (MATERIALS SCIENCE AND ENGINEERING)
For Straight PhD in MSE Program 58 units*

APPROVAL
28th UPD UC : 21 April 1992

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
MSE 201*	3	MSE 225	3
MSE 231	3	MSE 233	3
MSE 241	3	MSE 251	3
ES 201/ES 204**	3	MSE Laboratory Core Course[1]	1
		MSE Laboratory Core Course[1]	1
		MSE Laboratory Core Course[1]	1

SECOND YEAR

1st Semester 12 units		2nd Semester 12 units	
MSE Laboratory Core Course[1]	1	MSE Specialization Course[2]	3
MSE Laboratory Core Course[1]	1	MSE Specialization Course[2]	3
MSE Laboratory Core Course[1]	1	MSE Specialization Course[2]	3
MSE Specialization Course[2]	3	MSE Specialization Course[2]	3
MSE Specialization Course[2]	3		
MSE Specialization Course[2]	3		

THIRD YEAR

1st Semester 4 units		2nd Semester 3 units	
Preliminary Examination		Candidacy Examination	
MSE 296	1	MSE 400	3
MSE 400	3		

** Students with Metallurgical or Materials Engineering background must take a 3-unit specialization course instead of MSE 201*
*** Students with Geology or Engineering background are required to take at least an additional 3-unit of advanced mathematics; Advanced Mathematics: ES 201, ES 202, ES 203, ES 204*

[1] Laboratory Core Course: MSE 211, MSE 212, MSE 213, MSE 214, MSE 215, MSE 216, MSE 217, MSE 218, MSE 219

[2] Specialization Courses: MSE 243, MSE 243.1, MSE 245, MSE 245.1, MSE 253, MSE 255, MSE 265, MSE 266, MSE 267, MSE 268, MSE 271, MSE 271.1, MSE 271.2, MSE 275, MSE 276, MSE 281, MSE 282, MSE 283, MSE 283.1, MSE 285, MSE 286, MSE 287, MSE 287.1, MSE 298

DOCTOR OF ENGINEERING /PHILOSOPHY (CHEMICAL ENGINEERING)
For BS Graduate 57 units

APPROVAL
30th UPD UC : 12 December 1992 | BOR : 25 January 1993

FIRST YEAR

1st Semester 12 units		2nd Semester 12 units	
ES 201	3	ES 202	3
ChE 220	3	ChE 242	3
ChE 229	3	ChE 248	3
ChE 241	3	ChE 231	3

SECOND YEAR

1st Semester 12 units		2nd Semester 12 units	
ChE 205	3	ChE 247	3
ES 204	3	ChE 250	3
ChE 211	3	ChE 251	3
ChE 261	3	ChE 291	3
Qualifying Exam			

THIRD YEAR

1st Semester 12 units	
ChE 400	12

DOCTOR OF ENGINEERING /PHILOSOPHY (CHEMICAL ENGINEERING)
For MS Graduate 37-40 units

APPROVAL
30th UPD UC : 12 December 1992 | BOR : 25 January 1993

1st Semester 12 units		2nd Semester 12 units	
ChE 233	3	ChE 248	3
ChE 205	3	ChE 261	3
ChE 211	3	ChE 247	3
ChE 266	3	ChE 250	3

3rd Semester 13-16 units	
ChE 296	1-4
ChE 400	12

Checklists for Undergraduate and Graduate programs are for guidance of students only and are based on approved Program of Study (POS)

DIPLOMA IN REMOTE SENSING
21 units

APPROVAL
28th UPD UC : 21 April 1992

Core Course 12 units		Electives 9 units	
GE 202	3	Electives*	9
GE 203	3		
GE 204	3		
GE 215	3		

*Elective**
Electives to be chosen with the approval of the adviser

COURSE OFERINGS

DEPARTMENT OF CHEMICAL ENGINEERING

UNDERGRADUATE

Chemical Engineering (ChE)

2 **Elementary Chemical Engineering.** Elementary mass and energy balances for some unit operations and unit processes. (For non-chemical engineering students). Prereq: Chem 16, Math 17. 3 u.

26 **Fundamentals of Programming for Chemical Engineers.** Concepts and methods of programming as a computational tool; computer solutions to mathematical problems in chemical engineering. Prereq: Math 53. 5 h. (2 lec, 3 lab) 3u.

100 **Introduction to the Chemical Engineering Profession.** Introduction to chemical engineering: history and emerging trends in various fields. The role of chemical engineers in the development of society. The chemical engineering profession. Overview of unit operations, mass and energy balances, and chemical reaction engineering. Prereq: Chem 16. (1 lec) 1 u.

101 **Fundamentals of Chemical Engineering.** Problem-solving techniques in solving chemical engineering problems; Mass and energy balances in unit operations and unit processes; Principles of phase equilibrium as a applied to unit operations. Prereq: Chem 17, Math 53, ChE 100. 6 h. (3 lec, 3 lab) 4 u.

106 **Mathematical Methods in Chemical Engineering.** Mathematical solutions of problems in chemical engineering. Analytical and numerical solutions to ordinary and partial differential equations. Vector analysis. Prereq: ChE 26, Math 55, ChE 101. 5 h. (2 lec, 3 lab) 3u.

122 **Chemical Engineering Thermodynamics I.** Application of the first and second laws of thermodynamics to closed and open systems, flow and non-flow processes. Thermodynamic properties of fluids. Power cycles, refrigeration and liquefaction processes. Prereq: ChE 101, Math 55. 3 u.

123 **Chemical Engineering Thermodynamics II.** Thermodynamic properties of homogeneous mixtures. Phase and chemical reaction equilibria. Calculations involving models on homogeneous mixtures, phase and chemical reaction equilibria. Prereq: ChE 122, ChE 106. 3 u.

124 **Chemical Engineering Thermodynamics Laboratory.** Experiments on the PVT behavior, phase and chemical reaction equilibria and thermodynamic properties of homogeneous mixtures. Prereq: Chem 154, Chem 28, Chem 28.1, Chem 31.1. 6 h. (lab) 2 u.

125 **Chemical Reaction Engineering I.** Kinetics of homogeneous reactions. Analysis of various chemical reactors. Prereq: ChE 122, ChE 106, Chem 31. 3 u.

126 **Chemical Reaction Engineering II.** Kinetics of heterogeneous reactions. Catalysis. Heterogeneous reactors. Application of kinetics and thermodynamics to selected unit processes. Prereq: ChE 125, ChE 131. 3 u.

131 **Transport Processes.** Fundamentals of heat, mass and momentum transport. Differential balances; equations of change. Molecular and turbulent transport systems. Applications to interphase transfer. Prereq: ChE 106. 3 u.

132 **Stagewise Operations.** Unified treatment of stagewise operations. Numerical and graphical solution techniques. Design of multistage equipment. Prereq: ChE 106, ChE 123. 3u.

133 **Heat and Mass Transfer Equipment Design.** Applications of the principles of separation and rate processes to the design of heat and mass transfer equipment. Prereq: ChE 131. 5h (2 lec, 3 lab). 3 u.

134 **Momentum Transfer and Materials Handling Equipment Design.** Application of the principles of momentum transfer to process equipment design. The energy balance in flow systems. Materials handling. Prereq: ChE 131. 5 h. (2hlec, 3h lab) 3 u.

135 **Process Engineering Laboratory.** Experimental study of certain unit operations and processes. Prereq: ChE 133, ChE 134, ChE 125. 6 h. (lab) 2 u.

140 **Chemical Process Industries.** Survey of the different industrial chemical processes. Unit processes and operations in chemical industries. Mass and energy balances in industrial processes. Prereq: ChE 125, ChE 132, ChE 133, ChE 134. 5 h. (2h lec, 3h lab) 3 u.

141 **Chemical Process Development and Plant Economics.** Application of engineering economics to process flow synthesis and industrial plant design. General chemical process design considerations; Optimization of plant processes. Economic feasibility study. Prereq: ChE 140. 5 h. (2h lec, 3h lab) 3 u.

142 **Chemical Engineering Plant Design.** Chemical engineering components of the design of a chemical process industrial plant. Design of waste treatment and pollution management facilities. Prereq: ChE 141, ChE 150. 7 h. (1h lec, 6h lab) 3 u.

143 **Chemical Engineering Research I.** Design of Experiments. Conceptualization and proposal writing for a chemical engineering research project. Technical paper writing and presentation. Prereq: ChE 135, ChE 124. 4 h. (1h lec, 3h lab) 3u.

144 **Chemical Engineering Research II.** Continuation of ChE 143. Research project implementation. Prereq: ChE 143. (6h lab) 2u.

150 **Environmental Process Engineering.** Introduction on environmental systems and impacts of land use and industrial processes; environmental processes; nature, transport and reactions of environmental contaminants; environmental quality management; chemical engineering principles in gaseous, liquid, and solid waste treatment; sanitation and public health; waste management; sustainability. Prereq: Chem 31, ChE 125, ChE 134. 3u.

153 **Industrial Pollution Control.** Types, source and harmful effects of industrial pollutants. Measurement of pollution parameters. Industrial Pollution Prevention and Control. Prereq: Chem 31, ChE 125, ChE 134. 3 h. (lec) 3 u.

171 **Introduction to Biochemical Engineering.** Basic microbiology and biochemistry. Enzyme and fermentation kinetics. Continuous culture. Mass transfer in biological system. Prereq: Chem 31, Nat Sci 2. 3 u.

174 **Biochemical Engineering Laboratory.** Elementary experiments in biochemical engineering. Coreq: ChE 171. 3 h. (lab) 1 u.

182 **Chemical Process Dynamics and Control.** Introduction to process dynamics of simple chemical systems. Objectives and performance criteria of control systems. Prereq: ChE 125, ChE 133, ChE 134. 5 h. (2lec, 3 lab) 3 u.

190 **Plant Inspection and Seminar.** Visits to factories, chemical plants. Reports on such visits. Reports on assigned readings from technical literature. Prereq: ChE 140. 3 h. (lec) 1 u.

197 **Special Topics.** 3 u.; may be taken twice.

198 **Special Problems.** 3 u.; may be taken twice.

GRADUATE

Chemical Engineering (ChE)

202 **Biotechnology For Engineers.** Fundamentals and applications of biotechnology in engineering and industry; large-scale processes; products. Prereq: Chem 40, 40.1; BIO 120/equiv. 5h (2h lec, 3h lab). 3 u.

205 **Advanced Chemical Engineering Laboratory.** Study of research methods. Design of chemical engineering experiments and laboratories; equipment in unit operations; and chemical reactors. Computer-aided design. Prereq: ChE 136/equiv. 7 h. (1 class, 6 lab). 3 u.

211 **Optimization Methods in Chemical Engineering.** Application of linear, non-linear programming and other optimization methods to chemical engineering problems. Prereq: ES 204/ COI. 3 u.

220 **Advanced Chemical Engineering Thermodynamics I.** Thermodynamics of solutions. Multicomponent phase and chemical reaction equilibria. Prereq: ChE 123/equiv. 3 u.

221 **Advanced Chemical Engineering Thermodynamics II.** Application of thermodynamic principles to complex systems. Statistical thermodynamics. Introduction to non-equilibrium thermodynamics. Prereq: ChE 220/COI. 3 u.

224 **Electrochemical Engineering.** Applications of the basic concepts of electrochemistry to industrial processes. Design of continuous feed galvanic cells. Prereq: ChE 123/equiv. 3 u.

229 **Advanced Chemical Reaction Engineering I.** Reactor design for homogeneous reactions. Prereq: ChE 125. 3 u.

231 **Advanced Chemical Reaction Engineering II.** Reactor design for heterogeneous reactions. Prereq: ChE 125, ES 201/equiv. 3 u.

233 **Biochemical Reactor Design.** Design of various types of fermenter and biological reactors. Scale up. Prereq: ChE 231, 241. 3 u.

237 **Properties of Biological Materials.** Rheological, elastic, thermal, diffusive and chemical properties of biological materials in relation to biochemical reactor design. Property measurements. Prereq: COI. 3 u.

241 **Transport Phenomena.** Momentum, heat, and mass transport in solid, fluid and multi-phase systems. Laminar and turbulent flow of Newtonian and non-Newtonian fluids. Solution of the equations of continuity, motion, energy, and mass transfer. Prereq: ChE 133/equiv. 3 u.

242 **Advanced Heat Transmission.** Conductive and convective heat transfer in single and multiphase systems. Energy transport in macroscopic flow systems. Radiant heat transfer. Prereq: ES 201, ChE 133/equivs. 3 u.

244 **High Temperature Processes.** Solidification, homogeneous and heterogeneous nucleation, dendritic growth, topochemical gas-solid reactions and other high temperature processes. Prereq: ChE 242/COI. 3 u.

245 **Heat Transmission Laboratory.** Experiments illustrating the principles of heat transmission. Prereq: ChE 242. 3 u.

246 **Cryogenic Engineering.** Principles and applications of low temperature processes. Prereq: ChE 242/ COI. 3 u.

247 **Advanced Mass Transfer.** Diffusion in binary and multi-component systems. Simultaneous mass and heat transfer. Applications to chemical engineering operations. Prereq: ChE 133/equiv. 3 u.

248 **Stagewise Operations.** Phase equilibria; distillation and other multistage separation processes. Stage efficiencies. Prereq: ChE 133/equiv. 3 u.

250 **Computer-Aided Process Equipment Design.** Mathematical modelling, simulation and design of chemical process equipment. Use of available software for design. Prereq: ES 201, 204. 3 u.

251 **Advanced Chemical Process Dynamics and Control.** Application of regulation control theory to different chemical engineering operations and processes. Introduction to model analysis. Prereq: ChE 172/equiv. 3 u.

261 **Advanced Industrial Pollution Control.** Colloid stability. Kinetics of coagulation and flocculation. Design of industrial pollution equipment. Prereq: ChE 173/equiv. 3 u.

266 **Waste Utilization.** Utilization of agricultural and industrial wastes. Prereq: ChE 141/equiv. 3 u.

291 **Corrosion Engineering.** Corrosion theories. Thermodynamics and kinetics of corrosion. Measurement and control. Prereq: ChE 123, 125/equivs. 3 u.

292 **Biochemical Engineering.** Integration of the principles of chemical engineering, biochemistry and microbiology with application to the analysis of biochemical reaction sequences and related transport phenomena in fermentation operations. Prereq: ChE 202. 3 u.

293 **Enzyme Engineering.** Application of biochemical engineering principles to enzyme technology. Prereq: ChE 202. 3 u.

294 **Biochemical Engineering Practice.** Biochemical engineering experiments. Enzyme and whole cell immobilization. Pilot plant fermentation experiments. Prereq: ChE 202. 7 h. (1h lec, 6h lab) 3 u.

296 **Seminar.** 1 u.; maximum of 4 u.

296.1 **Seminar in Chemical Engineering.** Readings and public presentation on current research, issues and topics in chemical engineering. 1 h (seminar). 1 u.

296.1 **Research Seminar in Chemical Engineering.** Conceptualization, conduct of research and preparation of scientific manuscrpits on a research problem in chemical engineering. Prereq: ChE 296.1. 1 h (seminar). 1 u.

297 **Special Topics.** 3 u.; may be taken twice.

298 **Special problems.** 3 u.; may be taken twice, topics to be indicated for record purposes.

300 **Thesis.** 3 to 6 u.

400 **Dissertation.** 12 u.

INSTITUTE OF CIVIL ENGINEERING

GENERAL EDUCATION COURSE

Civil Engineering (CE)

10 **DMAPS: Disaster Mitigation, Adaptation and Preparedness Strategies.** Introduction to principles and practices of natural disaster and risk management by mitigation, adaptation, and preparedness strategies through civil engineering and related disciplines aiming for resilience. 3 u.

UNDERGRADUATE

Civil Engineering (CE)

14 **Solid Mechanics.** Introduction to continuum mechanics; special topics in mechanics, such as non-homogenous members, inelastic behavior, unsymmetrical bending, torsion, energy methods and applications. Prereq: ES 13. 3u.

15 **Fluid Mechanics for Civil Engineering I.** Fluid properties, flow variables: pressure, velocity and viscous stresses. Differential and integral formulations of continuity, momentum, and energy conservation principles. The Navier-Stokes equation, solution to special cases: fluid statics, ideal flow and viscous incompressible flow. Analytical and computational

techniques. Fluid instrumentation. Physical and numerical experiments with civil engineering applications. Prereq: ES 12. Co-req: CE 15, CE 27. 5 hrs. (2 lec, 3 lab) 3 u.

16 **Fluid Mechanics for Civil Engineering II.** Principles of similitude and dimensional analysis. Application to closed-conduit flow, flow around immersed bodies and open-channel flows. Case studies in pipe flow, flow through structures, flow around civil works structures, and flow through porous media. Prereq: CE 15. 4 hrs. (1 lec, 3 lab). 2 u.

21 **Engineering Statistics.** Frequency distribution, averages, measures of variation, simple probability, theory of large and small sampling. Correlation and applications in engineering. Prereq: Math 53. 3 u.

22 **Engineering Economy.** The fundamentals of engineering decisions. Relative economy of alternative materials, methods, processes, designs. Prereq: 4th year standing. 3 u.

26 **Analytical and Computational Methods in Civil Engineering I.** Programming concepts and methods; algorithms and software; matrix operatoins; concepts of dicrete mathematics. Prereq: Math 53. 5h (2h lec, 3h lab). 3u.

27 **Analytical and Computational Methods in Civil Engineering II.** Eigenvalue problems; nonlinear equations; function approximations; ordinary differential equations; analytical and numerical solutions of ordinary differential equations; vector analysis. Math 53, CE 26. 5h (2h lec, 3h lab). 3u.

28 **Analytical and Computational Methods in Civil Engineering III.** Partial differential equations; analytical and numerical solution of partial differential equations; Fourier series; tensor analysis; calculus of variations. CE 27. 5h (2h lec, 3h lab). 3u.

49 **City Planning.** Historical background of modern city planning. Some legal aspects of planning such as zoning laws, building codes, and private deed restrictions. Problems in site planning with relation to physical conditions, landscape construction and costs. Use of contour maps, layout of roads, grouping of buildings, surface and sub-surface drainage, utilities, and community services. Prereq: GE 12. 1 u.

110 **Hydrology.** Weather and hydrologic cycle; precipitation, evaporation, transpiration and infiltration; ground water flow; rainfall-runoff relations; unit hydrograph; storage and channel routing; flood and drought frequency analysis. Prereq: CE 15, CE 21. 3 u.

111 **Hydraulic Engineering.** Sizing of reservoirs; hydraulic analysis and design of dams, spillways, gates, outlet works, open channels and pressure conduits; sediment transport; pipe network analysis; theory of hydraulic machinery. Prereq: CE 16. 3 u.

112 **Water Reasource Engineering.** River Engineering; flood and sediment control; drainage; irrigation; hydropower; water supply; inland navigation; multyipurpose projects; integrated water resources management. Prereq: CE 110, CE 111. 3 u.

113 **Coastal Engineering.** Water waves; short- and long-term analyses; wave generation; tides and water levels; wave transformation and breaking; wave forces; design of structures; shore processes; shore protection; computational tools. Prereq: CE 16, CE 162. 3u.

114 **Multipurpose Water Resources Development.** Graphic and analytical optimization techniques; optimization by simulation; planning and implementation. Prereq: CE 112. 3 u.

121 **Construction Materials.** Engineering properties of common construction materials (soils, aggregates, concrete, metals, wood, and composite); concrete mix design; standard test methods; non-destructive testing; testing of small-scale structural elements. Prereq: ES 13, CE 21. 5 h. (2 lec, 3 lab) 3 u.

123 **Construction Engineering and Management I.** Project development processes, personalities, and project organization; legal and ethical aspects of the civil engineering profession; project documents and service engagement procedures; contract administration.PrereqCE 121. 2 u.

124 **Construction Engineering and Management II.** Cost engineering; productivity; quantitative methods for construction; site lay-out; planning and scheduling; construction equipment and methodology; pricing and bid strategy; network analysis; resource allocation; software application. Prereq: CE 22, CE 123. 3 u.

125 **Construction Engineering and Management III.** Site management; total quality approach; problem solving and decision-making; effective communication; motivation and leadership; resource management. Prereq: CE 124. 3u.

131 **Elements of Environmental Engineering.** Engineering principles in environmental sanitation and public health. Environmental effects of engineering projects. Prereq: Chem 16. 3 u.

132 **Sanitary Engineering I.** Unit operations in water and waste water treatment. Design of water and wastewater treatment plants. Prereq: CE 16, CE 131. 3 u.

133 **Sanitary Engineering II.** Engineering applications of new concepts of physical-chemical wastewater treatment. Prereq: CE 132. 3 u.

134 **Hazardous Waste Minimization.** Hazardous waste minimization as a waste management strategy; waste minimization techniques. Prereq: COI. 3 u.

135 **Environmental Geotechnology.** Landfill control and uses; contaminated groundwater and seepage; soil/ environment and soil/pollutant interaction; hazardous waste control and storage systems; durability and protection of geostructural members hazardous ground. Prereq: CE 131, 162. 3 u.

141 **Transportation Engineering I.** Characteristics of transportation systems; introduction to trasportation planning; traffic flow fundamentals; transportation and traffic surveys. Prereq: CE 21, CE 27. 3 u.

142 **Transportation Engineering II.** Planning and design of transportation facilities; road, rail, air, and water transportation. Prereq: GE 12, CE 141, CE 162. 3 u.

143 **Transportation Engineering III.** Urban transport planning and design using statistical techniques, computer methods, modelling and optimization. Policy formulation. Case studies. CE 142. 3 u.

155 **Structural Analysis.** Theory and applications of methods of structural analysis; influence lines. Preres: CE 14, CE 28. 3u.

156 **Design of Steel Members.** Behavior and design of structural steel members subject to axial load, flexure, shear and combined loads; connection design. Prereq: CE 155. 3u.

157 **Design of Reinforced Concrete Members.** Behavior and design of reinforced concrete members subject to axial load, flexure, shear; serviceability requirements. Prereq: CE 155. 3u.

158 **Structural Engineering Elective.** Selected topics in structural engineering. Prereq: CE 156, CE 157.3 u.

162 **Geotechnical Engineering I.** Geomorphology; phase relationships; soil plasticity; soil clariffication; mechanics of soils; shear strength of soild; compressibility of soils; soil permeability and seepage analysis. Prereq: Geol 11, ES 13, CE 15. 5 h. (2lec, 3 lab) 3 u.

163 **Geotechnical Engineering II.** Site investigations; lateral earth pressures; earth retaining structures; slope stability; bearing capacity and settlements; shalow and deep foundations; ground improvement techniques. Prereq: CE 162. 3 u.

164 **Geotechnical Engineering III.** Soil and rock dynamics. Seismicity and seismic risk analysis. Finite element analysis in geotechnical engineering. Special topics in geotechnical engineering. Prereq: CE 163. 3 u.

180 **Seminar.** Prereq: SS. 3 h. (lab). 1 u.

190 **Seminar and Research Methods in Civil Engineering.** Development of research proposal. Prereq: COI. 3 h . (lab) 1 u.

197 **Special Topics.** Prereq: COI. 3 u.; may be taken twice, topics to be indicated for record purposes.

198 **Special Problems.** Prereq: Candidacy for graduation. 3 u.

199 **Undergraduate Research Project.** Implementation or research project. Prereq: CE 190. 7h (1h lec, 6h lab). 3u.

GRADUATE

Civil Engineering (CE)

201 **Matrix Theory of Structures.** Structural theorems and strain energy concepts; matrix network formulation of structural analysis; vector transformations; linear structural elements and assemblages; constraints and releases. Prereq: COI. 3 u.

206 **Energy Methods in Civil Engineering.** Principle of virtual work; methods of weighted residuals; variational principles; energy principles; applications to linear and nonlinear problems. Prereq: ES 230/COI. 3 u.

211 **Free Surface Flow.** Open channel flow, the hydraulic jump, backwater curves. Waves and surges in canals and docks. River control, flood routing, and reservoir operations. Prereq: ES 15/equiv. 3 u.

212 **Applied Hydrology.** Basic hydrologic principles; hydrograph analysis. Modern hydrologic techniques applicable to problems in water power, water supply, irrigation and flood control. Prereq: ES 15. 3 u.

213 **Advanced Hydrology.** Probable maximum precipitation, estimation of maximum floods, statistical methods in hydrology. Prereq: CE 212. 3 u.

214 **Groundwater Development.** Groundwater movement, storage and exploration, basic principles of groundwater flow and aquifer testing; well design, construction, production tests and maintenance, groundwater recharge and runoff; development and management of aquifers. Prereq: CE 110/ COI. 3 u.

215 **Water Resources Planning.** Concepts in water resources planning; water inventories, use and control; water conservation measures and legislation; single-purpose and multi-purpose project planning; economic and financial analysis. Prereq: CE 112/COI. 3 u.

216 **Theory of Plasticity.** Mathematical theory of plasticity; plastic stress-strain laws; yield functions and associated flow rules; applications to problems in flexure and torsion; plane plastic flow. Prereq: ES 201, 230. 3 u.

217 **Hydraulic Design.** Hydraulic structures, gravity structures, reinforced concrete structures, earth structures, various forces acting on hydraulic structures, economic consideration, open channel. Prereq: CE 111/COI. 3 u.

219 **Hydraulic Measurements.** Principles of design and operation of instruments for the measurement of pressure, velocity, discharged and related fluid flow characteristics. Prereq: ES 15/equiv. 4 h. (1 class, 3 lab) 2 u.

220 **Soil Erosion and Sedimentation.** Erosion control structures; sediment transport, stable channel design; desilting and diversion structures. Prereq: ES 15. 2 u.

222 **Advanced Concrete Technology.** Structure of concrete; engineering properties of concrete; behavior of fresh and hardened concrete; materials and processes for special concrete; recent advances in concrete technology. Prereq: COI. 3 u.

225 **Advanced Construction Engineering.** Problems of the construction industry, including organization, financing, bonding and insurance problems. Analysis and possible improvement of present-day techniques and equipment employed in heavy and building construction. Prereq: CE 124/ equiv. 3 u.

226 **Structural Dynamics.** Response of structural components to transient loads and foundation excitation; single- and multi-degree-of-freedom systems; viscous and proportional damping; modal method; response spectra; introduction to wave propagation in solids. Prereq: ES 21/COI. 3 u.

236 **Environmental Benefits and Costs in Civil Engineering Projects.** Analysis of environmental benefits and costs of alternative schemes and technologies for development projects in civil engineering. Prereq: COI. 3 u.

240 **Transportation Systems Analysis and Planning.** Elements and features of transport systems, technological and operational characteristics of various modes of transportation; tools for transport system analysis; land use/transport interaction; forecast of transport demand; principles of planning, design, operation, maintenance and management. Prereq: COI. 3 u.

241 **Airport Engineering.** Aircraft characteristics and performance related to planning of terminal facilities. Air traffic control and navigation systems. Planning of airport locations and airport complexes. Geometric design of runways, taxiways, etc. Pavement design. Environmental considerations. Prereq: CE 240,249. 3 u.

242 **Traffic Engineering and Management.** Traffic regulation, control, and traffic signal systems; accidents and their prevention; parking and terminal problems. Coreq: CE 246. 3 u.

243 **Highway Engineering.** Route location. Advanced geometric design of roads, highway intersections and interchanges. Design of pavement and road facilities. Highway capacity analysis. Traffic control. Prereq: CE 240, 249. 5 h. (2 class, 3 lab) 3 u.

244 **Port and Harbor Engineering.** Ship performance and characteristics. Capacity analysis. Passenger and freight flow handling. Design of port facilities. Prereq: CE 240, 249. 3 u.

245 **Mass Transit Engineering.** Design and operation of mass transit systems including vehicle, track, station and terminal, and control system design. Analysis of technological, operating and performance characteristics of mass transit systems including capacity, cost, level of service and efficiency. Prereq: CE 240, 249. 3 u.

246 **Transportation and Traffic Surveys.** Different surveys required to provide information for transportation planning and engineering; methods of conducting surveys; analysis and presentation of survey results.Prereq: CE 21/equiv, COI. 3 u.

247 **Transportation Economics and Evaluation.** Concepts and principles of transportation economic analysis; transportation costs and benefits; user and non-user consequences, needs studies, finance and taxation; methods of evaluation of plans and projects and cost-effectiveness. Prereq: COI. 3 u.

248 **Traffic Flow Theory and Analysis.** Traffic flow theories applied to intersections, road links, and terminals; queuing tools used in traffic flow analysis; applications to real life situations; analysis and forecasts of congestion. Prereq: CE 21/equiv, 246. 3 u.

249 **Planning and Design of Transportation Facilities.** Location, layout and design of different transport facilities; passenger and cargo handling facilities, pedestrian facilities. Prereq: COI. 3 u.

250 **Pre-Stressed Concrete.** Principles and methods in pre-stressed concrete construction; ultimate strength design; time-dependent variables; long-time deflections; load factors. Prereq: CE 153/equiv. 3 u.

251 **Structural Safety and Reliability.** Concepts and methods of probabilistic structural mechanics; statistical consideration of loads and structure resistances; engineering significance of statistical extremes; factors of safety; reliability against wind and earthquake forces. Prereq: CE 21/equiv. 3 u.

252 **Design of Metal Structures.** Theories of behavior of structural metal components; interpretation of codes and specifications in relation to theory and experimental results; buckling of metal elements; special problems in metal connections. Prereq: CE 153/equiv. 3 u.

253 **Design of Reinforced Concrete Structures.** Ultimate strength and behavior of reinforced concrete; structural components, recent developments in concrete technology; review of current research; design specifications. Prereq: CE 153/equiv. 3 u.

255 **Theory of Plates and Shells.** Fundamental theories of bending and buckling of plates; flat slab floor systems; folded plate structural elements, thin–walled members; theory of shells

applied to tanks, shell roofs, hipped plates, stability problems. Prereq: ES 21, CE 153/equivs. 3 u.

256 **Structural Design for Dynamic Effects.** Response of structural assemblies to transient loads and foundation excitation; inelastic structural systems; dynamic loading from blasts and earthquakes; criteria for blast and earthquake-resistant designs; non-proportional damping. Prereq: CE 259/COI. 3 u.

257 **Discrete Methods of Structural Analysis.** Discrete formulation of structural problems; idealization of solid media and structures as lumped-parameter and finite element systems; substructure analyses; mixed structural systems; non-linearity in structures; structure-medium interaction phenomena. Prereq: CE 201/equiv. 3 u.

258 **Plastic Structural Analysis and Design.** Behavior of steel beyond the elastic range; concept of the plastic hinge in forming collapse configurations; analysis of collapse mechanisms, requirements for stability; incremental collapse, optimum design. Prereq: CE 151/equiv. 3 u.

259 **Earthquake Engineering.** Concepts of plate tectonics, elastic rebound and fault movements; measures of earthquake size; geological evaluation; seismological evaluation; construction over active faults; soil dynamics and site response; structure response; structural design and detailing; retrofit of existing structures. Prereq: CE 226/COI. 3 u.

260 **Soil and Rock Testing.** Field and laboratory test of soils and rocks; developments in testing methods. Prereq: CE 162/equiv. 7 h. (1 class, 6 lab) 3 u.

261 **Soil and Rock Mechanics.** Physico-chemical, hydraulic, and stress-strain characteristics of soils and rocks; analysis of deformations and stability of earth and rock masses; seepage. Prereq: ES 230/COI. 3 u.

262 **Foundation Engineering.** Design and construction aspects of structural foundation systems; soil-rockstructure interactions; case studies. Prereq: CE 264/COI. 3 u.

263 **Soil and Rock Dynamics.** Dynamic characteristics of earth materials; wave phenomena in soil and rock masses; analysis and design of substructures and earth structures for dynamic loads. Prereq: ES 230; CE 226, 261. 3 u.

264 **Geotechnical Engineering.** Application of soil and rock mechanics and related principles to civil engineering problems. Prereq: CE 162/equiv. 3 u.

265 **Soil and Rock Engineering Problems.** Boundary value problems in soil and rock mechanics; numerical methods of solution. Prereq: CE 216, ES 202. 3 u.

266 **Earth Structures.** Design and construction of earth and rock fill dams, levees, bulkheads, embankments and other earth structures. Prereq: CE 264/COI. 3 u.

268 **Critical State Soil Mechanics.** Engineering models and soil mechanics; elasticity; plasticity and yielding of soils; elastic-plastic stress-strain models for soils; critical states; strength of soils; stress-dilatancy models; triaxial tests; stress paths; cam-clay model; application of elastic-plastic models. Prereq: CE260, 261. 3 u.

269 **Ground Improvement Techniques.** Problematic soils; stability analysis; ground settlements; mechanical modification and densification of soils; granular piles; preloading; vertical drains; dewatering and ground water control; chemical stabilization; soil reinforcement; tiebacks and ground anchors; underpinning; case studies. Prereq: CE 261. 3 u.

270 **Fundamental Coastal Hydrodynamics.** Linear water theory; engineering wave properties; tides; waves in shallow water; wave refraction; diffraction; combined refraction-diffraction; reflection; shoaling; wave breaking; wave forces on fixed structures. Prereq: ES 15/equiv course in fluid mechanics; Coreq: ES 201. 3 u.

273 **Coastal Sediment Transport.** Beach morphology; mechanism of sediment transport; sediment movement due to oscillatory flow; sediment transport rate; models of coastal sediment transport; shoreline change models; cross-shore sediment transport; longshore sediment transport; beach evolution due to coastal structures. Prereq: CE 270. 3 u.

291 **Bridge Design.** Historical development; types of bridges; methods of analysis and design; specifications for highway and railroad bridges; recent developments. Prereq; CE 252/COI; CE 253/COI. 3 u.

296 **Seminar.** 1 u.; maximum of 3 u.

297 **Special Topics.** 3 u.; may be taken twice; topics to be indicated for record purposes.

298 **Special Problems.** Prereq: COA and approval of the faculty member who will supervise the study. 3 u.; may be taken twice, topics to be indicated for record purposes. 300 Thesis. 6 u.

301 **Environmental Impact Assessment in Civil Engineering Projects.** Prediction and assessment of impacts on the environment of projects in the field of structural, geotechnical, water resources, transportation and construction engineering. Prereq: COI. 3 u

304 **Probabilistic Method in Civil Engineering.** Concepts and methods of probabilty and statistics; probabilistic modeling; statistical decision theory; risk analysis; reliability analysis; probabilistic-based design; Markov and queuing models; Monte Carlo simulation; applications in civil engineering. Prereq: COI. 3 u.

306 **Finite Element Methods in Civil Engineering I.** Modeling; formulation and numerical solutions to linear problems using finite element method. Prereq: ES 201, 204. 3 u.

307 **Finite Element Methods in Civil Engineering II.** Modeling; formulation and numerical solution of nonlinear problems using finite element method. Prereq: ES 306/COI. 3 u.

308 **Mechanics of Fracture and Fatigue.** Elastic stresses at a crack; energy and stress intensity criteria for crack growth; effect of plastic zone at the crack; fracture testing; fatigue characterization by stress-life and strain-life; damage index; crack propagation; fail safe and safe life analyis. Prereq: ES 230/COI. 3 u.

311 **River Mechanics and Sediment Transport Modeling.** Overview of river mechanics; erosion and sedimentation; one-and-two dimensional flow; unsteady open channel flow equations; velocity profiles; mechanics of sediment-laden flows; incipient motion; bedforms; bedload; suspended load and total load; mathematical modeling of river and reservoir sedimentation. Prereq: COI. 3 u.

313 **Stochastic Tehniques in Water Resources.** Time series analysis; spatial analysis; applications of stochastic techniques to water resource systems. Prereq: COI. 3 u.

315 **Mathematical Modeling of Water Resources Systems.** Modeling concepts and approaches; methods of solutions; applications to watershed hydrology; river; lake and estuarine flow hydraulics; and groundwater flow. Prereq: COI. 3 u.

316 **Optimization and Simulation of Water Resources Systems.** Concepts and models of water resources systems; simulation and optimatization models; application to watersheds, rivers, lakes, reservoir, groundwater aquifer and conjuctive use of surface and groundwater resources; simulation and optimization techniques incorporating risk and uncertainty. Prereq: COI. 3 u.

318 **Groundwater Flow and Contaminant Transport.** Basic concepts and mechanisms of groundwater flow and contaminant transport; derivation of general groundwater flow equation; methods of solutions of groundwater flow equation; mass transport in saturated groundwater zone, derivation of advection dispersion equations; transformation; attenuation or retardation mechanisms; methods of solution of mass transport equations; mass transport in the unsaturated zone; groundwater remediation measures. Prereq: COI. 3 u.

322 **Advanced Topics in Concrete Technology.** Modeling of concrete structure and behavior; concrete micromechanics. Prereq: CE 222/COI. 3 u.

340 **Advanced Transportation Systems Analysis and Planning.** Disaggregate models in transportation; fuzzy logic; advanced tools in planning including geographic information system (GIS) applications. Prereq: CE 240. 3 u.

341 **Advanced Traffic Flow Theory and Analysis.** Traffic theories applied to highways and intersections; macroscopic and microscopic analyses of traffic flow-hydrodynamic analogies; gap acceptance; car following. Prereq: CE 248. 3 u.

342 **Advanced Traffic Engineering and Management.** Application of computer simulation, expert systems and intelligent transportation systems (ITS) for solving and evaluating traffic problems. Prereq: CE 242. 5 h. (2 lec, 3 lab) 3 u.

350 **Advanced Structural Analysis.** Material and geometric nonlinear problems; stability analysis; nonlinear analysis strategies and numerical techniques. Prereq: CE 250. 3 u.

351 **Random Structural Vibrations.** Probability distributions for maxima and extreme values; stationary and ergodic random processes; excitation and response autocorrelation functions; spectral density functions; response characteristics of lightly-damped, linear, narrow-band systems; stochastic response of linear system with multiple degrees of freedom; extreme response of nonlinear systems. Prereq: CE 251, 256, 304. 3 u.

352 **Advanced Design of Metal Structures.** Design of continuous beams, plate girders, composite steel and concrete members, steel plates and shells; braced and unbraced frames. Prereq: CE 252/COI. 3 u.

353 **Advanced Design of Reinforced Concrete Structures.** Members subject to bi-axial bending and axial load; slenderness effects on beam-columns; seismic design provisions; design for torsion; two-way slabs. Prereq: CE 253/COI. 3 u.

356 **Advanced Structural Dynamics.** Methods of structural dynamics for discretized and continuous systems in free and forced vibration; formulation and solution of partial differential equation of motion; potential and kinetic energy methods; mode-superposition; Rayleigh quotient; numerical solution to the eigenvalue problem; direct integration methods; frequency domain analysis; introduction to nonlinear dynamics. Prereq: CE 256. 3 u.

358 **Wind Engineering.** Concepts of atmospheric boundary layer; extreme wind climatology; wind tunnel; bluff-body aerodynamics; aeroelastic phenomena; along-wind response and across-wind response; pressures on low rise structures; vibrations of high-rise and long-span structures; prevention of windinduced discomfort in and around structures. Prereq: CE 256/COI. 3 u.

360 **Geotechnical Testing and Instrumentation.** Site investigation techniques; soil and rock sampling; laboratory testing for strength and compressibility; triaxial tests; odometer tests; in-situ testing techniques; laboratory and field instrumentation; case studies. Prereq: CE 260, 261. 7 h. (1 lec, 6 lab). 3 u.

361 **Advanced Soil Mechanics.** Stress and strain in soils; effective stress principles; continuum mechaSnics; flow through porous media; consolidation theory; stability analysis; seepage analysis; analytical and numerical methods. Prereq: CE 360, ES 201, 204. 3 u.

397 **Special Topics in Civil Engineering.** Prereq: COI. 3 u.

398 **Special Problems in Civil Engineering.** Prereq: COI. 3 u.

400 **PhD Dissertation.** 12 u.

DEPARTMENT OF COMPUTER SCIENCE

UNDERGRADUATE

Computer Science (CS)

11 **Computer Programming I.** Introduction to computer science. Problem-solving strategies. Algorithm development. Coding conventions. Debugging. Fundamental programming constructs: types, control structures, functions, I/O. Basic data structures. Coreq: Math 17 or Math 60, or equivalent. 5 h. (2 class, 3 lab). 3 u.

12 **Computer Programming II.** Advanced programming techniques. Recursion. Abstract data types: stacks, queues, linked structures. Programming interfaces. Introduction to object-oriented programming: classes, inheritance, polymorphism. Event-handling. Exception handling. API programming. Prereq: CS 11. 5 h. (2 class, 3 lab) 3 u.

21 **Computer Organization and Assembly Language Programming.** Digital logic and data presentation. Computer architecture and organization. Interfacing and I/O strategies. Memory architecture. Functional organization. Multiprocessing. Graphics systems. Assembly language programming. Prereq: CS 12/ES 26/equiv. 6 h. (3 class, 3 lab) 4u.

30 **Discrete Mathematics for Computer Science.** Combinatorial structures and their applications to computer science. Prereq: Math 17 or Math 60, or equivalent . 3 u.

32 **Data Structures.** Concepts, algorithms and applications of complex data structures: tables, trees, graphs, heaps, generalized lists, multilinked structures. Basic algorithmic techniques and analysis: sorting algorithms, hash tables, binary search trees, balanced trees. Prereq: CS 12/ES 26/ equiv. 3 u.

120 **Internet Technologies.** Programmer-oriented survey of contemporary authoring, distributing, browsing, client server and other technologies; role, use and implementation of current Internet tools; security and privacy issues. Prereq: CS 32/COI. 3 u.

130 **Mathematical Methods in Computer Science.** Vector spaces. Linear transformations. Matrices and determinants. Ordinary differential equations and systems of ordinary differential equations; Fourier series; Laplace transforms. Prereq: Math 55. 3 u.

131 **Numerical Methods.** Interpolations, numerical differentiation and integration. Numerical solutions of algebraic and transcendental equations, systems of equations, ordinary and partial differential equations. Prereq: CS 12, 130. 3 u.

133 **Automata Theory and Computability.** Alphabet, words, languages, and algorithmic problems, finite automata and hierarchy of languages, Turing machines, tractable and intractable problems, uncomputable functions, the halting problem. Prereq: CS 30. 3 u.

134 **Computational Complexity.** Time complexity; the classes P and NP; NP-completeness; the polynomial hierarchy; space complexity; intractability. Prereq: CS 133. 3 u.

135 **Algorithm Design and Analysis.** Algorithm analysis: asymptotic analysis, time and space tradeoffs, recurrence relations. Greedy, divide and conquer, heuristics and other algorithm design strategies. Fundamental computing algorithms for sorting, selection, trees and graphs. Intractability and approximation. Prereq: CS 32, CS 30. 3 u.

137 **Computer Algebra.** Arithmetic in basic algebraic domains; the Euclidean algorithm; polynomial greatest common divisors and resultants; polynomial factorization. Prereq: CS 135/COI. 3u.

140 **Operating Systems.** Survey of operating systems. Memory management: virtual memory, segmentation, paging, fetch and replacement policies. Processor and process management: scheduling, concurrency, synchronization and mutual exclusion, deadlock. Device management. Security. File systems: sequential, direct access, and indexed sequential files. Implementation of file organization. Prereq: CS 21. 5 h. (2 lec, 3 lab) 3 u.

145 **Computer Networks.** Network models and layers; terminal and file transfer protocols; message handling protocols; concurrency; network interconnection; distributed computation; overview of networking and communication software. Prereq: CS 140. 5 h. (2 lec, 3 lab) 3 u.

150 **Programming Languages.** History and overview of programming languages. Programming paradigms: imperative, functional, object-oriented, logical. Type systems. Data and execution control. Declaration and modularity. Introduction to syntax and semantics. Introduction to language translation. Prereq: CS 32. 5 h. (2 lec, 3 lab) 3 u.

153 **Introduction to Computer Security.** Computer security models and protocols. Security issues. Cryptographic algorithms and digital signatures. Risk assessment. Prereq: CS 140. Coreq: CS 145, CS 192. 3 u.

155 **Compiler Construction.** Grammar specification, lexical analysis, parsing techniques, semantic analysis, code generation and optimization, runtime storage administration, error detection and recovery. Prereq: CS 133, 150. 3 u.

160 **File Processing.** Logical and physical file structures. Secondary storage devices. Sequential, direct and indexed files. Single-key and multiple-key retrieval. Data compaction. Implementation of file organizations. Prereq: CS 32. 3u.

165 **Database Systems.** Database concepts: data independence, architecture, models, administration, relational algebra and calculus, normalization, structured query language, query optimization, transactions, concurrency, recovery, security. Survey of database management systems. Prereq: CS 135. 5 h. (2 lec, 3 lab) 3 u.

171 **Topics in Theoretical Computer Science.** Prereq: COI. 3 u.; may be taken twice, topic to be indicated for record purposes.

172 **Topics in Net-Centric Computing.** Prereq: COI. 3 u.; may be taken twice, topic to be indicated for record purposes.

173 **Topics in Software Technology.** Prereq: COI. 3 u.; may be taken twice, topic to be indicated for record purposes.

174 **Topics in Computer Systems.** Prereq: COI. 3 u.; may be taken twice, topic to be indicated for record purposes.

175 **Topics in Computational Science.** Prereq: COI. 3 u.; may be taken twice, topic to be indicated for record purposes.

176 **Topics in Intelligent Systems.** Prereq: COI. 3 u.; may be taken twice, topic to be indicated for record purposes.

180 **Artificial Intelligence.** Fundamental principles of artificial intelligence. Search methods. Knowledge representation and reasoning. Agents. Machine learning and neural works. Current research applications. Prereq: CS 32, COI. 3 u.

191 **Software Engineering I.** Principles of software engineering. Software Project management; requirements engineering; systems analysis and design. Prereq: CS 32, Junior standing. 3 u.

192 **Software Engineering II.** Software architecture and design patterns; software quality assurance; software implementation and maintenance. Prereq: CS 191. 5 h. (2 lec, 3 lab). 3 u.

194 **Undergraduate Research Seminar.** Prereq: Junior standing. 1 u.

195 **Practicum.** Prereq: CS 192. 180 h. 3 u.

196 **Seminar on Ethical and Professional Issues in Computing.** Prereq: SS. 1 u.

197 **Special Topics.** Prereq: SS. 3 u.; may be taken twice, topic to be indicated for record purposes.

198 **Special Problems I.** Prereq: CS 192, SS. 7 h. (1 lec, 6 lab). 3 u.

199 **Special Problems II.** Prereq: CS 198. 7 h. (1 lec, 6 lab). 3 u.

200 **Undergraduate Thesis.** Prereq: CS 198. 3 u.

GRADUATE

Computer Science (CS)

204 **Theory of Computation.** Formal models of computation; recursive function theory; undecidability. Resource-bounded computational complexity, non-determinism, NP-completeness. Prereq: CS 133/COI. 3 u.

208 **Complexity Theory.** Computational models, measures of complexity, complexity classes: nondeterministic, alternating, probabilistic, parallel. Boolean circuits. Complete problems. Prereq: CS 204. 3 u.

210 **Advanced Algorithms and Data Structures.** Advanced data structures; algorithm design techniques; mathematical techniques in the analysis of algorithms. Prereq: CS 135/ equiv. 3 u.

211 **Combinatorial Optimization.** Design and analysis of algorithms for combinatorial optimization problems, worst-case complexity, NP- Completeness proofs, heuristics. Open problems. Prereq: COI. 3 u.

213 **Communications Theory.** Mathematical theory of communication. Information Theory, Communication Channels. Coding. Cryptography. Prereq: COI. 3u.

214 **Parallel Algorithms.** Models of parallel computation. Performance measures, scalability, pipelining, techniques for analyzing parallel algorithms. Interconnection network topologies. Applications. Prereq: CS 210. 3 u.

216 **Randomized Algorithms.** Construction and analysis of randomized algorithms. Expected performance of randomized algorithms, fundamental limitations on probabilistic computations, complexity issues, applications. Prereq: CS 135, Stat 130/COI. 3 u.

220 **Survey of Programming Languages.** Comparative study of different types of modern programming languages; imperative, functional, logic-based and object-oriented. Syntax, semantics and implementation of programming languages. Prereq: CS 150/equiv. 3 u.

222 **Programming Language Theory.** Fundamental concepts underlying all programming languages. Semantic aspects including binding times, visibility, retention, storage management, abstraction mechanisms and extensibility. Operational and denotational semantic specifications. Prereq: CS 150/equiv. 3 u.

225 **Compiler Design and Construction.** Theory of compiler design and construction: techniques in error correction and recovery; code generation and optimization. Prereq: CS 220. 3 u.

231 **Numerical Computing.** Algorithm design for numerical computation. Error analysis. Performance evaluation of numerical software. Prereq: CS 131/COI. 3 u.

236 **Scientific Computing.** Problems and methods in scientific computing. Applications from science and engineering. Prereq: COI. 3 u.

237 **Biomedical Informatics.** Computational methods for managing and analyzing information about biomedical systems. Standards and tools in biomedical informatics. Prereq: COI. 3 u.

239 **Parallel Computing.** Parallel computer architectures. Programming for parallel architectures. Representation, program dependence, control structures. Prereq: COI. 3 u.

240 **Computer Graphics.** Solid modeling: Euler operators, finite element methods. Rendering: filling, shading, ray tracing. Natural modeling: L-systems, fractals. Image processing: filtering, antialiasing, enhancement. Prereq: COI. 3 u.

242 **Data Visualization.** Visualization techniques for data from science, business, social science, demographics, and information management. Prereq: COI. 3 u.

247 **Cryptography.** Primality testing, finite fields, elliptic curves. Protocols: public key cryptography, digital signatures, zero knowledge proofs, and other cryptographic protocols. Prereq: COI. 3 u.

250 **Advanced Operating Systems.** Synchronization and communication mechanisms, virtual memory management, file systems, deadlock control, resource allocation, protection and access control. Case study of specialized systems. Prereq: CS 140/equiv. 3 u.

253 **Computer Security.** Encryption, digital signatures, authentication, key management. Secure electronic commerce. Network Security. File security. Prereq: COI. 3 u.

255 **Advanced Computer Networks.** The OSI Reference Model and layers. Distributed computing. Networked multimedia systems. Clint-server computing. Communication and internetworking. Prereq: CS 250. 3 u.

256 **Computer Systems Performance Analysis.** Overview of performance evaluation. Measurement techniques and tools. Applications of probability theory and techniques. Experimental design and analysis. Simulation and queuing models. Prereq: COI. 3 u.

257 **Distributed Systems.** Computer communications netwoks and their protocols. Event ordering and synchronization. Deadlocks. Network operating systems and languages for distributed computing. Distributed databases. Fault tolerance and recovery strategies. Applications. Prereq: CS 140/equiv. 3 u.

258 **Mobile Computing.** Mobile computing systems. Data management, packet transmission, mobile IP, routing protocols, reliability and issues in mobile wireless networks. Prereq: COI. 3 u.

259 **Network Performance, Modeling and Monitoring.** Network performance evaluation. Measurement techniques and tools. Simulation, queuing models, case studies, practicals. Prereq: CS 255, 256/COI. 3 u.

260 **Advanced Software Engineering.** Structured approach to requirements analysis, system design, implementation and maintenance of software systems. Formal description and documentation techniques. Prereq: CS 192/equiv. 3 u.

262 **Methods of Software Development.** Modern approaches to software development. Prototyping and automated tools. Computer Aided Systems Engineering (CASE) methods and tools. Object-oriented Programming Systems (OOPS). Prereq: CS 260. 3 u.

265 **Software Quality Assurance.** Quality Management, Quality Assurance, Quality Control. Measurement and Analysis. Maturity Model. Prereq: CS 260 or COI. 3u.

266 **IT Project Management.** Detailed discussions of project management knowledge areas and processes. Case studies. Simulations and walkthrough of real-world IT projects from initiation and planning to evaluation and closing. Prereq: COI. 3u.

267 **Software Engineering for the Web.** Software process and requirements analysis, design, dvelopment and testing for web-based systems, software development tools, configuration management systems, case studies. Prereq: CS 260, CS 270 or COI. 3u.

268 **Web Science.** The Web as a full communications medium that fosters full collaboration, social interaction, and commerce. Case studies. Prereq: CS 267. 3u.

270 **Advanced Database Systems.** Data models and their underlying mathematical foundations; database manipulation and query languages; functional dependencies; physical data organization and indexing methods; concurrency control; crash recovery; database security; distributed databases. Prereq: CS 165/equiv. 3 u.

271 **Database Theory.** Relational database model, query languages, domain independence, relational calculus, query optimization, constraints. Prereq: CS 165/equiv. 3 u.

280 **Intelligent Systems.** Fundamental issues in Intelligent Systems. Intelligent search and optimization methods. Knowledge representation and reasoning. Learning, natural language understanding, pattern recognition, knowledge-based systems and other methods in Intelligent Systems. Prereq: COI. 3 u.

281 **Robotic Systems.** Biologically-motivated robotic systems. Reactive, deliberative, and hybrid architectures. Knowledge representation for robotics systems. Sensor fusion and perceptual strategies. Adaptation and social behavior. Prereq: CS 280/equiv. 3 u.

282 **Computer Vision.** Image formation; early vision; segmentation from texture and motion; object representation; matching and inference; knowledge-based vision. Prereq: COI. 3 u.

283 **Data Mining.** Decision trees, association rules, clustering. Intrusion detection. Design and use of serial, distributed and parallel data mining algorithms. Prereq: CS 165, 280/COI. 3 u.

284 **Machine Learning.** Pattern recognition, parametric and non-parametric learning, decision trees, Bayesian and neural networks, reinforcement learning, genetic algorithms, computational learning theory. Prereq: CS 280/COI. 3 u.

286 **Natural Language Understanding.** Computational properties of natural languages. Morphological, syntactic and semantic processing from an algorithmic perspective. Models of acquisition and parsing. Prereq: CS 280/COI. 3 u.

290 **Advanced Topics in Theoretical Computer Science.** Prereq: COI. 3 u., may be taken twice, topic to be indicated for record purposes.

291 **Advanced Topics in Net-Centric Computing.** Prereq: COI. 3 u., may be taken twice, topic to be indicated for record purposes.

292 **Advanced Topics in Software Technology.** Prereq: COI. 3 u., may be taken twice, topic to be indicated for record purposes.

293 **Advanced Topics in Computer Systems.** Prereq: COI. 3 u., may be taken twice, topic to be indicated for record purposes.

294 **Advanced Topics in Computational Science.** Prereq: COI. 3 u., may be taken twice, topic to be indicated for record purposes.

295 **Advanced Topics in Intelligent Systems.** Prereq: COI. 3 u., may be taken twice, topic to be indicated for record purposes.

296 **Seminar.** Prereq: COI. 1 u., may be repeated for a maximum of 3 u.

297 **Special Topics.** Prereq: COI. 3 u.; may be repeated if topics are different; topic to be indicated for record purposes.

298 **Special Problem.** Prereq: Completion of 12 u. including 6 u. of specialization courses. 3 u.; may be taken twice; problem to be indicated for record purposes.

300 **Thesis.** 6 u.

301 **Communication Complexity.** Communication complexity and its applications to parallel computing. Communication complexity measures, lower bound techniques. Prereq: CS 210/COI 3 u.

315 **Algorithms in Bioinformatics.** Algorithm design techniques applied to Bioinformatics Problems, DNA Sequencing, Gene Expression Analysis, and Protein Folding. Prereq: CS 135/COI 3 u.

318 **Approximation Algorithms.** Approximate methods for solving a wide range of intractable or hard problems. Prereq: CS 210/COI. 3 u.

334 **Computational Systems Biology.** Analysis of molecular interaction networks and pathways. Qualitative and quantitative methods and tools applied to biochemical systems. Prereq: COI. 3 u.

338 **Computational Models of Biological Processes.** Formal models and heuristic approaches for biological processes. Prereq: COI. 3 u.

341 **Knowledge Engineering.** Reasoning systems to support decision making, learning and action. Prereq: CS 280/COI. 3 u.

351 **Pervasive Computing and Communication.** Technologies for ubiquitous computing.Prereq: CS 255, CS 267, and CS 280/COI. 3 u.

360 **Formal Methods.** Program specification, verification, and refinement. Prereq: COI. 3 u.

369 **The Semantic Web.** Web technologies, ontology engineering, social network analysis and web standards. Prereq: CS 267. 3 u.

371 **Security Engineering.** Security issues in the design and engineering of software-based systems for different platforms. Prereq: CS 253/COI. 3 u.

380 **Computational Intelligence 1.** Metaheuristic algorithms and their utility in solving engineering and scientific problems. Prereq: CS 280/COI. 3 u.

381 **Computational Intelligence 2.** Agent-based systems and their applications to real-world problems. Prereq: CS 280/COI. 3 u.

385 **Artificial Neural Networks.** Computational models inspired by the structural and functional aspects of the brain. Prereq: CS 280/COI. 3 u.

389 **Digital Image Processing.** Tools and techniques for transformation of images for subsequent human or machine interpretation. Prereq: COI. 3 u.

390 **Independent Study.** Prereq: Completion of 18 units of CS graduate courses including 6 units of Specialization courses. 3 u., may be taken twice.

397 **Special Topics.** Prereq: COI. 3 u., may be taken twice provided that topics are different.

400 **Dissertation.** Prereq: completion of all coursework requirements for the program. 12 u., may be spread over 2 semesters.

UNDERGRADUATE

Information Technology (IT)

100 **Introduction to Information Technology.** Overview of computer hardware and software. Using the World Wide Web and the Internet, problem solving, applications. Social and ethical issues in computing. 5 h. (2 lec, 3 lab) 3 u.

110 **Information Systems in Enterprises.** Systems concepts. Enterprise information systems. Information resources in organizations. Enterprise information system architecture. Programming. Internet and ecommerce applications. Prereq: IT 100/CS 11/ES 26/equiv. 5 h. (2 lec, 3 lab) 3 u.

120 **Application Development.** Program design, data structures, programming and fundamental design techniques. Software engineering principles. Prereq: ES 26, CS 12, or COI. 3 u.

GRADUATE

Information Technology (IT)

201 **Information Systems and Technology.** Concepts in information systems and technology, data management, computer programming. Applications. Computers and Society. Prereq: COI. 5 h. (2 lec, 3 lab) 3 u.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

UNDERGRADUATE

Computer Engineering (CoE)

23 **Synthesis of Sequential Circuits.** Minimization of synchronous sequential circuits; synthesis of synchronous sequential circuits using structured techniques; delays and hazards; asynchronous Huffman circuits; physical characteristics of logic gate implementations. Prereq: EEE 11, 21, 34. 5 h. (2 lec, 3 lab). 3 u.

111 **Advanced Digital Design.** Combinational and sequential circuits; structured design; digital design using programmable devices; hardware description language (HDL)-based digital design; simulation; testing of digital circuits. Coreq: EEE 105. 5 h. (2 lec, 3 lab) 3 u.

113 **Advanced Computer Organization.** Instruction sets; central processor implementations; pipelining; hardwired and microprogrammed control; reduced instruction set computer (RISC) processors; datapaths; arithmetic and logic units (ALUs); memory. Prereq: CoE 111, EEE 105. 6 h (3 lec, 3 lab). 4 u.

115 **Introduction to Embedded Microcontrollers.** Introduction to embedded microcontrollers in electronic and electromechanical systems. Hardware and software design techniques. Systems interfaces, data acquisition and control. High speed design techniques. Prereq: EEE 105. 5h (2 lec, 3 lab). 3 u.

121 **Introduction to Digital Signal Processing.** Discrete-time systems in frequency domain; digital filter design; linear prediction and optimum linear filters. Prereq: EEE 25, 35. 6 h. (3 lec, 3 lab). 4 u.

123 **Introduction to Digital Image and Video Processing.** Digital image fundamentals; introduction to two-dimensional digital signal processing (DSP); image enhancements and restoration algorithms; image filters; image coding and compression; video coding and standards; some applications of video and image processing. Prereq: EEE 35. 6 h. (3 lec, 3 lab) 4 u.

127 **Audio and Speech Signal Processing.** Fundamental audio synthesis concepts; advanced techniques of audio signal processing, analysis and modeling; engineering models for speech signal analysis, synthesis and recognition. Prereq: CoE 121. 5 h. (2 lec, 3 lab). 3 u.

129 **Real-Time Digital Signal Processing.** Digital signal processor architectures; data converters; realtime concepts and programming; digital filtering; real-time spectral analysis. Prereq: CoE 121, EEE 105. 5 h. (2 lec, 3 lab). 3 u.

133 **Computer Systems Engineering I.** History and overview of computer systems engineering. Computer engineering ethics. Software risks and reliability. Life cycles. Project management. Prereq: EEE 105. 2 u.

134 **Computer Systems Engineering II.** Requirements analysis and elicitation. Architectural design. Implementation, testing and maintenance issues.Prereq: CoE 133. 4h (1 lec, 3 lab). 2 u.

135 **Operating Systems.** Overview and examples of operating systems. System calls. Process management. Threads. Scheduler. Interprocess communication and synchronization. Deadlock and starvation. Memory management. Virtual memory. I/O systems. File system. Prereq: EEE 13. 5 h (2 lec, 3 lab). 3 u.

141 **Introduction to Digital Integrated Circuit Design.** Concepts, economics and trends of integrated circuits (IC); MOS transistor characteristics and models; basic digital building blocks; structured digital circuits and systems. Prereq: EEE 21, 41. 6 h. (3 lec, 3 lab) 4 u.

143 **Introduction to Analog Integrated Circuit Design.** IC fabrication processes. Analog device modeling. Circuit simulation. Amplifiers, comparators and other analog systems. Prereq: EEE 51. 6 h. (3 lec, 3 lab). 4 u.

151 **Computer Networks.** Principles and practices of computer networking; structures and components of networks; packet switching; layered architectures; open systems interconnect (OSI) reference model; transmission control protocol/internet protocol (TCP/IP). Prereq: EEE 13, 107. 6 h (3 lec, 3 lab) 4 u.

153 **Advanced Computer Networks.** Advanced topics in computer networks, including internet architecture and design, multicast and advanced routing. Quality of service and congestion control. Network measurement and modeling. Mobile and ad-hoc networks. Web technologies and the Semantic Web. Application-layer overlay networks. Security and privacy. Emerging applications. Prereq: CoE 151. 5h (2 lec, 3 lab). 3 u.

197 **Special Topics in Computer Engineering.** Prereq: COI. 2-4 u. (any combination of lec or lab); may be repeated for additional credit provided that the special topic should be indicated for record purposes.

198 **Special Problems in Computer Engineering.** Prereq: Approved project proposal from EEE 190, research laboratory affiliation. 11 h. (2 lec, 9 lab) 5 u.

UNDERGRADUATE

Electronics and Communications Engineering (ECE)

113 **Communication Electronics.** Resonant circuits and filters. Analog modulation and demodulation circuits. Frequency syhthesis and phase locked loops. Basic concepts in radio frequency (RF) circuit design. Other communications circuits. Prereq: EEE 53, EEE 54, EEE 100, EEE 107. 5h (2 lec, 3 lab). 3 u.

117 **Instrumentation Electronics.** Sensors in control systems; signal conditioning; data acquisition systems; actuators and controllers; industry standards. Prereq: EEE 34, 51. 5 h. (2 lec, 3 lab). 3 u.

123 **Digital Instrumentation and Control Techniques.** A/D-D/A conversion. Process control. Fundamentals of robotics. Data acquisition. Real time applications. Prereq: EEE 101. 3 u.

129 **Simulation and Control Laboratory.** System modeling; computer–aided control system design and computer simulation; op amps as feedback compensators; DC motor dynamics and control; Closed-loop control and responses to step and ramp inputs. Prereq: EEE 52/COI, 101. 5 h. (2 lec, 3 lab). 3 u.

131 **Introduction to Robotics.** Coordinate transformations. Forward and inverse kinematics. Manipulator dynamics. Control of manipulators. Path planning. Prereq: EEE 101, ES 12, and ES 21 or COI. 3 u.

133 **Introduction to Mobile Robotics.** Mobile robot control. Software architectures. Interoceptive and exteroceptive sensors. Sensor interpretation. Map building and navigation. Mobile robot construction. Prereq: EEE 35, ES 12 and EEE 11 or COI. 5h (2 lec, 3 lab). 3 u.

141 **Digital Communications.** Sampling and quantization; baseband pulse transmission; multiplexing; digital modulation techniques; bit error rates and spectral efficiency; clock recovery; information theory and error control coding; spread spectrum modulation. Prereq: EEE 107. 5 h. (2 lec, 3 lab) 3 u.

151 **Communication Networks.** Telephony; telephone traffic, switching and signaling systems; multiplexing; trunking theory; modem standards; optical communication systems; open systems interconnect (OSI) layers for communication systems. Prereq: EEE 107. 3 u.

153 **Wireless Communications.** Radiowave propagation; antenna basics; large–scale path loss models; small–scale fading; cellular and satellite communication systems; multiple access techniques; current topics of interest in wireless communications. Prereq: EEE 23; Coreq: ECE 141. 3 u.

155 **Modern Audio Engineering.** Fundamentals of sound and hearing; audio tests and measurements; electrical and environmental noise and noise reduction in audio systems; microphones and loudspeakers; audio processing electronics and acoustics; practical audio systems. Prereq: EEE 107. 5 h. (2 lec, 3 lab) 3 u.

157 **Microwave Engineering I.** Review of electromagnetics; transmission line theory and waveguides; the Smith chart; network analysis and port parameters; impedance matching; passive and active microwave ciruits. Prereq: EEE 23, 107. 3 u.

159 **Microwave Engineering II.** Microwave materials and processes; laminates; metals; solders; packaging; connectors; resistance, inductance, and capacitance (RLC) measurements; transmission lines; microstrip circuits; test and measurement equipment and software for microwave communication systems. Prereq: ECE 157, EEE 100. 5 h. (2 lec, 3 lab) 3 u.

197 **Special Topics in Electronics and Communications Engineering.** Prereq: COI. 2-4 u. (any combination of lec or lab); may be repeated for additional credit provided that the special topic should be indicated for record purposes.

198 **Special Problems in Electronics and Communications Engineering.** Prereq: Approved project proposal from EEE 190, research laboratory affiliation. 11 h. (2 lec, 9 lab) 5 u.

UNDERGRADUATE

Electrical Engineering (EE)

121 **Introduction to Power Electronics.** Switching converter principles, harmonics, pulse-width modulation, phase control and phase modulation. Single-phase and three-phase rectifiers. AC voltage controllers, DC/DC converters, and DC/AC inverters. Converter transfer functions. Prereq: EEE 42, EEE 53. 5h (2 lec, 3 lab) 3 u.

123 **Electric Motor Drives.** Electric drive systems; steady-state analysis of direct current, induction, synchronous, and reluctance motor drives; efficiency, harmonics, and converter–motor interaction. Prereq: EE 121, EEE 43. 3 u.

143 **Electrical Machine Dynamics and Control.** Dynamic models and characteristics of electrical machines. Applications and control of direct-current, synchronous, induction and reluctance machines. Prereq: EEE 43. 3 u.

145 **Electrical Equipment and Devices.** Operating principles, characteristics, and applications of transformers, switchgear, and other electrical equipment and devices used for power system protection and control. Prereq: EEE 43, EEE 103. 3 u.

146 **Electric Power Measurements and Equipment Characterization.** Power measurements. Performance evaluation and parameter measurement of electrical machines and transformers. Prereq: EEE 43, EEE 44, EEE 103. 3 h (3 lab) 1 u.

147 **Energy-efficient Lighting Systems.** Fundamentals of lighting, vision, and color. Electric light source and ballast technologies. Luminaires and optical control. Light loss factors. Average illuminance calculations. Calculation of illuminance at a point. Lighting quantity and quality assessment. Design of energy-efficient lighting for interiors. Design of energy-efficient lighting for exteriors. Strategies and technologies for control of energy-efficient lighting. Daylighting. Building energy codes and standards. Lighting economics. Prereq: EEE 41, EEE 101. 3u.

148 **Electrical Machine Design.** Design of transformers, rotating machines, and selected electrical equipment and devices. Prereq: EE 143. 3u.

151 **Power System Operation.** Philippine Grid Code. Voltage and frequency control. Operating reserve. Unit commitment. Economic dispatch. Optimal power flow. Energy interchange. System security and reliability. Transmission network operations in competitive electricity markets. Prereq: EEE 103. 5h (2 lec, 3 lab). 3 u.

152 **Advanced Power Systems Analysis.** Large scale power system studies using computer methods; matrix techniques and numerical methods. Network building. Load flow studies, fault studies, rotor angle stability. Electromagnetic transients analysis. Prereq: EEE 13, EEE 103. 5h (2 lec, 3 lab) 3 u.

153 **Electric Power Distribution Systems.** Substation, subtransmission, and distribution system design. Distribution system models and load flow, short-circuit, reliability, and system loss analysis. Distribution planning. Distribution automation.Prereq: EE 103, EEE 145. 3 u.

157 **New Energy Systems.** Non-conventional energy resources and conversion technologies; new energy systems for off-grid applications; grid integration issues of non-conventional and new energy systems; planning and operations of electric power systems with intermittent energy systems. Prereq: EEE 103. 3u.

158 **Electrical System Design.** Choice of systems and selection, arrangement and protection of components for power, lighting and auxiliary systems of residential, institutional, commercial, and industrial power systems; illumination design. Prereq: EEE 103. 5 h. (2 lec, 3 lab) 3 u.

159 **Industrial Power Systems.** Selection and arrangement of electrical equipment for distribution, control, protection and metering in industrial plants, substations and modern power plants. Prereq: EEE103. 5 h. (2 lec, 3 lab) 3 u.

197 **Special Topics in Electrical Engineering.** Prereq: COI. 2-4 u. (any combination of lec or lab); may be repeated for additional credit provided that the special topic should be indicated for record purposes.

198 **Special Problems in Electrical Engineering.** Prereq: Approved project proposal from EEE 190, research laboratory affiliation. 11 h. (2 lec, 9 lab) 5 u.

GRADUATE

Electrical Engineering (EE)

212 **Linear System Theory.** Theory and application of discrete and continuous-time linear dynamical systems. Review of applied linear algebra; least-norm and least-squares methods. Autonomous linear dynamical systems; interpretations of eigenvalues, eigenvectors, matrix exponential, and invariant sets. Singular value decomposition with applications. Linear dynamical systems with inputs and outputs; transfer matrices. Observability and state estimation; controllability and state transfer. Examples and applications from digital filters, circuits, signal processing, and control systems. Prereq: EEE 35/equiv, Math 114/equiv. 5 h. (2 lec, 3 lab) 3 u.

214 **Probability and Random Processes in Electrical Engineering.** Review of combinatorial probability. Random variables and vectors. Discrete and continuous distributions. Conditional and multivariate probabilities. Functions of random variables. Mathematical expectations. Autocorrelation and power spectral density. Stochastic models. Stationarity and cyclostationarity. Higher order statistics, cumulants and polyspectra. Spectral-correlation density. Prereq: EEE 25/ equiv. 5h (2 lec, 3 lab) 3 u.

217 **Electromagnetic Fields II.** Review of Maxwell's equations. Propagation phenomena of plane waves in dielectric and conducting media. Transmission lines, waveguides and resonators. Antennas and radiation. Fiber optics and optoelectronic systems. Prereq: EEE 23/equiv. 3 u.

218 **System Identification.** Introduction to point estimation, least squares, Bayes risk, and maximum likelihood. Optimum mean-square recursive estimation for non-dynamic stochastic systems. State estimation for discrete-time and continuous-time dynamic systems. Parameter identification of stochastic systems using maximum likelihood. Stochastic approximation, least squares, and random search algorithms. Applications to controls, communication, and signal processing. Prereq: EE 212, 214. 3 u.

220 **Analog Integrated Circuits.** Integrated circuit devices and modeling. Noise analysis and modeling. Review of basic operational amplifier design and compensation. Advanced current mirrors and operational amplifiers. Operational transconductance amplifiers. Common-mode feedback circuits. Comparators. Sample and holds. Voltage references and translinear circuits. Discrete-time signals. Switched-capacitor circuits. Prereq: CoE 143/equiv. 6 h (3 lec, 3 lab) 4 u.

221 **Electronic Amplifier Design.** Linear and non-linear models of field-effect and bipolar junction transistors at low and high frequencies; theory, design and application of class A, B, C, D, E, F amplifiers, wide band low-pass amplifiers, distributed amplifiers, power amplifiers, tuned amplifiers, feedback amplifiers, operational amplifiers, parametric amplifiers, sense amplifiers, and other special amplifiers; biasing; gainbandwidth; noise mechanisms and low-noise design; passive components; performance evaluation and optimization; integrated circuit implementations; design projects. Prereq: COI. 4 u.

223 **Design of Signal Processing Systems.** System modeling. Computational algorithms. Architecture mapping. Hardware optimizations. SoC applications. Prereq: EE 227, EE 274. 3u.

224 **Mixed Signal Systems.** Signals and filters. Sampling and aliasing. Analog and digital filters. Analog-to-digital converters. Digital-to-analog converters. Sample/hold amplifiers. Mixed-signal applications. Prereq: EE 220. 5 h. (2 class, 3 lab). 3 u.

225 **Solid State Electronics and Semiconductor Devices.** Conduction mechanisms in semiconductors and metals. Physics, characteristics and models of p-n junction diode. Bipolar junction transistors. Junction and MOS fiels-effect transistors. Trends in scaled MOSFETs. Short channel MOSFETs. Prereq: EEE 41/equiv. 4 u.

226 **Digital Integrated Circuits.** Fundamentals of MOSFETS. Technology and modelling. Scaling and limits of scaling. Design for deep-submicron CMOS- high speed. Design techniques for low power. Arithmetic circuits. Driving interconnect, high-speed signaling. Timing. Memory design. Prereq: CoE 141/ equiv. 6 h (3 lec, 3 lab). 4 u.

227 **Modern VLSI Design.** Digital systems and VLSI. Transistors and layout. Logic functions. Combinational logic networks. Sequential machines. Systems architecture design and HDLs. Subsystem design and IP components. CAD systems and algorithms. Prereq: EEE 21 or equivalent. 5h (2 lec, 3 lab). 3 u.

229 **RF Integrated Circuit Design.** Introduction to RF and wireless technology. Characteristics of passive devices at RF. High-frequency amplifier design. Analysis of distortion in amplifiers. Low-noise amplifiers and mixers. Oscillators. Frequency synthesizers. Power amplifiers. Phased-locked loops. Modulators and demodulators. Transceiver architectures. Prereq: EE 220. 3 u.

231 **Advanced Feedback Control Systems.** Transfer functions. Block diagrams. Signal flow graphs. Root locus, Bode, Nyquist and polar plots. Sensitivity. Stability. Compensation techniques. Multivariable systems. Disturbance rejection. Robust control. Adaptive control, state-variable representation and feedback; state-space design; optimal control, computer simulations; design projects. Prereq: EEE 101/equiv. 3 u.

233 **Digital Control Systems Design.** Z-transforms and state variable representation of discrete-time systems; models for mixed continuous and discrete-time systems; modeling asynchronous sampling; analysis and design by root locus, frequency response, and state-space techniques; controllability, observability and observer design; linear quadratic optimal control and state estimation; optimization and design issues of mixed continuous and discrete-time systems; inter sample behavior; robust control; sampling rate selection; effects of quantization and finite precision errors; multi-variable control and optimization; multirate systems; computer simulations; design projects. Prereq: EEE 101/equiv. 5h (2 lec, 3 lab) 3 u.

234 **Advanced Data Acquisition System.** Sensors and industrial standards. Storage and display devices. Sensor networks. Prereq: COI. 5h (2 lec, 3 lab). 3u.

235 **Nonlinear Control Theory.** Introduction to nonlinear control with emphasis on differential geometric methods. Linear and nonlinear dynamical systems analysis methods. Describing functions. Lyapunov theory. Popov and the circle

criteria. Bifurcation analysis. Controllability, accessibility and observability of nonlinear systems. Differential geometry and nonlinear control from the geometric point of view. Prereq: EE 212. 3 u.

236 **Principles of Robotics.** Definition of robots and manipulators. Different transformations involved in the study of manipulators. Kinematics and dynamics. Trajectory planning. Prereq: COI. 3u.

237 **Advanced Robotics.** Dynamical models for manipulator in Lagrange and Newton-Euler formulations. Controller design based on manipulator dynamics. PID-controllers, eigenvalue assignment and adaptive self-tuning control. Controllers for compliant motion. Prereq: ECE 131. 3 u.

238 **Mobile Robotics.** Locomotion. Robot kinematics. Perception. Navigation and planning. Map-building. Mobile robot localization. Prereq: COI. 5h (2 lec, 3 lab) 3u.

240 **Power Electronics I.** Applications of semiconductor devices and circuits to power systems: power control, conditioning, processing and switching. Prereq: EEE 53 or equivalent. 5 h. (2 lec, 3 lab) 3 u.

241 **Linear and Switching Power Supplies.** Linear converters. Switchmode Topologies. DC/DC, AC/DC, DC/AC converters. Applications. Power Supply Simulation. Prereq: EEE 53 or equivalent. 5 h (2 lec, 3 lab) 3 u.

242 **Industrial Electronics.** Electrical Transients. Three Phase Circuits. Fourier Series. Transformers. Rectification. AC/DC Thyristor converters. Forced communication. PWM Motor Control. AC Power control. Applications. Prereq: EEE 101, EEE 103/equiv. 3 u.

243 **Electromagnetic Compatibility.** Transmission Lines. Emissions. Modeling. Susceptibility. PCB Design. Shielding. Grounding. Prereq: EEE 23, EEE 53/equiv. 3u.

245 **Advanced Theory of Electrical Machines.** Reference frames and generalized machine theory. Modeling and analysis of rotating machines during steady state, transient, and dynamic conditions. Prereq: EEE 43/equiv. 3 u.

246 **Dynamics and Control of Electric Motor Drives.** Phase- and-chopper-controlled DC motor drives. Dynamic modeling of AC machines. Frequency-, phase-, and vector-controlled induction motor drives. Permanent magnet AC, brushless DC, and switched-reluctance motor drives. Simulation of electric drive systems. Prereq: EEE 43/equiv, EEE 51/equiv. 3 u.

248 **Power Amplifiers.** Linear Amplification. Voltage and Current Mode Amplifiers. Amplifier Classes A, B, AB, C. Trans-conductance Amplifiers. Composite Amplifiers. Resonant and Switchmode Amplifiers. Prereq: EEE 53/equiv, EE 121/equiv. 5 h (2 lec, 3 lab) 3 u.

249 **Power Electronics II.** Principles of Steady State Converter Analysis. Steady State Equivalent Ciruit Modeling. Converter Circuits. AC Circuit Modeling. Converter Transfer Functions. Prereq: EE 240/equiv. 5 h (2 lec, 3 lab) 3 u.

251 **Fault Studies.** Symmetrical components. Sequence impedances of transmission lines, synchronous machines and transformers. Phase-domain and sequence-domain analysis of unbalanced and simultaneous faults. Prereq: EEE 103/equiv. 5 h (2 lec, 3 lab) 3 u.

252 **Load Flow Analysis.** System modeling and matrix analysis of balanced and unbalanced three-phase power systems. Solution of a system of linear and nonlinear equations. Sparsity techniques and optimal ordering. Load flow studies for balanced and unbalanced three-phase power system. Prereq: EEE 103/equiv. 5 h (2 lec, 3 lab). 3 u.

254 **Surge Protection in Power Systems.** Electrical surges including traveling waves due to lightning and switching. Principles of lightning protection. Multi-velocity waves. Electromagnetic transient simulations. Insulation coordination. Application of surge protection devices. Prereq: EEE 25/equiv, COI. 5 h (2 lec, 3 lab) 3 u.

255 **Electric Power Transmission and Distribution System Planning.** Forecasting models for network planning. Cost models for transmission and distribution facilities. Technical and economic evaluation. Optimization in transmission and distribution planning. Reliability evaluation of transmission and distribution networks. Prereq: EEE 103 or equivalent. 3 u.

256 **Power System Protection.** Fundamental principles. Selection and application of protective devices and protection algorithms. Protection of transmission lines, transformers, generators, motors, buses, and other equipment. Phase and ground fault protection. Coordination of protective devices. Testing of relays and protection algorithms. Prereq: EEE 103/ equiv. 5 h. (2 lec, 3 lab) 3 u.

257 **Electric Power Transmission and Distribution Network Automation.** Transmission and distribution (TandD) system automation requirements. Sensors, actuators and controllers. TandD automation equipment. Remote Terminal Units (RTUs). Distribution Management Systems. Supervisory Control and Data Acquisition Systems (SCADA). Decision Support Applications. Communications options and communications protocols for TandD utility automation. Design of transmission, substation, and distribution feeder automation. Case studies and applications. Prereq: EEE 103 or equivalent. 5 h (2 lec, 3 lab). 3 u.

258 **Electric Power Quality.** Modeling for power quality analysis. Harmonics. Time and frequency domain methods of analysis. Grounding. Voltage sags and swells. Electrical transients. Measurement techniques. Miligation techniques. Power quality standards. Prereq: EEE 103, EEE 35/equiv. 3 u.

260 **Embedded Systems Hardware I.** Design of 8, 16, 32-bit microprocessor-based systems using microprocessor integrated circuits and softcores (system-on-a-programmable-chip). Advanced microprocessor features and peripherals. Memory technologies. Interfacing using simple bus protocols. Prereq: EE 227. 5 h. (2 lec, 3 lab) 3 u.

261 **Embedded Systems Hardware II.** Complex bus protocols. Video. Mass storage. Circuit board-level design of embedded systems. High speed circuit board design techniques. Signal integrity issues. Prereq: EE 260. 5 h. (2 lec, 3 lab) 3 u.

263 **Finite State Machines.** Review of clocked sequential circuits. State minimization. State assignment. Pulsed sequential circuits. Fundamental mode sequential circuits. Delays and hazards. Timing driven analysis. State Identification. State Machine Testing. FSM applications. Prereq: EEE 21/equiv. 3u.

264 **Computer Architecture.** Evolution of computer architecture. Principles of computer system design. Computer system components. Instruction set design. Processor micro-architecture. Pipelining. Cache and virtual memory organizations. I/O structures. Instructures level parallelism. Prereq: EEE 105/equiv. 3 u.

265 **Advanced Computer Architecture.** Vector machines. Out-of-order execution. Dynamic scheduling. Thread-level parallelism. VLIW machines. Speculation techniques. Compiler support. Multiprocessor architectures. Multicore architectures. Coherency issues. Interconnection networks. Prereq: EE 264. 3 u.

267 **Embedded Software and Operating Systems.** Overview of Embedded Systems. Kernel. Bootloader. Toolchain. Root Filesystems. Memory Technology Devices. I/O Subsystem. Device Driver. Introduction to Applicants Programming. Prereq: EE 260 and EEE 13 or equivalents. 5h (2 lec, 3 lab) 3 u.

268 **Embedded Software Applications Development.** Software Engineering methodologies applied to embedded systems program development. Quality Assurance techniques. Software maintenance issues. Functional and non-functional software properties. Prereq: COI. 5 h. (2 lec, 3 lab) 3 u.

269 **Digital Systems Testing.** Test economics and motivation. Fault models and simulation. Test pattern generation. Measures for testability. Design for testability. Memory testing. Prereq: EEE 21, EEE 41/equiv. 3 u.

270 **Digital Communications I.** Methods of digital modulation and demodulation. Signal Space methods in digital communications. Communication over AWGN and band-limited channels, including channel capacity. Carrier and symbol synchronization. Source coding and lossless compression. Channel coding, including block codes, convolutional codes and Viterbi decoding. Current topics of interest. Prereq: EEE 107 or equivalent. 5h (2h lec, 3h lab). 3 u.

271 **Microwave Theory and Techniques.** Analysis and synthesis of transmission lines and waveguides. Microwave resonators. Microwave network analysis. Analysis and design of passive and active devices. Noise in microwave circuits. Circuit models of active devices. Magnetic materials and their applications. Microwave test and measurement principles. Prereq: EE 217. 3 u.

272 **Radiowave Propagation and Radio Link Design.** Transmission loss. Free-space propagation. Propagation at low and high frequencies. Microwave propagation. Propagation over plane and spherical surfaces. Propagation in the ionosphere, troposphere and near-earth. Antennas. Design considerations for noise, diffraction, refraction, absorption, multipath interference, and scattering in wireless communications, including mobile communications and satellite links. Prereq: EE 23 or equivalent. 3 u.

273 **Antenna Engineering.** Radiation from simple and extended sources and arrays. Antenna theorems. Scattering concepts. Analysis and design of dipoles, slot, horn, lens, reflector, traveling wave, microstrip and integrated circuit antennas and arrays. Modern antenna systems. Receiving antenna considerations. Prereq: EE 23 or equivalent. 3 u.

274 **Digital Signal Processing I. S**ampling theorem. Discrete time signals and LTI systems. Discrete convolution. Z-transform. FIR and IIR Digital filters. Discrete Fourier transform. Fast-Fourier Transform. State-space analysis. Prereq: EEE 35/ equiv. 5h (2 lec, 3 lab). 3 u.

275 **Networking Technologies I.** Layered network architecture. Link layer protocol. Packet switching. LAN and WAN routing. Transport protocols. Applications. Prereq: EEE 13 and EEE 107, or their equivalents. 5 h (2 lec, 3 lab). 3 u.

276 **Statistical Communication Theory.** Principles and applications of detection and estimation theories in communication systems. Bayes and the Neyman-Pearson criteria. Cramer-Rao bound. Minimum variance unbiased estimation, maximum likelihood, EM, MAP, linear MMSE estimation. Hypothesis testing. Applications in modern digital communications, radar and sonar signal processing. Prereq: EE 214, EE 274. 3u.

277 **Coding and Information Theory.** Error detecting and error correcting codes. Block codes and convolutional codes. Analysis and design of error-control channel codes. Modeling of information sources, including zero-memory and Markov models. Construction of compact source codes. Entropy, mutual information and channel capacity. Shannon's noiseless and noisy coding theorems. Examples of modern source and error control codes. Prereq: EE 25 or equivalent. 3 u.

279 **Networking Technologies II.** Distribued systems and applications. Network architectures and technologies. Network protocols. Routing and congestion control. Modeling, simulation and performance analysis. Emerging applications. Prereq: COI. 5 h. (2 lec, 3 lab) 3 u.

280 **Wireless Communication Systems.** Radio propagation and antennas. Large scale and small scale propagation models. Performance of wireless communication systems in fading channels. Coding, equalization and diversity. TDMA, FDMA, CDMA, SDMA and random access protocols. Examples of modern and practical systems, including cellular systems, wireless local area networks, wireless personal area networks and broadband wireless access systems. Co-req: EE 270/ equiv. 3u.

281 **Optical Communications Systems.** Optical fiber fundamentals. Single mode and multimode fibers. Optical fiber bandwidth. Optical sources, light-emitting diodes and lasers. Optical detectors, modulators, switches and directional couplers. Optical communications systems design. Wavelength division multiplexing and other topics of interest. Prereq: EEE 41/ equiv. 3 u.

282 **Adaptive Filtering and Array Processing.** Theory and applications of adaptive filtering in systems and signal processing. Iterative methods of optimization and their convergence properties. Transversal filters. LMS and gradient-search algorithms. Kalman Filtering and least-squares algorithms. Array fundamentals. Optimum array processing. Adaptive beam forming. Space-time processing and space-time coding. MIMO. Current topics of interest. Prereq: EE 274 or equivalent. 5 h (2 lec, 3 lab) 3 u.

283 **Digital Image Processing.** Digital image fundamentals. Introduction to two-dimensional digital signal processing. Image enhancements in spatial and frequency domain. Image transforms. Image restoration. Color image processing. Wavelets and image compression. Morphological image processing. Image segmentation, representation and description. Introduction to object recognition and computer vision. Advanced topics and applications of image processing and analysis. Prereq: CoE 121 or EE 274 or COI. 5 h (2 lec, 3 lab). 3 u.

284 **Speech Signal Processing.** Feature extraction. Speech Recognition. Hidden Markov Modeling. Speech production models. Pitch detection. Prosody. Speech Synthesis. Speech coding. Prereq: EEE 35 or equivalent. 3u.

285 **Digital Video Signal Processing.** Digital video fundamentals. Video formation, perception and representation. Fourier analysis of video signals. Frequency response of the human visual system. Video sampling and rate conversion. Video modeling. 2-D and 3-D motion estimation. Video coding: waveform-based coding and content-dependent coding. Scalable video coding. Stereo and multi-view sequence processing. Video compression standards. Error control in video communications. Advanced topics and applications of video analysis, processing, streaming, compression, error control and transmission. Prereq: CoE 121 or EE 274 or COI. 5 h (2 lec, 3 lab). 3 u.

286 **Digital Audio Signal Processing.** Digital audio signal analysis and manipulation. Speech and musical instrument synthesis. Digital audio recording and reproduction. Prereq: EEE 35 and EEE 11, or COI. 5 h (2 lec, 3 lab). 3 u.

290 **Directed Studies.** Independent study or investigation of directed, current research areas in electrical and electronics engineering. Collaborative peer discussions of study results and findings. Prereq: COI. 3 u. Course may be repeated for credit, up to a maximum of 12 units, provided that the topics are different.

296 **Seminar.** 1 u. per semester; maximum of 3 u.

298 **Special Problems.** 3 u.; Course may be repeated for credit, up to a maximum of 12 units, provided that topics are different; topics to be indicated for record purposes.

299 **Electrical Engineering Project.** Prereq: COI. 3 u.

300 **Thesis.** 3 to 6 u.

317 **Mathematical Methods for Electromagnetics I.** Analytical and numerical methods of solving practical problems in electromagnetics, including fundamental theorems, plane wave functions, cylindrical wave functions, variational techniques, geometric theory of diffraction, method of moments, finite difference time domain method and Galerkin's method. Computer programming exercises. Prereq: EE 217, ES 204. 3 u.

318 **Mathematical Methods for Electromagnetics II.** Variational techniques, geometric theory of diffraction, Galerkin's method, finite difference time domain method, method of moments; recent topics of interest; computer programming exercises. Prereq: EE 317. 3 u.

320 **Analysis and Design of High Performance Digital Integrated Circuits.** Parasitic models and second order effects of field-effect and bipolar transistors, and interconnects; clock skew and other timing issues; design of high-performance combinational and sequential logic circuits; arithmetic and memory structures and devices; charge-coupled device circuits; signaling, synchronization, noise and clock and power distribution issues; extraction of circuit parameters from process parameters; optimization at the device and circuit levels; circuit-systems issues: design projects. Prereq: EE 226; Coreq: EE 325. 4 u.

322 **Analysis and Design of Monolithic Information Processing and Communication Circuits.** Small and large-signal models of field-effect and bipolar transistors; amplifiers, switched capacitor networks, sample and hold, multiplexers, analog to digital and digital to analog converters, active filters, comparators, analog multipliers, relaxation oscillators, phase detectors, phase-locked loops, voltage-controlled oscillators, mixers, sampled-data filters, digital decimation and interpolation filters; charge-coupled device circuits; architectural and circuit level performance evaluation; design projects. Prereq: EE 220; Coreq: EE 325. 4 u.

325 **Semiconductor Devices II.** Compound semiconductors and hetero-junctions; dielectric and optical properties; optical processes; physics and models of high-frequency, high-speed and optoelectronic devices including HFET, HBT, MESFET, quasi-ballistic transistors and other sub-micron transistor concepts, and charge-coupled devices. Prereq: EE 225. 3 u.

326 **Optoelectronic Devices.** Optical properties and processes; optical detectors, light-emitting diodes, solar cells, modulators, switches, directional couplers, lasers and others of interest. Prereq: EE 325. 3 u.

327 **Advanced VLSI Design.** Advanced VLSI technologies; system architecture; system behavior modeling in VHDL or C; CAD tools for standard cell, custom design or hybrid techniques; integration of heterogenous CAD tools; automated and manual synthesis; advanced circuit design and testing methods; synthesis of the different levels of design hierarchy; design projects. Prereq: EE 227. 3 u.

330 **Optimal Control.** Theoretical methods in optimal control theory. Topics include the review of the optimality conditions: Lagrange and Kuhn-Tucker. The calculus of variations and the Pontryagin minimum principle with applications to minimum energy problems. Geometric methods will be applied to the solution of minimum time problems. Computational methods, singular problems, observer theory, and sufficient conditions for existence of solutions are also discussed. Prereq: EE 212. 3u.

353 **Power System Reliability.** Basic reliability concepts. Methods for reliability modeling and evaluation. Reliability measures. Reliability of generation, transmission, distribution, composite, and interconnected systems. Prereq: EEE 25/ equiv. 3 u.

355 **Power System Planning.** Financial modeling. Load forecasting. Production simulation. Generation planning. Network planning. System planning in a competitive electricity industry. Prereq: EEE 103/equiv. 3 u.

357 **Power System Dynamics and Stability.** Modeling, analysis, and simulation of power systems subjected to small and large disturbances. Steady state, transient, and dynamic stability assessment and enhancement. Multi-machine studies. Recent developments. Prereq: EEE 103/equiv. 3 u.

358 **Economic Operation of Power Systems.** Economics of energy generation and operation. Optimization methods. Mixed-generation dispatch. Unit commitment. Optimal load flow. Competitive markets for electricity generation. Recent developments. Prereq: EEE 103/equiv. 3 u.

359 **Power Systems Operation and Control.** Modern power system operational and control problems and solution techniques, including load frequency control, automatic generation control, system voltage control, security assessment, state estimation, and contingency analysis. System control centers. Interconnected systems. Prereq: EEE 103/equiv. 3 u.

370 **Digital Communications II.** Communication over band-Wlimited and fading channels. Multipath propagation. Channel equalization and adaptive techniques. Fractionally-spaced equalizers. Decision feedback equalization. Spread spectrum systems, multiuser access and detection. Current topics of interest. Computer exercises. Prereq: EE 270. 3 u.

371 **Microwave Integrated Circuits I.** Computer-aided analysis and design of distributed circuit structures and their applications in passive and active microwave circuits including dividers, directional couplers, circulators, filters, transistor amplifiers, attenuators; experimental characterization; design projects. Prereq: EE 271, 325. 3 u.

372 **Microwave Integrated Circuits II.** Computer-aided analysis and design of distributed circuit structures and their applications in passive and active microwave circuits including transistor amplifiers, mixers, modulators, demodulators, oscillators, frequency converters, phase shifters, harmonic generators; noise models and low-noise design; monolithic MIC; fabrication processes of monolithic circuits; experimental characterization; design projects. Prereq: EE 371. 3 u.

374 **Digital Signal Processing II.** Multirate processing. Optimal methods in filter design. Superior filter stuctures. Advanced finite word length effects. Non-parametric and parametric spectrum estimation. Adaptive filters, Wiener filters and algorithms. Time-frequency analysis and wavelets. Linear prediction. Current topics of interest. Computer exercises. Prereq: EE 214/equiv, 274. 3h (2 lec, 1 lab) 3 u.

398 **Special Problems.** 3 u.

400 **Dissertation.** 12 u.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERING

GENERAL EDUCATION COURSE

Electrical and Electronics Engineering (EEE)

10[a] **Everyday EEE: Kuryente, Radyo atbp.** Electrical and electronics engineering in everyday life. 3 u.

UNDERGRADUATE

Electrical and Electronics Engineering (EEE)

1 **Essentials of Electrical and Electronics Engineering.** Analysis of alternating current (AC) and direct current (DC) circuits; motors and generators, characteristics and methods of control; diode and transistor circuits; current digital circuits and logic gates; transducers and transducer circuits; operational amplifiers; motor control; feedback control systems; introduction to digital control; programmable logic controllers. Prereq: ES 21/Math 121.1/equiv, Physics 72/102. 6 h. (3 lec, 3 lab) 4 u**.**

3 **Elementary Electrical Engineering.** Fundamentals of electric and magnetic circuits; transformers; direct and alternating current machinery; elementary distribution systems and electrical wiring. Prereq: Math 54, Physics 72. 3 u.

4 **Industrial Electronics and Equipment.** Electrical measurements and some of their industrial applications. Operating principles, characteristics and application of electrical equipment. Equipment and devices used for system protection control. Applications in power and industrial systems. Modern control device in industry. Prereq: EEE 1 or EEE 3. 5h (2 lec, 3 lab). 3 u.

5 **Introduction to Semiconductor Devices and Circuit Theory.** Elementary circuit analysis; semiconductor devices; introduction to transducers, operational amplifiers, and digital design. Prereq: Math 54, Physics 72, Physics 72.1. 6h (3 lec, 3 lab). 3 u.

7 **Microcontroller-based Data Aquisition Systems.** Analog-to-digital conversion. Digital-to-analog conversion. Sensors and transducers. Signal conditioning. Data acquisition systems. Microcontroller programming and interfacing. Data transfer and visualization. Prereq: EEE 1 or EEE 3. 5h (2 lec, 3 lab). 3 u.

11 **Programming Fundamentals.** Programming fundamentals. Data types. Control loops. Fundamental principles of software engineering. Functions. Standard libraries. Arrays and strings. Structure and union. File I/O. Fundamental data structures. Pointers. Prereq: Math 17. 5h (2 lec, 3 lab). 3 u.

13 **Programming Applications in Electrical and Electronics Engineering.** Data structures. Algorithm performance. System calls. Fundamental database concepts. Graphical user interface principles. Fundamental network programming. Prereq: EEE 11 or equiv. 5h (2 lec, 3 lab). 3 u.

21 **Switching Theory and Digital Logic Design.** Combinational logic analysis and design. Digital integrated circuit building blocks. Design of digital subsystems. Analysis and synthesis of sequential circuits. Introduction to hardware description languages. Prereq: Math 17. 3 u.

23 **Electromagnetic Fields I.** Vector analysis; steady electric and magnetic fields; dielectric and magnetic materials; time-varying fields. Maxwell's equations; introduction to uniform plane waves and transmission lines; applications to electrical engineering. Prereq: Physics 72. Coreq: Math 55. 4 u.

25 **Probability and Statistics for Electrical and Electronics Engineers.** Review of descriptive statistics; combinatorial probability; single and bivariate random variables; expectation; sum of two independent random variables; introduction to estimation; introduction to random processes. Prereq: Math 55. 3 u.

31 **Introduction to Electrical and Electronics Engineering.** Fundamental concepts and laws in electrical and electronics engineering. Magnetism. Electrical and electronic devices. DC analysis of resistive networks. Overview of different fields in electrical and electronics engineering. Demonstration of basic concepts. Prereq: Math 17. 3 u.

33 **Electric Circuit Theory.** Network theorems. AC circuit analysis. Equilibrium equations for resistance-inductance-capacitance (RLC) networks. Transient analysis of first-order and higher-order networks. Sinusoidal steady-state analysis. Polyphase circuits. Prereq: Math 53, EEE 31. 4 u.

34 **Electrical Measurements Laboratory.** Laboratory procedures and practice; data collection and analysis; laboratory documentation; standard electric instruments and circuits; basic electric circuit behavior; transducers. Coreq: EEE 33. 3 h. (lab) 1 u.

35 **Signals and Systems.** Mathematical modeling of signals and systems. Continuous– and discrete–time signals. System analysis techniques and their applications to electric and electronic circuits, filter design, communications, control and signal processing. Linear time–invariant (LTI) systems. Frequency domain representation of signals and system transfer functions. Fourier–, Laplace– and Z–transforms. Prereq: Math 54, EEE 11, EEE 33. 6h (3 lec, 3 lab). 4 u.

41 **Introduction to Semiconductor Devices and Circuits.** Semiconductor devices: diodes, bipolar junction transistors, field effect transistors; device models and circuit applications;

[a]*Math, Science and Technology domain*

regions of operation; large and small signal modeling and analysis; semiconductor theory. Prereq: EEE 23, 33. 3 u.

42 **Semiconductor Devices and Circuits Laboratory.** Characteristics, parameters, and non–idealities of actual diodes, bipolar junction transistors (BJTs) and field effect transistors (FETs); basic circuit applications. Prereq: EEE 34; Coreq: EEE 41. 3 h. (lab) 1 u.

43 **Electromechanical Energy Conversion.** Basic principles. Generalized machine model. Direct current, synchronous and induction machines. Prereq: EEE 23, 33. 3 u.

44 **Electrical Machine Operation and Control.** Operation and control of fractional horsepower direct current (DC) and alternating current (AC) motors; motor control devices and circuits; programmable logic controllers. Prereq: EEE 34; Coreq: EEE 43. 3h (3 lab) 1 u.

51 **Electronic Circuits I.** Transistor amplifiers. Feedback amplifiers. Operational amplifiers. Linear regulators. Prereq: EEE 41. 3 u.

52 **Electronic Circuits Laboratory I.** Performance measurements and behavior analysis of analog circuits. Prereq: EEE 42; Coreq: EEE 51. 1 u.

53 **Electronic Circuits II.** Active switching circuits. Waveshaping circuits. Pulse and digital circuits. Analog and digital circuit building blocks. Linear and switch-mode regulators. Prereq: EEE 21, EEE 41. 3 u.

54 **Electronic Circuits Laboratory II.** Construction, performance measurements and behavior analysis of pulse, wave-shaping, timing and digital circuits. Prereq: EEE 42; Coreq: EEE 53. 3h (3 lab) 1 u.

100 **Electronic Circuits Prototyping Laboratory.** Basic prototyping skills for electronic circuits including soldering, schematic design entry, printed circuit board (PCB) layout and routing, PBC fabrication. Safe laboratory practices. Computer aided design tools. Overview of industrial prototyping processes and standards. Prereq: ES 1, EEE 42. 3h (3 lab) 1 u.

101 **Control Systems Theory.** Continuous and discrete systems. Open and closed loop systems. Transfer functions. Block diagrams. Signal flow graphs. State variables. State transition matrix. Stability. Controllability and observability. Prereq: ES 12, EEE 35; Coreq: EEE 41. 3 u.

103 **Introduction to Power Systems.** Electric power industry.; power system components and system modeling; load flow concept; symmetrical components; fault calculations. Prereq: EEE 33. 3 u.

105 **Computer Organization.** Instruction sets. Computer arithmetic. Datapath and control. Memory system organization and architecture. Interfacing and communication. Assembly language programming. Prereq: EEE 11, EEE 21, EEE 41. 6 h. (3 lec, 3 lab) 4 u.

107 **Introduction to Communication Systems.** Signals and spectra; noise and distortion; transmission, reception, and detection; continuous–wave modulation and baseband digital pulse modulation; examples of practical communication systems. Prereq: EEE 25, 34, 35. 5 h. (2 lec, 3 lab) 3 u.

190 **Project Proposals, Inspection Trips, and Seminars.** Project proposal documentation and presentation; visits to companies, factories, and electrical power plants; seminars on topics such as research, technical writing, presentation skills, career planning, engineering ethics, and technopreneurship. Prereq: SS, research laboratory affiliation. 4 h. (1 lec, 3 lab) 2 u.

ENERGY AND ENVIRONMENTAL ENGINEERING PROGRAM

UNDERGRADUATE

Energy (EgyE)

101 **Introduction to Energy Engineering.** Energy resources, conversion, uses, and conservation. Prereq: SS. 3 u.

197 **Special Topics.** 3 u.; may be taken twice.

GRADUATE

Energy (EgyE)

201 **Energy Resources, Uses and Systems.** World, regional and national energy resources and demand. Energy data system: boundaries framework, flow diagrams, reference energy system, input/output. Non-renewable resources: oil, natural gas, coal, nuclear. Renewable energy resources: solar, wind, hydro, biomass, geothermal, ocean. Energy use: residential, commercial, industrial, transport, etc. Energy Technologies and Energy Issues. Prereq: COI. 3 u.

205 **Energy Engineering Laboratory.** Laboratory methods in energy engineering. Prereq: COI. 1 u.

211 **Energy Conservation.** Energy conservation techniques. Conservation methods in the home, in transportation, in industrial and commercial sectors. Inter-fuel substitution. Factors in the design of low-energy consumption buildings. Prereq: COI. 3 u.

220 **Coal Technology.** Coal properties; Philippine coal resources and coal utilization. Coal mining; Coal cleaning; and conversion technology; Environmental concerns. Prereq: COI. 3 u.

221 **Solar Energy I.** Solar energy collection, storage, and utilization. Design and economics. Prereq: COI. 3 u.

222 **Biomass Energy.** Biomass production. Biomass conversion including: compaction, combustion, gasification, pyrolysis, hydrolysis and fermentation. Vegetable oil extraction and transesterification. Biogas production. Energy crops. Environmental and societal aspects of biomass energy. Prereq: COI. 3 u.

223 **Wind, Hydro, and Ocean Energy Systems.** Resource assessment, analysis, design, operations, utilization, and environmental and societal aspects of wind, hydro, and ocean energy systems. Prereq: COI. 3 u.

225 **Nuclear Energy.** Design and economics of nuclear energy systems. Environmental and societal aspects. Prereq: COI. 3 u.

231 **Energy Economics and Systems Evaluation.** Setting of objectives. Value systems analysis. Multiple criteria evaluation. Economics of energy. Technological, economic, societal and environmental factors. Prereq: CE 22/equiv/COI. 3 u.

235 **Energy Technology Assessment.** Methods of technology assessment. Technical, economic, environmental, social and institutional impact analyses of energy systems. Prereq: COI. 3 u.

236 **Energy Systems Modeling.** Macro-economic growth models. Inter-industry /Input-Output models. Energy market models. Energy aggregation. Factor analysis. Representation of the energy sector network. Network-based energy system modeling. Specific industry models including electric power, gas, coal, oil. Prereq: COI. 3 u.

251 **Energy Planning.** Energy and development. Energy supply analysis. Energy demand analysis. Supply-demand balancing. Electric power system planning. Rural electrification planning. Prereq: COI. 3 u.

272 **Waste Heat Recovery and Cogeneration.** Identification, evaluation, and recovery of waste heat. Applications and case studies. Prereq: COI. 3 u.

273 **Power Plant Technology.** Fuel selection. Steam cycles. Power plant design. Control of pollutant emissions, power economics. Prereq: COI. 3 u.

290 **Special Project.** A countryside-oriented project on energy alternatives, conservation or development to be undertaken individually by the student. The output of the project shall be a device, process, system, or concrete proposals for specific action which will be of practical benefit to people in the rural communities. 3 u.

296 **Seminar.** Prereq: COI. 1 u. May be taken thrice.

297 **Special Topics.** Prereq: COI. 3 u.; may be taken twice.

298 **Special Problems.** Prereq: COI. 3 u.; may be taken twice.

300 **Master's Thesis.** 6 u.

320 **Energy Resource Assessment.** Definition and measurement of energy stocks and flows. Fuel cycle. Exploration and production techniques. Technologies and utilization. Methods of energy resource assessment. Methods of energy demand analysis. Prereq: EgyE 201 or COI. 3 u.

321 **Solar Energy II.** Physics of semiconductors and materials in photovoltaic devices; physical models of solar cell operation; characteristics, design, and fabrication of common types of solar cells; approaches to increasing solar cell efficiency; radiant energy transfer and its application to solar exchangers; energy balances for solar exchangers; theory, economics, and practice of solar-thermal energy applications. Prereq: COI. 3 u.

322 **Advanced Biomass Energy.** Equilibrium and kinetic models of thermochemical conversion systems. Oil extraction equilibria. Transesterification kinetics. Lignocellulosic chemistry. Hydrolysis and fermentation kinetics. Design of biomass energy systems. Prereq: EgyE 222 or COI. 3 u.

323 **Advanced Wind, Hydro and Ocean Energy Conversion Systems.** Geographical, meteorological and aerodynamic analysis of wind energy potential. Hydrological and hydraulic analysis of hydro energy potential. Assessment of wave, tide, current and ocean thermal energy. Survey and classification of wind, hydro and ocean energy conversion technology. Case analysis, modeling, design, operations and performance of wind, hydro and ocean engineering systems. Prereq: EgyE 223 or COI. 3 u.

324 **Geothermal Energy.** Description of geothermal energy and comparison with other forms of energy. Types and geographic locations. Design and economics of geothermal energy systems. Types of geothermal power plants. Operational, maintenance, environmental and social concerns; direct uses of geothermal energy; heat pump basics. Prereq: COI. 3 u.

332 **Energy Optimization and System Dynamics.** Total system design. Systems theory and application of modeling and simulation techniques in energy systems design. Optimization system dynamics. Prereq: EgyE 236 or COI. 3 u.

397 **Special Topics.** Prereq: COI. 3 u. May be taken more than once provided the topic is not the same.

398 **Special Problems.** Prereq: COI. 3 u.

400 **PhD Dissertation.** 12 u.

UNDERGRADUATE

Environmental Engineering (EnE)

31 **Technology and Environment.** Perspectives on ecology, energy and materials, population and socioeconomic factors: water quality; air quality; solid wastes and hazardous materials; environmental quality planning and management, and land use. Prereq: 3rd yr. standing. 3 u.

80 **Special Problems.** 3 u., may be taken twice.

GRADUATE

Environmental Engineering (EnE)

202 **Research Methods in Environmental Engineering.** Quantitative and qualitative research in the design of experiments in Environmental Engineering. 3 u (lec).

203 **Introduction to Environmental Engineering.** Overview of the environmental engineering profession and its coverage which includes air, water, soil and groundwater pollution sources and its control, laws and regulations. This course also tackles global issues such as climate change and disaster risk reduction management and its implications to environment engineering. 4 u (lec).

205 **Environmental Engineering Laboratory I.** Theory and methods for environmental (air , water, soil) quality parameter measurement and waste characterization. Prereq: Chem 16/ equiv. 7 h. (1 class, 6 lab) 3 u.

210 **Water Quality Control and Management.** Methods and economics of water quality control; river and estuary models for water quality parameters; water quality management. Prereq: EnE 203. 3 u.

213 **Biological Treatment Process Design.** Theory of biological treatment processes and design of a treatment plant. Prereq: EnE 203. 3 u.

214 **Chemical Treatment Process Design.** Theory of chemical treatment processes and design of treatment plants. Prereq: EnE 203. 3 u.

215 **Advanced Water Treatment Process.** Carbon adsorption; reverse osmosis; dialysis and electrodialysis; ion exchange; equipment design. Prereq: EnE 203. 3 u.

216 **Water Safety and Distribution.** Design of the components of the different types of water treatment plant; preparation of treatment and safe distribution system for a particular community; development of a water safety plan. Prereq: EnE 203. 3 u (lec).

218 **Surface-chemical Technologies for Environmental Applications.** Design of surface chemical technologies for clean water. Prereq: EnE 203. 3 u (lec).

220 **Environmental Engineering Laboratory II.** Experimental study and equipment design of certain pollution control operations and processes. Prereq: COI. 7 h. (1 lec, 6 lab) 3 u.

252 **Indoor Air Quality Management.** Sources, effects and control of indoor air pollution; design strategies to attain indoor air quality that meets standards. Prereq: EnE 203. 3 u (lec).

253 **Air Quality Monitoring and Modeling.** Characteristics, sources, effects, monitoring and modeling of air pollution. Prereq: EnE 203. 3 u (lec).

254 **Air Quality Control and Management.** Design of commonly used air pollution control devices, stack design and ground level concentration calculations. Prereq: EnE 203. Co-req: EnE 253. 3 u (lec).

260 **Fundamentals of Geoenvironmental Engineering.** Principles and processes in the field of geoenvironmental engineering, vadose zone hydrology and environmental soil physics. Prereq: EnE 203. 3 u (lec).

261 **Soil and Groundwater Remediation Technologies.** Treatment processes and systems for polluted soil and contaminated groundwater remediation. Prereq: EnE 260. 3 u (lec).

270 **Solid Waste Disposal and Management.** Composition and quantity of solid wastes generated by residential, commercial and industrial establishments; disposal methods and management. Prereq: EnE 203. 3 u.

272 **Landfill Design and Operation.** Design, operation and maintenance of sanitary landfills and its management upon closure. Prereq: EnE 203. 3 u (lec).

280 **Environmental Impact Assessment.** Evaluation, estimation and prediction of the effects of structures, processes, and systems upon the environment and the effects of environmental changes upon human populations. Prereq: EnE 203. 3 u.

281 **Decision Analysis for Environmental Engineering.** An introduction to decision analysis approaches, tools and techniques for incorporating environmental, economic efficiency and effectiveness criteria. Prereq: EnE 203. 3 u (lec).

282 **Environmental Decision Support Systems.** Concepts, principles, elements, architecture, and implementation of decision support systems as applied to environmental problems. Prereq: EnE 203. Co-req: GmE 203. 3 u (lec).

283 **Disaster Risk Management.** Principles and techniques in the management and mitigation of natural and human-induced hazards to prevent or mitigate the adverse effects to society. Further focus on the identification of analysis of factors that constrain and promote effective disaster risk assessment at the community level. Prereq: EnE 203. Co-req: GmE 203. 3 u (lec).

296 **Seminar.** 1 u.; may be taken thrice.

298 **Special Problems.** 3 u.; may be taken twice.

300 **Thesis.** 6 u.

302 **Chemical Processes in Environmental Engineering.** Application of principles of chemical equilibrium, chemical kinetics and thermodynamics to air and water quality. Prereq: Chem 16/ME 63/equiv. 3 u.

303 **Biological Processes in Environmental Engineering.** Application of the principles of biochemistry and microbiology to air and water quality, wastes and their engineering management; biologically mediated changes in water and in domestic and industrial wastewater. Prereq: EnE 212/213/ equiv. 3 u.

304 **Numerical Solutions in Environmental Engineering.** Mathematical formulation and solution of problems involving pollutant movements and behavior in environmental processes and air/water pollutant dynamics employing ordinary and partial differential equations and advanced mathematical methods in transport phenomena. Prereq: ES 201/equiv. 3 u.

305 **Environmental Modeling.** Application of mathematical programming and modeling of engineered solutions involving multi-media environmental systems such as air pollution, groundwater flow and solute transport, and surface water quality; Stochastic models. Prereq: ES 204/equiv. 3 u.

372 **Hazardous Waste Management.** Sources and characteristics of hazardous wastes; concepts and applications of management of hazardous wastes from generation, treatment and disposal; waste minimization; remediation; environmental auditing and quantitative risk assessment. Prereq: EnE 270/302/equiv. 3 u.

382 **Environmental Health Engineering.** Biological, chemical and physical environmental stressors; impacts of environmental health hazards on people in the community and the workplace; prevention and mitigation of these impacts through behavioral and engineering control and health impact assessment. Prereq: EnE 210/280/equiv. 3 u.

400 **PhD Dissertation.** 12 u.

ENGINEERING SCIENCES

GENERAL EDUCATION COURSE

Engineering Sciences (ES)

10[a] **Forces at Work.** Principles of engineering mechanics and their relevance to everyday life. 3 u.

[a]*Math, Science and Technology domain*

UNDERGRADUATE

Engineering Sciences (ES)

1 **Engineering Drawing.** Technical sketching, lettering, instrumental drawing. Multiview projections. Pictorial drawing. Conventions and dimensioning. Graphs and charts. 6 h. (lab) 2 u.

11 **Statics of Rigid Bodies.** Distributed loads and friction; resultants and equilibrium of force-couple systems using vector mechanics; frames, trusses, beams and cables; geometric properties of sections. Prereq: Math 54. 5 h. (2 lec, 3 lab) 3 u.

12 **Dynamics of Rigid Bodies.** Applications of vector mechanics to the kinematics and kinetics of particles and rigid bodies; Newton's second law; D'Alembert's principle; work and energy; impulse and momentum. Prereq: ES 11. 5 h. (2 lec, 3 lab) 3 u.

13 **Mechanics of Deformable Bodies I.** Stresses and strains considering axial, torsional, flexural and combined loading; analysis and design of structural members, machine elements, pressure vessels, riveted and welded connections; mechanical properties of materials. Prereq: ES 11. 3 u.

14 **Mechanics of Deformable Bodies II.** Special topics in mechanics of materials, such as curved bars, impact, and fatigue. Theories of failure of materials. Introduction to theory of elasticity. Prereq: ES 13. 3 u.

15 **Mechanics of Fluids.** Statics, kinetics and dynamics of fluids. Effects of weight, viscosity and compressibility. Flow past internal boundaries. Flow past external boundaries. Similitude and dimensional analysis. Lift and propulsion. Prereq: ES 12. 3 u.

16 **Mechanics of Fluids Laboratory.** Principles of experimental analysis and design. Experimental investigation of a particular project. Prereq/Coreq: ES 15. 6 h. (lab) 2 u.

21 **Mathematical Methods in Engineering.** Matrix algebra and solution of systems of linear equations; ordinary differential equations; Fourier series; Laplace transforms, with applications to the solution of initial- and boundary-value problems in engineering. Coreq: Math 55. 3 u.

26 **Introduction to Computer Programming.** Basic computer concepts; simple data types; input/ output; control statements; arrays; subprograms; computer applications. Prereq: Math 53. 5 h. (2 class, 3 lab) 3 u.

GRADUATE

Engineering Sciences (ES)

201 **Advanced Mathematical Methods in Engineering I.** Application of Fourier series, special functions and integral

transforms to the solution of boundary and initial value problems in engineering. Prereq: ES 21/equiv. 3 u.

202 **Advanced Mathematical Methods in Engineering II.** Applications of vector analysis, curvilinear coordinates, and conformal mapping to the solution of engineering problems. Prereq: ES 21/equiv. 3 u.

204 **Numerical Methods in Engineering.** Roots of single equations, systems of linear and non-linear equations; ordinary differential equations; partial differential equations; applications. Prereq: ES 26/equiv. 3 u.

230 **Continuum Mechanics I.** Tensor analysis. Kinematics, dynamics and thermodynamics of continuous bodies. Constitutive equations for thermoelastic solids. Introduction to linear elastic theory. Prereq: ES 13, 202. 3 u.

231 **Continuum Mechanics II.** Theories of constitutive equations and their application to fluid mechanics, viscoelasticity, plasticity and nonlinear elasticity. Prereq: ES 230/equiv. 3 u.

233 **Theory of Stability.** Elastic and inelastic stability of columns, beams, plate elements, introduction to the buckling of shells; post-buckling strength. Prereq: ES 14, 21. 3 u.

234 **Advanced Mechanics of Materials.** Fundamental stress-strain relationships; theories of failure; special topics in beams; introduction to energy methods, plates, inelastic analysis, stability problems. Prereq: ES 13, 21. 3 u.

235 **Photoelasticity.** Introduction to the theory of elasticity. Stress and strain. The basic properties of light with particular reference to the use of double refraction and interference as applied to a loaded specimen. Methods of separating the principal stresses. Prereq: ES 13, 14; Coreq: Differential Equations. 5 h. (2 class, 3 lab) 3 u.

240 **Systems Analysis.** Linear graph theory and lumped parameter electro-mechanical systems. Matrix formulation and treatment of systems equations. Prereq: ES 201. 3 u.

241 **Mechanics of Vibration.** Single, multiple mass systems with or without translation and rotation; impedance on mobility methods; distributed mass systems, self-induced vibration. Prereq: ES 12, a course in Differential Equations. 3 u.

242 **Advanced Dynamics.** Advanced dynamics of rigid bodies in systems of engineering interest. Lagrange's equations. Prereq: ES 241, a course in Advanced Calculus. 3 u.

250 **Similitude in Engineering.** Dimensional analysis. The Pi-Theorem. Laws of similarity and principle of similitude. The various dimensionless criteria: Reynold's Number, Froude's Number, Prandl's Number, Nusselt's Number, etc. Selected examples from various fields of engineering illustrating the applications of these numbers. Prereq: ES 15. 5 h. (2 class, 3 lab) 3 u.

251 **Intermediate Fluid Mechanics.** Intensive study of the effects of gravity, viscosity, surface tension and compressibility of fluid motion. Prereq: ES 15. 3 u.

252 **Hydrodynamics.** Frictionless fluid flow; two-dimensional flow; conformal mapping; three-dimensional flow; vortex motion; elements of wave motion. Prereq: ES 15/equiv, 202. 3 u.

253 **Advanced Fluid Mechanics.** Principles and fundamental characteristics of fluid flow with emphasis on engineering applications. Study of Newtonian and non-Newtonian fluids, compression flow and 2-phase flow. Prereq: ES 15, 16/equiv, COI. 3 u.

257 **Experimental Fluid Mechanics.** Laboratory techniques in fluid flow investigations, design of hydraulic models; interpretation of experimental data. Prereq: ES 15, CE 21/equiv. 4 h. (1 class, 3 lab) 2 u.

296 **Seminar.** 1 u./sem.; maximum of 3 u.

297 **Special Topics in Engineering Sciences.** Prereq: COI. 3 u.; may be taken more than once provided that topics are indicated for record purposes.

298 **Special Problems.** 3 u.; may be taken twice, topics to be indicated for record purposes.

300 **Thesis.** 6 u.

DEPARTMENT OF GEODETIC ENGINEERING

GENERAL EDUCATION COURSE

GEODETIC ENGINEERING (GE)

1[a] **Earth Trek.** A guided exploration into the tools and techniques of earth observation and measurement. 3 u.

UNDERGRADUATE

GEODETIC ENGINEERING (GE)

10 **General Surveying I.** Use of principal surveying instruments; surveying measurements and error theory; basic plane surveying operations and computational methods of position, horizontal and vertical distance measurements, traverse and areas; basic cartography. Prereq: Math 53. 5 h. (2 class, 3 field) 3 u.

11 **Elementary Surveying.** History and development of surveying; basic concepts of and instrumentation for surveying

[a] *Math, Science and Technology domain*

measurements; applications to engineering, geology, architecture and other disciplines. Prereq: Math 17/equiv. 4 h. (1 class, 3 field) 2 u.

12 **General Surveying II.** Introduction to different surveying operations and techniques; control, topographic, hydrographic, and mine surveying; introduction to astronomic and satellite geodesy. Prereq: GE 10. 8 h. (2 class, 6 field) 4 u.

16 **Elementary Photo-Interpretation.** (For non-geodetic engineering students) Principles of photogrammetry; aerial photo-interpretation of cultural and natural features. Prereq: GE 10/11. 4 h. (1 class, 3 lab) 2 u.

117 **Construction and Industrial Surveying.** Route surveying: horizontal route alignment, route surveying, vertical route alignment, earthworks, construction surveys, construction management, computer aided design for construction and industrial surveying. Prereq: GE 12. 5 h. (2 class, 3 field) 3 u.

118 **Hydrographic Surveying.** Introduction to hydrographic surveying; sounding; bathymetry; precise instrumentations for hydrographic surveying; applications of hydrographic surveying. Prereq: GE 12. 5 h (2 lec, 3 lab). 3 u.

119 **Land Surveying.** Survey project controls; comparative equipment, procedures and precisions; regulations governing property surveys in the country; transformation of coordinates to the Philippine Plane Coordinate System (PPCS), PRS '92, land management and administrative titling and survey requirements, basic CADD. Prereq: GE 12, Requires students to be at least 4th year standing. 8 h. (2 lec, 6 lab) 4 u.

120 **Introductory Object-Oriented Programming for Geospatial Applications.** Concept of object-based and basic-oriented programming; applications; control structures; arrays and methods; exception handling; graphics and GUI programming in developing numerical computation application for Geodetic Engineers. Prereq: GE 10. 7 h (1 lec, 6 lab). 3 u.

122 **Mathematical Methods in Geodetic Engineering.** Matrices; systems of equations; interpolation; differentiation and integration; ordinary differential equations; linear differential equations; code development for numerical solutions. Prereq: Math 55, GE 120. 5 h (2 lec, 3 lab). 3 u.

128 **Adjustment Computations for Spatial Data Analysis.** Concepts of measurement and error; statistical testing; variance-covariance propagation; error propagation in survey measurements; introduction to least square adjustments. Prereq: GE 122. 3 h (lec). 3 u.

129 **Adjustment Computation for Geodetic Applications.** Standard and general least squares adjustment; adjustment of geodetic control network adjustment (trilateration, triangulation and traverse network; GPS adjustment); constraint equations. Prereq: GE 12, GE 128. 8 h (2 lec, 6 lab). 4 u.

143 **Laws on Natural Resources.** Pertinent provisions of the Civil Code on property and its ownership; study of the mining law, petroleum act, coal land act, modes of acquiring mineral lands; public land laws; forest laws; and others. 3 u.

145 **Mining Laws.** Study of the Philippine mining law, the petroleum act and the coal land act, proper legal procedures for the application for mineral land leases and permits and the requisite for their final approval. 1 u.

148 **Land Registration Law.** Fundamentals of the law on ordinary and cadastral land registration in connection with the Torrens system; Real Estate Development Laws, Indigenous People's Rights Act; Agrarian and Urban Land Reform. 3 h (lec). 3 u.

149 **Contracts, Surveying, Laws and Ethics.** Requisites of contracts; obligations of contracting parties; nullity and enforcement of contracts; stud of actual cases involving contract; Republic Act 9200- The Geodetic Engineering Law; Code of Ethical and Professional Standard; other surveying laws. Prereq: COI. 2 h (lec). 2 u.

151 **Introduction to Geodesy.** History and development of geodesy; the international geodetic community; basic concepts in geodesy; positioning systems and positioning methods; time systems and time coordination; application of geodesy. Prereq: GE 12. 3 h (lec). 3 u.

152 **Reference Systems and Reference Frames.** Different kinds of reference systems and reference frames; geometry of the reference ellipsoid; computation of geodetic positions; coordinate transformation and map projections; International Terrestrial Reference Frames (ITRF); the Philippine Reference System (PRS). Prereq: GE 122, GE 151. 6 h (3 lec, 3 lab). 4 u.

153 **Earth's Gravity and Geoid Modelling.** Earth's gravity field; normal and anomalous gravity field; geoid; height systems; geoid height modeling and methods; geoid models; geodynamics of the earth. Prereq: 151; Coreq: 152. 5 h (2 lec, 3 lab). 3 u.

154 **Satellite Positioning Systems.** Introduction and overview of satellite-based positioning systems (SPS); orbit description; structure; acquisition and processing of SPS signals; mathematical methods for positioning using SPS; SPS surveying; processing transformation; error sources; software modules, SPS applications; prospects satellite geodesy. Prereq: GE 120, GE 152; Coreq: EEE 3. 5 h. (2 lec, 3 lab) 3 u.

155 **Geodetic Control Network.** Principles and methods of the establishment and densification of geodetic control network including horizontal, vertical, and gravity control network; accuracy standards and specifications of geodetic control network. Prereq: GE 154. 2 h (lec). 2 u.

155.1 **Horizontal Control Network Laboratory.** Project planning and implementation of a horizontal geodetic control network establishment and densification. Coreq: GE 155. 3 h (lab). 1 u.

155.2 **Vertical and Gravity Network Laboratory.** Project planning and implementation of a vertical and gravity control network establishment and densification. Prereq: GE 129; Coreq: GE 155. 3 h (lab). 1 u.

173 **Digital Cartography.** Overview of cartography; maps; mapping standards in the Philippines; terrain modeling; computer-aided design (CAD) for survey applications; Graphic Information Systeme (GIS). Prereq: GE 117, GE 118, GE 119; Coreq: GE 155. 3 h. (2 lec, 1 lab). 3 u.

198 **Special Problems.** Research and written report on various subjects or problems on geodetic engineering. Presentation and discussion of the written reports submitted by students before the class. Subjects to be assigned to students by the faculty in-charge. Prereq: Candidacy for graduation. 5 h. (2 class, 3 lab) 3 u.

GRADUATE

GEODETIC ENGINEERING (GE)

202 **Principles of Remote Sensing.** Physical and mathematical principles of data extraction and analysis involving remotely-sensed visible, infrared, thermal and radar imagery. Introduction to image processing. Prereq: COI. 5 h. (2 lec, 3 lab) 3 u.

203 **Principles of Geographic Information Systems.** Use of analogue and digital techniques in spatial information collection, storage and analysis. Various geographic information systems. Map projection and registration of data sets. Prereq: COI. 7 h. (1 lec, 6 lab) 3 u.

204 **Applied Resource Information Systems.** Theory of resource information systems in resource management. Application in mapping, monitoring and prediction of various resources. Prereq: GE 202, 203/equiv. 7 h. (1 lec, 6 lab) 3 u.

212 **Remote Sensing Systems.** Theory, construction and operation of remote sensing data acquisition systems and other instrumentation. Prereq: GE 202/equiv. 5 h. (2 lec, 3 lab) 3 u.

214 **Applied Image Processing.** Theory and application of image processing technique and computer modelling of environmental processes related to remotely-sensed data. Prereq: GE 202/equiv. 7 h. (1 lec, 6 lab) 3 u.

290 **Special Project.** A research or application-oriented project on resource development, utilization or management to be undertaken individually by the student. Prereq: GE 202, 203, 215. 3 u.

300 **Master's Thesis. P**rereq: GE 202, 203, 215/equiv. 6 u.

GEOMATICS ENGINEERING (GmE)

205 **Object-Oriented Programming for Geomatic Applications.** Nature of digital image and other geographic data. Computer systems used in reading, analyzing and displaying these data. Numerical and statistical techniques. Spatial data analysis. Prereq: COI. 5 h. (2 lec, 3 lab). 3 u.

210 **Spatial Visualization.** Theory and application of both abstract and realistic visualization in two, three, and four dimensions. Color theory; communication theory; cartography; map animation; hypermapping; environmental visualization; and augmented reality; three-dimensional modeling and transformations; perspective; hidden surface algorithms; illumination models; texture mapping; ray tracing; animation; applications of scientific and environmental visualization for planning and management in built and natural environments. Prereq: GmE 203. 5 h (2 lec, 3 lab). 3 u.

211 **Satellite Geodesy.** Theory and applications of modern satellite geodesy; theory and applications of satellite positioning, particularly in a geodetic context. Specific topics include: time systems, orbit computation, geodetic datum definition and coordinate systems, introduction to satellite positioning, error modeling, practical applications and considerations, data processing strategies, heights from GPS and geoid modeling and recent developments in satellite geodesy. Prereq: COI. 5 h (2 lec, 3 lab). 3 u.

216 **Field Techniques in Applied Geodesy and Remote Sensing.** Field techniques for analysis, modeling and accuracy assessment in remote sensing and geographic information systems. Application in resource mapping, monitoring and prediction. Prereq: GmE 202, GmE 211. 7 h (1 lec, 6 lab). 3 u.

217 **Cadastral Data Management.** Introduction to Land Administration; Land Policy; Land Tenure and Security; Legal Aspects; Land Registration and Cadastre; Land Reform; Spatial Data Infrastructure; Land Information Systems; ICT and Land Administration; Information system modeling- UML Cadastral data analysis and modeling; Core Cadastral Domain Model; Marine cadastre; Property valuation and taxation. Prereq: GmE 203. 5 h (2 lec, 3 lab). 3 u.

220 **Spatial Databases.** Fundamentals of spatial databases; spatial data modeling including entity-relationship and object-oriented data models; indexes and access methods including B-trees; and query languages and query processing. Prereq: GmE 203. 5 h (2 lec, 3 lab). 3 u.

221 **Spatial Analysis.** Spatial data types; data structures for spatial data; point patterns; measures of dispersion; arrangements; patterns of lines; paths, branching, topology and concepts of distance; patterns of area; patterns in fields; the role of spatial scale and spatial aggregation problems; exploratory spatial data analysis; and spatial autocorrelation. Prereq: GmE 203. 5 h (2 lec, 3 lab). 3 u.

222 **Advanced Geographic Information Systems.** Theory and application of advanced techniques in resource estimation, prediction and evaluation using GIS. Design of GIS; Temporal GIS; 3-D GIS; Spatial data quality; Error propagation; Model integration/coupling with GIS; Agent-Based Modeling. Prereq: GmE 203. 5 h (2 lec, 3 lab). 3 u.

223 **Integrated Spatial Systems.** Fundamental concepts, theory, and applications of integrating spatial technologies with enabling technologies, such as wireless communications and the Internet; studies in positioning technologies and measurement integration; distributed GIS, web mapping, interoperability; location-based services. Prereq: GmE 203. 5 h (2 lec, 3 lab). 3 u.

230 **Microwave Remote Sensing.** Theory and application of microwave remote sensing in resource mapping, monitoring and prediction; Radar development; Side Looking Radars (SLAR); Synthetic Aperture Radar, Imaging polarimetry, interferometry, radar altimetry, passive microwave systems. Prereq: GmE 202. 5 h (2 lec, 3 lab). 3 u.

231 **Lidar Remote Sensing.** Principles, technologies and applications of Lidar ("Light Detection and Ranging") remote sensing; Laser ranging; Airborne laser scanning; Lidar system design; full-wave laser scanning; quantitative Lidar simulation; Lidar data retrieval; Lidar sensitivity and error analysis. Prereq: GmE 202. 5 h (2 lec, 3 lab). 3 u.

232 **Hyperspectral Remote Sensing.** Principles, technologies and applications of hyperspectral remote sensing; spectral matching; spectral mixing analysis; high-dimensional implications for supervised classification. Prereq: GmE 202. 5 h (2 lec, 3 lab). 3 u.

233 **Close-Range Photogrammetry.** Principle and methods of close-range digital photogrammetry; industrial, engineering and other applications of vision metrology. Prereq: GmE 202. 5 h (2 lec, 3 lab). 3 u.

241 **Mathematical Geodesy and Adjustments of Geodetic Observations.** Review of Least Squares Adjustments; Network deformation and analysis; Theory of Elasticity; Least-squares Collocation; Non-linear Adjustments; Datum Transformation Techniques; Ring Theory and Polynomial Theory as applied to problems in Geodesy. Prereq: COI. 5 h (2 lec, 3 lab). 3 u.

242 **Satellite Positioning, Signal Processing and Numerical Methods.** Space-based positioning systems (such as GPS) are used in conjunction with sophisticated mathematical modelling to solve the problems of determining 3-D position on and near the surface of the earth. Static and kinematic positioning with the Global Positioning System (GPS). Inertial positioning; VLBI positioning; satellite laser ranging. Horizontal, vertical and three-dimensional networks; pre-analysis and post-analysis; theory of heights; gravimetry; global and local geoid determination; astrogeodetic, gravimetric and combined methods; leveling by GPS and the geoid. Introduction to signal processing, time series analysis and FFT techniques. Kalman filtering. Prereq: GmE 211, GmE 241. 5 h (2 lec, 3 lab). 3 u.

243 **Satellite-Based Positioning Systems (SBPS) Technology Development.** SBPS receiver-software interface development; GPS functional library; GPS data platform and processing core; Concept of precise kinematic positioning and flight-State monitoring; precision estimation and comparisons. Applications of GPS Theory and Algorithms. 7 h (2 lec, 6 lab). 3 u.

UNDERGRADUATE

GEOINFORMATICS (GIM)

175 **Geographic Information Systems: Theory and Applications.** Design and implementation of geographical information systems (GIS) and Spatial data management including: concept of information and GIS; georeferencing; spatial data modeling; spatial representation; geoprocessing; input/output operations; file storage; database management systems and distributed processing. GIS data models and structures. Spatial indexing. Algorithms for data manipulation, transformation. Spatial analysis and visualization. Techniques involved in project specification, design and implementation and the selection of computer hardware and software for GIS, Strategies and steps on GIS design and implementation. Interoperability, including internet-based handling of spatial data and web-based geo-information services. Prereq: COI; Corereq: GE 173. 5h (2 lec, 3 lab). 3 u.

177 **Land Development and Valuation.** Land development patterns and concepts; growth and sustainability; land development design elements and processes; site analysis and land use planning; land valuation methods. Prereq: GE 175 or COI; Coreq: GE 189. 5 h (2 lec, 3 lab). 3 u.

GEOSPATIAL ENGINEERING (GsE)

188 **Modern Photogrammetry.** Mono and stereo photogrammetry; principles of vertical photography and stereoscopy; optics; image coordinate refinement; theory of orientation and aerial triangulation; digital image processing; DEM, contour and orthophoto generation; principles of satellite photogrammetry; close-range applications. Prereq: GE 129, GE 173. 8 h (2 lec, 6 lab). 4 u.

189 **Remote Sensing: Theory and Applications.** Fundamental concepts of remote sensing; electromagnetic radiation principles; history of aerial photography and space imaging; elements of visual interpretation; sensors and platform characteristics; digital image processing; information extraction; thermal infrared, microwave and LIDAR remote sensing; thematic mapping applications. Prereq: GE 188, EEE 3. 8 h (2 lec, 6 lab). 4 u.

Geodetic and Geospatial Engineering and Geoinformatics

190 **Seminar in Geodetic and Geospatial Engineering and Geoinformatics.** Undergraduate research proposal and data gathering.Prereq: Students must be at least 5th year in standing. 1 h (lec). 1 u.

191 **Geodetic and Geospatial Engineering and Geoinformatics Practicum I.** On-the-Job Training Preparation. Prereq: Students must be at least 4th year in standing and must be taken in 2nd semester of the academic year. 1h (lec). 1 u.

192 **Geodetic and Geospatial Engineering and Geoinformatics Practicum II.** On-the-Job Training. Prereq: Students must be at least 4th year in standing and must be in during summer of the academic year. (2 u. lab., minimum of 144 hours). 2 u.

199 **Undergraduate Research.** Undergraduate research proper and defense.Prereq: Students must be at least 5th year in standing. 12 h (lab). 4 u.

DEPARTMENT OF INDUSTRIAL ENGINEERING AND OPERATIONS RESEARCH

UNDERGRADUATE

Industrial Engineering (IE)

3 **Introduction to Industrial Engineering.** Systems concepts, the industrial organization and its functions, overview of industrial engineering tools. Prereq: 3rd yr. Standing. 3 u.

10 **Basics of Industrial Engineering.** Overview of industrial engineering, its areas of specialization and the practice of the Industrial Engineering Profession. 1 u.

21 **Industrial Materials and Processes.** Industrial materials and processes and their effects on production system decisions. Prereq: Chem 16, ES 1, Physics 72. 3 u.

27 **Probability and Statistics for Industrial Engineering.** Applications of logic and probability in industrial engineering; random variables and their functions, descriptive statistics, discrete and continuous probability distributions and their applications. Sampling theory. Estimation and tests of hypotheses. Prereq: Math 54. 3 u.

28 **Statistical Analysis for Industrial Engineering.** Regression, correlation, analysis of variance, design of experiments and their applications in industrial engineering. Prereq: IE 27. 3 u.

31 **Industrial Organization and Management.** Basic features governing the organization, administration, and financing of industries. Relations between labor and management. Prereq: 3rd yr. Standing. 3 u.

32 **Methods Engineering.** Productivity concepts and techniques; methods study and work measurement; wage payment; indirect and expense labor standards; training practices. Prereq: IE 21, 27, 31. 5 h. (2 lec, 3 lab) 3 u.

33 **Systems and Procedures.** Systems documentation and charting; introduction to information management and related ISO standards; systems and procedures best practices. Coreq: IE 32. 2 u.

41 **Operations Research I.** Operations research methodology; optimization models for linear systems; linear programming; duality and sensitivity analysis; transportation, assignment, and network models. Prereq: ES 21. 3 u.

50 **Engineering Economics for Industrial Engineering.** Concepts and tools of economic analysis for decision-making. Interest and money-time relationships. Single and multiple project evaluation. After-tax economy studies. Decisions recognizing risk and uncertainty. Prereq: Acctg 1. 3 u.

122 **Product Design and Development.** Framework for product life cycle design, integrated product and product design, development protyping, and evaluation. Prereq: IE 21. Coreq: Shop 7. 7.5 h. (2 lec, 3 lab) 3 u.

135 **Industrial Quality Control.** Statistical process control. Specifications and tolerances. Acceptance sampling. Reliability and life testing. Quality improvement. Prereq: IE 28, 32. 3 u.

136 **Manufacturing Systems.** Primary activities of a manufacturing firm. Manufacturing practices. Prereq: 4th year standing. 3 u.

137 **Quality Systems in Manufacturing.** Concepts of quality. World-class quality programs and standards. Performance measurement and competitive priorities. Benchmarking. Coreq: IE 136. 3 u.

138 **Manufacturing Management.** Organizational and financial aspects of manufacturing. Manufacturing management principles. Prereq: 4th yr. standing. 3 u.

139 **Reliability Engineering for Industrial Systems.** Basic concepts of reliability engineering. Reliability measurement system. Reliability analysis methods. Failure mode and effects analysis. Fault tree analysis. Risk analysis. Human reliability. Life testing. Reliability testing and evaluation. Design for reliability applications. Prereq: IE 135; IE 143. (3h lec) 3 u.

142 **Operations Research II.** Matrix approach to linear programming; integer programming; dynamic programming; goal programming; game theory. Prereq: ES 26, IE 41. 3 u.

143 **Stochastic Processes in Engineering.** Elements of stochastic processes; queuing theory and decision models; Markov chains, renewal theory and its applications to engineering problems. Prereq: IE 27. 3 u.

144 **Systems Simulation.** Simulation of complex discrete-event systems with applications in manufacturing and service organizations; random number and variate generation, input distribution modeling, statistical analysis of simulation output; case studies. Prereq: ES 26, IE 28, 32. 5 h. (2 class, 3 lab) 3 u.

151 **Production Systems.** Capacity planning. Forecasting. Production planning. Scheduling and inventory control. Maintenance. Production Control. Production information system. Prereq: IE 135, 141, 150. 5 h. (2 class, 3 lab) 3 u.

152 **Manufacturing Planning and Design.** Manufacturing process design. Location and layout of facilities. Material flow systems. Materials handling. Storage and distribution. Prereq: IE 151. Coreq: IE 144. 3 u.

153 **Project Development and Management.** Phases of project feasibility studies. Project development, evaluation and management. Prereq: BA 115, IE 22, 151. 5 h. (2 class, 3 lab) 3u.

154 **Information Systems I.** Concepts and frameworks of information systems. Analysis and design of information systems. Prereq: ES 26, IE 33. 3 u.

155 **Industrial Systems Design.** Total systems design. Integration of sub-systems with concentration on optimal total systems implementation. A project and case study oriented course. Prereq: IE 153, 154. 5 h. (2 class, 3 lab) 3 u.

156 **Information Systems II.** Implementation considerations in information systems design. Relational database systems. Prereq: IE 154. 3 u.

157 **Software Tools for Industrial Engineering.** Introduction to computer software packages for Industrial Engineering applications. Prereq: ES 26, COI. (2 h lec, 3 h lab) 3 u.

158 **Supply Chain Management for Industrial and Service Systems.** An overview of concepts, processes, and best practices that are used in the management of supply chains. Supply chain management, procurement, customer relationship management, finance, information technologies, logistics activities and case studies. Prereq: IE 151. (3 h lec) 3u.

159 **Introduction to Technology Entrepreneurship.** Fundamentals of technology entrepreneurship, intellectual property, industry creation, and technology strategy. Opportunity recognition and evaluation. Business model development. Management of ventures. Prereq: SS / COI for non-IE students. (3 h lec) 3 u.

160 **Ergonomics.** Origins and development of human factors and ergonomics; movement, cognitive and environmental factors in ergonomic workplace design and evaluation; tools and techniques of ergonomic risk assessment. Prereq: IE 32/COI. 5 h. (2 class, 3 lab) 3 u.

161 **Safety and Health Management.** Hazard analysis techniques, human error analysis, safety standards and hazard communication; application of human factors and engineering practice in accident prevention and the reduction of health hazards in living and work environments. Prereq: IE 160/COI. 3u.

197 **Special Topics.** 3 u.

198 **Special Problems.** Prereq: SS. 3 u.

GRADUATE

Industrial Engineering (IE)

201 **Industrial Management and Productivity.** Organization theory, management principles, managerial functions, the industrial environment, functional areas of the industrial enterprise, human behavior and motivation; productivity concepts and techniques, methods engineering, systems and procedures. 3 u.

202 **Production Systems and Processes.** Introduction to production systems and functions, production processes and engineering materials. 3 u.

211 **Quantitative Methods in Industrial Engineering.** Estimation and tests of hypotheses in industrial engineering problems, regression and correlation, statistical control charts, acceptance sampling plans, specifications and tolerances, reliability and life-testing. Prereq: Math 54/equiv. 3 u.

214 **Introductory Operations Research.** Operations research methodology, basic linear programming, network analysis, dynamic programming, integer programming, and queuing theory. Prereq: Math 54/equiv. 3 u.

230 **Statistical Design and Analysis for Engineers.** Sampling and sampling distributions, estimation and hypothesis testing, analysis of variance, factorial designs, randomized blocks, latin squares and related designs, fractional replication and confounding nested or hierarchical designs, regression analysis, response surface methodology, analysis of covariance. Prereq: IE 28/equiv. 3 u.

231 **Analysis of Production Systems.** Mathematical and statistical decision models for the design, operation and control of production systems. Forecasting, inventory, capacity, aggregate planning, scheduling, maintenance and cost control models. Coreq: IE 241. 3 u.

241 **Operations Research I.** Fundamental models in Operations Research: advanced topics in linear and integer programming, dynamic programming and game theory, elementary queuing models. Prereq: IE 214/COI. 3 u.

242 **Operations Research II.** Intermediate models in Operations Research: advanced queuing models, stochastic processes

including discrete and continuous Markov chains, Markov decision process, Poisson processes and renewal theory, non-linear programming. Prereq: IE 230. 3 u.

243 **Advanced Methods and Standards.** Advanced work in motion and time study, wage analysis and payment systems, speed and effort rating, and job evaluation. Prereq: COI. 3 u.

245 **Advances in Production Systems.** Current and emerging trends in the analysis and design of production systems. Prereq: IE 231, 241. 3 u.

251 **Engineering Economic Analysis.** Economic evaluation methods for industrial projects; deterministic and stochastic methods; deterministic investment analysis; application of algebraic, linear and non-linear programming models; comparison of multiple projects under singular or multiple constraints. Prereq: IE 241. 3 u.

252 **Advanced Operations Research.** Advanced topics in non-linear programming and applications: Modeling of large-scale systems, interior point algorithms; project work on applications involving analytical Operations Research models. Prereq: IE 241, 242. 3 u.

253 **Information Systems I.** Concepts and frameworks of information systems. Analysis and design of information systems. Systems analysis and design tools and techniques. Prereq: ES 26/equiv. 3 u.

254 **Information Systems II.** Implementation considerations in computer-based information systems design. Database systems. Security and privacy issues in information systems. Information systems management. Prereq: IE 253. 3 u.

255 **Facilities Systems Design.** Design of complex industrial systems involving physical facilities for the production of goods and services. Facilities planning and materials handling. Prereq: IE 245/COI. 3 u.

256 **Human Factors Engineering.** Application of engineering, psychological and physiological principles to the analysis and design of human work systems. Prereq: IE 243/COI. 3 u.

281 **Systems Simulation.** Simulation of complex discrete-event systems with application in manufacturing and service organizations; random number and variate generation, input distribution modeling, statistical analysis of simulation output and variance reduction techniques; project work using a high-level simulation language or a general high-level programming language; continuous simulation. Prereq: IE 230, ES 26/ equiv. 3 u.

296 **Seminar.** 1 u./sem; maximum of 3 u.

298 **Special Problems.** Prereq: COI. 3 u.; may be taken twice, topics to be indicated for record purposes.

299 **Special Project.** Independent study on topics in the area of specialization. Prereq: IE 296. 3 u.

300 **Thesis.** Maximum of 6 u.

DEPARTMENT OF MECHANICAL ENGINEERING

UNDERGRADUATE

Mechanical Engineering (ME)

10 **Survey of Manufacturing Processes.** Mechanical manufacturing processes: casting, hot and cold forming; sheet metal work; machining; joining. Chemical manufacturing processes: material handling; size reduction and classification; separation of fluids, solids, and gases. Materials and processes in the packaging of integrated circuits in plastic and ceramic packages. Plant visits. Prereq: 3rd yr. standing. 3 u.

41 **Mechanisms.** Introduction to types of mechanisms and mobility. Linkages. Cams. Spur, bevel, helical and worm gearing. Gear train analysis and assembly. Synthesis of planar mechanisms. Prereq: ES 1, Math 53. 5 h. (2 class, 3 lab) 3 u.

63 **Thermodynamics.** First and second laws of thermodynamics. Properties of thermodynamic media. Ideal gases. Thermodynamic cycles. Prereq: Physics 72, Math 54. 3 u.

73 **Mechanical Measurement and Instrumentation.** Fundamentals of mechanical measurements. Design and execution of experiments; statistical analysis and analysis of experimental data. Calibration of measuring instruments. Prereq: ME 63; Coreq: ES 15. 5 h. (2 class, 3 lab) 3 u.

91 **Numerical Methods for Mechanical Engineers.** Numerical computation for linear and non-linear equations. Eigenvalue, initial-value and boundary value problems. Numerical solutions to ordinary and partial differential equations. Introduction to the Finite Element Method. Prereq: ES 21, 26. 5 h. (2 lec, 3 lab) 3 u.

101 **Mechanical Equipment for Buildings.** Principles and operation of mechanical equipment such as airconditioners, elevators, dehumidifiers, pumps, and exhaust fans. 3 u.

122 **Fluid Machinery.** Principles and operation of rotodynamic fluid machines such as turbines, fans, blowers, pumps, and compressors. System design and equipment selection. Prereq: ES 15. 3 u.

126 **Aerodynamics of the Airplane.** Air foils. The airplane and its components. Forces acting on the airplane. Propulsion systems. Performance and stability. Prereq: ES 15. 3 u.

131 **Manufacturing Processes.** Principles in metal production. Pattern making and foundry processes. Cold and hot working, welding, brazing, soldering, and riveting. Materials

production. Projects. Plant visits. Prereq: 4th yr. standing; Coreq: MetE 143. 6 h. (3 lec, 3 lab) 4 u.

136 **Machine Tool Operations.** Principles and processes in metal cutting, forming and fabrication. Safety in shop operations. Projects. Prereq: 4th yr. standing; Coreq: MetE 143. 5 h. (2 lec, 3 lab) 3 u.

142 **Kinematics and Dynamics of Machinery.** Position, velocity and acceleration analysis of mechanisms. Force analysis of mechanisms. Engine dynamics. Balance of machinery. Prereq: ES 12, ME 41. 5 h. (2 class, 3 lab) 3 u.

143 **Mechanical Vibrations.** Introduction to mechanical vibrations. Types of vibrations. Multi-degree of freedom systems. Vibrations in Continuous Systems. Vibration Control. Instrumentation for vibration measurement. Experiments. Prereq: ES 21, ME 142. 5 h. (2 lec, 3 lab) 3 u.

153 **Machine Design I.** Topics in mechanics of materials such as two-dimensional and three-dimensional state of stress, multi-plane bending and combined loading, built-up and composite sections, curved beams, compression members, thick and thin walled pressure vessels, deflection analysis, theories of failure for static and fatigue loading. Prereq: ES 13; Coreq: Met E 143. 3 u.

154 **Machine Design II.** Design and analysis of machine elements such as fasteners, welds, springs, bearings, gears, shafts, brakes, clutches and flexible mechanical elements. Prereq: ME 41, 153. 3 u.

155 **Machine Design III.** Projects in analysis and design of machine elements and mechanical equipment. Prereq: ME 143, 154. 6 h. (lab) 2 u.

164 **Fundamentals of Heat and Mass Transfer.** Principles of heat and mass transfer. Conduction, convection, radiation and phase-change heat transfer. Mass transfer in gases, liquids and solids. Heat exchangers and their applications. Prereq: ME 63, 91. 5 h. (2 lec, 3 lab) 3 u.

165 **Internal Combustion Engines.** Principles of internal combustion engine operation. Cycle analysis. Fuels and fuel metering. Combustion in spark-ignition and compression-ignition engines. Engine friction, lubrication, and cooling. Engine design, performance, and emissions characteristics. Prereq: ME 63. 3 u.

176 **Control Systems I.** Mathematical modeling of physical systems, system response characteristics. Analysis and design of continuous control systems. Prereq: ES 21, ME 73. 5 h. (2 lec, 3 lab) 3 u.

177 **Control Systems II.** Alternative methods of mathematical modeling of physical systems. Analysis and design using advanced methods. Frequency response techniques and design. Discrete control systems. Prereq: ES 21, ME 73, 176. 2 u.

180 **Inspection Trips and Seminars.** Visits to factories, power plants, utility companies, shops and related installations. Technical reports and projects in line with the above. Prereq: 5th year standing. 6 h. (lab) 2 u.

183 **Refrigeration and Air-Conditioning.** Standard vapor compression cycle, components, system analysis and balance. Psychrometry, air conditioning processes, cooling load and heating load calculations, fan and duct design, cooling coils and heat exchanger design. Alternative refrigeration systems. Prereq: ME 164. 6 h. (3 lec, 3 lab) 4 u.

188 **Power Plant Engineering.** Fundamentals in power generation and power plant technology. Power plant cycles and methods employed to improve cycle efficiency. Plant components and subsystems. Equipment reliability. Load curves, utilization factors and determination of plant capacity. Variable load operation. Non-fossil fuel power plants. Renewable sources of energy. Considerations in plant design and equipment selection. Environmental effects of power stations. Prereq: ME 122, 164, 165. 6 h. (3 lec, 3 lab) 4 u.

192 **Industrial Electrical and Electronic Equipment.** Electromechanical energy conversion and associated equipment. Actuators and transducers. Theory and characteristics of electrical equipment. Associated devices and circuits for their protection and control. Applications in power and industrial systems. Modern control devices in industry. Prereq: EEE 1. 5 h. (2 lec, 3 lab) 3 u.

197 **Special Topics.** Prereq: COI. 3 u.; may be taken twice, topics to be indicated for record purposes.

198 **Special Problems.** Prereq: COI. 3 u.

GRADUATE

Mechanical Engineering (ME)

211 **Safety Engineering.** Principles and practice of industrial safety and accident prevention. Local laws on industrial safety. 3 u.

222 **Fluid Machinery and Systems.** Fluid mechanics and thermodynamics of turbomachinery. Transient analysis of fluid flow. Prereq: ME 122. 3 u.

224 **Design of Fluid Machinery and Systems.** Design of turbines, blades and vanes, propellers, pumps, and fluid machinery systems. Prereq: ME 122. 5 h. (2 class, 3 lab) 3 u.

226 **Gas Dynamics.** The fluid mechanics of compressible flow. Shock phenomena. Hodograph method. Method of characteristics. Supersonic flow. Prereq: ME 63. 3 u.

231 **Metal Cutting and Forming.** Mechanics of metal cutting and forming. Factors affecting metal working. Advances in the field. Prereq: ME 136. 3 u.

236 **Tool Engineering.** Design and analysis of dies, jigs, fixtures, hand tools and machine tools. Prereq: ME 155. 3 u.

242 **Intermediate Mechanisms.** Kinematics of planar motion. Approximate and multiply-separated-position synthesis of planar mechanisms. Graphical and analytical methods in synthesis. Prereq: ME 142. 3 u.

243 **Advanced Mechanisms.** Analysis and synthesis of spatial mechanisms. Motion and geometric considerations in the design of pair elements. Prereq: ME 242. 3 u.

258 **Advanced Machine Design.** Special topics in stress and strain analysis. Optimization in the design of machine elements. Statistical considerations in design. Projects. Prereq: ME 155. 3 u.

259 **Composite Materials.** Properties and mechanics of composite materials. Stiffness, compliance, and strength of fibers, lamina, and laminates. Prereq: ME 153. 3 u.

260 **Advanced Heat Transfer I.** Transient conduction and convection. Multi-phase systems. Exact and approximate solutions. Boundary layer problems. Prereq: ES 201, ME 64. 3 u.

264 **Advanced Heat Transfer II.** Radiation heat transfer in absorbing and non-absorbing media. Shape factors. Thermal radiation from gases and flames. Solar energy. Prereq: ES 201, ME 64. 3 u.

267 **Advanced Thermodynamics I.** Thermodynamics of unsteady flow processes. Entropy, availability and reversibility. Thermodynamics of compressible flow. Prereq: ME 63. 3 u.

268 **Advanced Thermodynamics II.** Thermodynamic relations. Thermodynamic equilibrium. Real gases. Statistical thermodynamics. Prereq: ME 267. 3 u.

281 **Advanced Refrigeration.** Processes, cycles and systems. Design problems and special applications such as low temperature systems, liquefaction and production of industrial gases. Prereq: ME 181. 3 u.

282 **Advanced Air-Conditioning.** Psychrometry. Thermal comfort. Load profiles. System analysis and design. Prereq: ME 182. 3 u.

286 **Combustion.** Theoretical and experimental analyses of combustion and explosion processes. Detonation waves. Ignition, propagation and stability of flames. Combustion calculations. Prereq: ME 187. 3 u.

287 **Fuels and Thermal Power.** Characteristics of gaseous, liquid and solid fuels. Indigenous fuels. Combustion of fuels in furnaces, kilns, gas producers, engines and other thermal devices. Fuel treatment. Prereq: ME 187. 3 u.

296 **Seminar.** 1 u. per semester; maximum of 3 u.

298 **Special Problems.** 3 u.; may be taken twice, topics to be indicated for record purposes.

300 **Thesis.** 6 u.

UNDERGRADUATE

Shop Practice (SP)

1 **Hand Tools.** Exercises in material processing using hand and light power tools such as hammers, chisels, hand drills, saws, files, etc. 3 h. (lab) 1 u.

3 **Machine Tools.** Exercises in machining operations with the use of lathes, shapers, milling machines, and other machine tools. Prereq: ME 131. 3 h. (lab) 1 u.

4 **Welding, Foundry, and Allied Practices.** Exercises in pattern making, core making, molding and metal casting, welding and allied processes. Prereq: ME 136. 3 h. (lab) 1 u.

5 **Pattern-Making, Welding, and Foundry Practice.** An abridged combination of Shop Practice 1 and 4. 3 h. (lab) 1 u.

6 **Machine Work.** The abridgement of Shop Practice 3. 3 h. (lab) 1 u.

7 **General Shop Practice.** The use of equipment for machining, welding, casting and allied practices. 3 h. (lab) 1 u.

DEPARTMENT OF MINING, METALLURGICAL AND MATERIALS ENGINEERING

UNDERGRADUATE

Materials Engineering (MatE)

10 **Engineering Materials.** A survey of the different engineering materials; relationship of structure and properties to their applications. Prereq: Physics 72. 3 u.

11 **Fundamentals of Materials Engineering I.** Structure and composition of materials (metals, polymers, ceramics and composite materials); properties and behavior in service environments. Prereq: Chem 16, Physics 72. 3 u.

14 **Design and Analysis of Experiments in Materials Engineering.** Basic statistical concepts; design and analysis of experiments; optimization techniques; data presentation and report writing. Prereq: Math 54. 3 u.

100 **Metallic Materials.** Mechanisms of development and control of microstructure of metals; phase transformations and heat treatment; strengthening mechanisms; heat treatment practices metal forming; metallography. Prereq: MatE 11. 3u.

100.1 Metallic Materials Laboratory. Tensile and compressive strength measurements; heat treatment of steel and other metals/alloys; precipitation hardening; determination of the hardenability of steel and other metals/alloys. Prereq: MatE 11; Coreq: MatE 100. 1 u.

101 Thermodynamics of Materials. Basic thermodynamic quantities and laws; phase transformations and chemical reactions; partial molal and excess quantities; phase of variable compositions; free energy of binary systems, surfaces and interfaces. Prereq: Chem 17 and MatE 11. 3 u.

103 Kinetics of Materials and Processes. Reaction rates, mechanisms, and transport phenomena in materials application to nucleation, crystal growth, recrystallization, precipitation, sintering, solid state reactions, the role of kinetics in the development of microstructures. Prereq: MatE 101, Math 54. 3 u.

104 Thermodynamics and Kinetics Laboratory. Demostrative applications of the thermodynamic and kinetic principles relevant to materials engineering; determination of kinetic parameters; investigation of surface thermodynamic properties; thermal analysis of bulk materials. Coreq: MatE 103. 6h (lab). 2 u.

105 Analytical Techniques in Materials Engineering. Concepts, operation principles of x-ray diffractometry, compositional analysis, spectroscopy, surface analysis, microscopy, non-destructive tests and other emerging analytical techniques. Prereq: MatE 11 and Chem 28. 3u.

105.1 Analytical Techniques in Materials Engineering Laboratory. Laboratory exercises in available analytical methods for materials characterization including data acquisition and calculations involved in techniques for thermal analysis, x-ray diffraction, imaging, spectroscopy, etc.; sample preparation, equipment conditioning and detection limits, etc. Prereq: Chem 28; Coreq: MatE 105. 3 h. (lab) 1 u.

111 Mechanical Deformation of Materials. Mechanisms of deformation and fracture mechanics; failure of materials (fatigue, creep, stress corrosion) and strengthening mechanisms; plastic deformation processing, tools and equipment (forging, rolling, extrusion, drawing, forming and machining). Prereq: MatE 11, ES 13 and ES 21. 3 u.

121 Electronic Materials. Electrical and magnetic materials and their properties; band theory of solids and lattice vibrations; periodic structures; lattice waves; electron states; static properties of solids; electron-electron interactions; dynamics of electrons in solids. Prereq: MatE 11 and Physics 73. 3 u.

121.1 Electronic Materials Laboratory. Laboratory exercises in the characterization of the electrical, magnetic, and optical properties of materials. Coreq: MatE 121. 3h (lab). 1 u.

123 Thin Films Processing Laboratory. Laboratory exercises in vacuum technologies and thin film deposition techniques as applied to semiconductor device fabrication; characterization of thin films. Prereq: MatE 104. 2 u.

131 Polymeric Materials. Structure, properties and synthesis of polymers; processing fabrication techniques and conversion to plastics; applications, performance, and degradation of polymers. Prereq/Coreq: MatE 11 and Chem 31/none. 3 u.

131.1 Polymeric Materials Laboratory. Synthesis of polymers; processing, fabrication techniques and conversion to plastics; characterization. Prereq: MatE 105.1 and MatE 103; Coreq: MatE 131. 3h (lab). 1 u.

141 Ceramic Materials. Structure, properties and synthesis of ceramics; processing, fabrication techniques; applications, performance and degradation of ceramics. Prereq: MatE 103. 3 u.

141.1 Ceramic Materials Laboratory. Synthesis of ceramic; processing, fabrication techniques; characterization. Prereq: MatE 105.1 amd MatE 103. 3 u.

151 Composite Materials. Structure and properties of fibers; matrices and final composites; fabrication techniques and processing of composites; degradation and failure analysis of composites. Prereq: MatE 111, 131, 141. 3 u.

151.1 Composite Materials Laboratory. Laboratory exercises in the fabrication and characterization of composite materials. Prereq: MatE 151. 3h (lab). 1 u.

161 Fundamentals of Nanotechnology. Principles of nanoscience and nanotechnology; experimental tools of nanotechnology; diversity of nanostructures, nanomaterials and nanosystems; current and future nanotechnology applications. Coreq: MatE 151. 3h (lec). 3 u.

171 Degradation of Metals. Degradation of metals by corrosion, oxidation, mechanical wear, fatigue, erosion; thermodynamics and kinetics of corrosion; forms of corrosion, its detection and prevention; effects of the environment on metal performance. Prereq: MatE 111. 3 u.

173 Forensic Engineering in Materials. Failure analysis of materials; destructive and non-destructive testing methods related to failure analysis and reliability testing; industrial standards for materials. Prereq: 5th yr. Standing. 3 u.

180 Economic Analysis in Materials Engineering. Introduction to economic analysis applied to materials engineering; cost estimation; overview of feasibility study preparation. Prereq: 3rd yr. Standing. 2 u.

181 **Biomaterials.** Qualification for biomedical applications; molecular and cellular interactions of biomaterials; classifications based on composition, function, clinical application; basic biomedical device design, fabrication and testing considerations. Coreq: MatE 151 or COI for non-MatE students. 3h (lec). 3 u.

182 **Green Materials.** Materials life cycle; materials selection for environmental impact consideration; environmental applications and hazards of nanomaterials. Coreq: MatE 151 or COI for non-MatE students. 3h (lec). 3 u.

183 **Construction Materials.** Manufacture and use of high performance construction materials including but not limited to concrete, steel, polymeric materials, geosynthetics, masonry materials and coatings, and fiber reinforced cement and polymer composites. Coreq: MatE 151 or COI for non-MatE students. 3h (lec). 3 u.

184 **Materials for Energy.** Energy problem; materials for harvesting energy; fuel cells, batteries and energy storage; materials issues in efficiency and degradation; safety risks in energy storage; emerging technologies. Coreq: MatE 151 or COI for non-MatE students. 3h (lec). 3 u.

185 **Materials for Electronic Devices.** Materials important in solid state electronics; dielectrics, semiconductors and superconductors; semiconductor device fabrication; electronic device assembly; microelectronic materials manufacturing; quality and reliability aspects. Coreq: MatE 151 or COI for non-MatE students. 3h (lec). 3 u.

190 **Seminar and Research Methods in Materials Engineering.** Preparation of undergraduate research proposal, data gathering, and preliminary experimentation. Prereq: MatE 151. 2u.

195 **Materials Selection.** Introduction to engineering design and materials and materials selection; materials processing; systematic product design conceptualization. Prereq: MatE 151. (1h lec, 3h lab). 2 u.

196 **Product Design and Prototyping.** Product development; design with materials; computational and structural design; cost, life cycle and risk analysis; design strategy, implementation and evaluation; prototype development. Prereq: MatE 195. 6h (lab). 3 u.

197 **Special Topics.** Special topics related to materials engineering. May be repeated for a maximum of six units. Prereq: 5th yr. Standing. 3 u.

199 **Undergraduate Research Project.** Undergraduate Research Paper and Defense.

Summer Plant Practice. 8 wks. of on the job training in a related plant. Prereq: 4th yr. Standing. Must have passed MetE 12. No credit.

UNDERGRADUATE

Metallurgical Engineering (MetE)

11 **Principles of Metallurgy.** An introduction to mineral dressing; to pyro-, hydro-, and electro-metallurgy, and to adaptive metallurgy. Terminology, principles and processes. Coreq: Chem 17. 3 u.

12 **Metallurgical Measurements.** Measurement and data acquisition in metallurgy. Coreq: Physics 72. 3 h. (lab) 1 u.

13 **Methods of Metallurgical Analysis.** Classical and modern methods of metallurgical analysis. Prereq: MetE 11. 6 h. (lab) 2 u.

14 **Metallurgical Experimental Design.** Statistical concepts. Design and analysis of metallurgical experiment. Optimization techniques. Quality control methods. Data presentation and report writing. Prereq: Chem 17. 3 u.

15 **Economic Analysis in Metallurgy.** Introduction to economic analysis applied to metallurgy; cost estimation; overview of feasibility study preparation. Prereq: 3rd yr. Standing. 2 u.

17 **Metallurgical Thermodynamics.** Principles of thermodynamics. Application of thermodynamics to metallurgical systems. Prereq: MetE 11. 3 u.

18 **Metallurgical Thermodynamics Laboratory.** Demonstrative application of thermodynamic principles. Determination of some thermodynamic quantities. Prereq: MetE 17. 3 h. (lab) 1 u.

19 **Kinetics of Metallurgical Reaction.** Reaction rates, mechanisms and transport phenomena, applications to microstructure development, nucleation, crystal growth, grain growth, re-crystallization, precipitation, sintering and solid state reactions. Prereq: MetE 17, 4th yr. Standing. (3h lec) 3 u.

120 **Ore Dressing.** Theory and practice of comminution, sizing and concentration of ores and industrial minerals. Process design and equipment selection. Prereq: MetE 11, Geol 40/COI. 3 u.

121 **Mineral Processing I.** Size reduction and separation; gravity, magnetic and electrical concentration; dewatering; materials handling. Prereq: MetE 11. 3 u.

127 **Mineral Processing II.** Flotation. Production of industrial minerals. Tailings disposal. Prereq: MetE 121/COI. 3 u.

128 **Mineral Processing Laboratory.** Coreq: MetE 120/127. 6 h. (lab) 2 u.

132 **Hydrometallurgy.** Physical chemistry of hydrometallurgical processes. Dissolution, solution purification, metal winning from solutions. Electrochemical phenomena and corrosion. Prereq: MetE 17. 3 u.

134 **Pyrometallurgy.** Unit process of high temperature metallurgy. Production and utilization of heat. Slags and refractories. Prereq: MetE 17. 3 u.

135 **Extractive Metallurgy Laboratory.** Experiments in hydrometallurgy and pyrometallurgy. Prereq: MetE 132, 134. 6 h. (lab) 2 u.

136 **Production Metallurgy.** Production of refined metals from ores. Integration and application of principles of minerals engineering and extractive metallurgy. Prereq: MetE 134. 3 u.

141 **Engineering Materials.** The nature of engineering materials: metals, polymers, wood and wood products, ceramics, glass and vitreous products, concrete and related materials, semiconductors, magnetic materials, composite and new materials. Prereq: 3rd yr. Standing. 3 u.

143 **Elements of Materials Science.** Structure and composition of materials. Properties and behavior in service environments. Metals, ceramics, organic and composite materials. Prereq: Chem 16, Physics 72. 3 u.

146 **Physical Metallurgy I.** Origin, mechanisms of development and control of internal structure of metals. Phase transformation and heat treatment. Deformation and fracture. Strengthening mechanisms. Prereq: MetE 143; Coreq: MetE 17. 3 u.

147 **Physical Metallurgy II.** Continuation of MetE 146 placing emphasis on the detailed study of the alloy series. Heat treatment practice. Metal forming. Prereq: ES 13, MetE 146. 3 u.

148 **Physical Metallurgy Laboratory.** Coreq: MetE 147. 6 h. (lab) 2 u.

149 **Failure and Degradation of Metals.** General introduction to the failure behavior of metals, ductile and brittle behavior; failure analysis techniques, NDT, fractography; failure modes such fatigue, wear, creep, corrosion, hydrogen degradation, degradation of metals in industrial applications. Prereq: MetE 147, 5th year Standing. (3 h lec) 3 u.

150 **Adaptive Metallurgy Laboratory.** Application of adaptive metallurgy principles, casting of metal, mechanical forming processes, consolidation and joining. Characterization of fabricated metals. Prereq: MetE 148, MetE 149. (3 h lab). 1 u.

156 **Metallurgical Plant Design.** Elements of plant design including choice of process, equipment and materials, site and plant layout. Prereq: SS. 6 h. (lab) 2 u.

197 **Special Topics.** 3 u.; may be taken twice.

198 **Special Problems.** Independent work in a construction, design or research project. Prereq: MetE 12, 13, 128; Coreq: MetE 148. 3 u.

Metallurgical Plant Practice. 8 wks. One summer of field work in an operating metallurgical plant as arranged by Dept. faculty. May include ore dressing mills, cyanide plants, metal processing plants, or the University Metallurgical Pilot Plant.

199 **Research Laboratory.** Application of research techniques to designated topics. Prereq: MetE 198 (6 h lab). 2 u.

GRADUATE

Metallurgical Engineering (MetE)

210 **Advanced Metallurgical Thermodynamics.** Application of thermodynamic principles in prediction of stable phases. Prereq: MetE 17. 3 u.

213 **Rate Processes.** Heat and mass transfer, kinetics and mechanisms of reactions in metallurgical systems. Prereq: MetE 132. 3 u.

217 **Minerals Industry Analyses.** Microeconomic and macroeconomic analyses of the minerals industry; market conditions, structure and price formation of major mineral commodities; government regulations and global trends affecting the mineral sector. Prereq: Econ 11. 3 u.

218 **Process Synthesis.** Metallurgical process synthesis, flowsheet development and associated economic analysis. Prereq: MetE 136/COI. 3 u.

221 **Advanced Mineral Processing I.** Technology of mineral beneficiation, current plant procedures, operating controls, plant research, metallurgical accounting, materials inventory and economic recoveries. Prereq: MetE 127. 3 u.

222 **Advanced Mineral Processing II.** Special topics in flotation and comminution theory, mineral physics, thermal decripitation, use of radioactive tracers and ion exchange resins. Prereq: MetE 127. 3 u.

231 **Advanced Extractive Metallurgy I.** Theory, operation and economics of modern industrial hydrometallurgical processes, including electroplating, electrowinning, and electrolytic refining. Prereq: MetE 132. 3 u.

232 **Advanced Extractive Metallurgy II.** Problems in roasting, smelting, and refining. Pyro- and electrometallurgical processes. Prereq: MetE 134/COI. 3 u.

235 **Physical Chemistry of Steelmaking.** Analysis of iron extraction and steelmaking processes, with emphasis on blast furnace, basic oxygen furnace, and electric furnace; application of deoxidizers, vacuum and inert gas processes for product purification. Prereq: MetE 134/COI. 3 u.

241 **Advanced Physical Metallurgy.** Electron theory of metals, theory of crystal binding, solid solutions and compound formation; phase stability; solid state phase transformations; microstructures and mechanical properties. Prereq: MetE 147. 3 u.

243 **Heat Treatment of Ferrous and Special Alloys.** Types of ferrous alloys; interrelationships among composition, microstructure, service requirements and mechanical properties of ferrous alloys; industrial heat treatment practices; special alloys. Prereq: MetE 146. 3 u.

251 **Metal Casting.** Metallurgy of cast metals. Unit foundry operations. Sand testing and control. Melting and casting practices. Manufacture of special cast metals and alloys. Prereq: MetE 147. 3 u.

257 **Deformation Processing.** Fundamentals of plastic deformation processing: forging, rolling, extrusion and drawing; tools and equipment. Prereq: MetE 147/COI. 3 u.

296 **Seminar.** 1 u./sem; maximum of 3 u**.**

298 **Special Problems.** 3 u.; may be taken twice, topics to be indicated for record purposes.

300 **Thesis.** 3-6 u.

UNDERGRADUATE

Mining Engineering (EM)

10 **Principles of Mining.** Socio-eonomic importance and characteristics of the mineral industry. Principles of mineral exploration, mine development, exploitation and rehabilitation. Introduction to surface and underground mining methods. Prereq/Coreq: Geol 11. 3 u.

36 **Underground Mining.** Criteria for the selection of underground mining method including coal mining. Techniques, unit operations and mine systems involved in the different underground mining methods. Development planning, engineering layout and extraction. Underground haulage systems, draw and grade control. Prereq: EM 10. 3 u.

45 **Surface Mining.** Engineering and economic factors in the planning and design of open pit and other surface mining methods, including coal mining. Selection and use of various equipment and systems involved in surface mining. Concepts of stripping ratios, grade control and mine planning. Prereq: EM 10. 3 u.

146 **Rock Mechanics.** Introduction to rock mechanics. Physical and engineering properties of rocks, rock failures and fundamentals of rocks mass and rock response to applied loads. Principles and design of underground openings and pit slopes, ground support, tunneling, monitoring and other practical applications. Prereq: EM 36, 45, ES 13. 5 h. (2 class, 3 lab) 3 u.

152 **Mine Management.** Introduction to mine administration, corporate planning, organization, maintenance management, mine labor cost analysis, industrial relations and human resource development. Corporate social responsibility and quantitative management analysis. Prereq: SS. 3 u.

154 **Mine Economics.** Feasibility studies, methods of sampling, ore reserve estimations and statistical analysis for evaluating mineral deposits. Engineering economic principles with emphasis on the economic evaluation of mineral development and mining projects. Prereq: Econ 11/100.2, Stat 101, SS. 3 u.

156 **Mine Plant Design.** Analysis and design of: materials handling systems including hauling and hoisting, mine de-watering, compressed air and power systems. Some operations research applications in mining. Prereq: EEE 3, ES 13, 15, SS. 3 u.

157 **Mine Ventilation.** Fundamentals of mine ventilation, including gas, dust, temperature and humidity control. Economics of airflow, natural and mechanical ventilation. Analysis and design of ventilation systems. Prereq: ES 15, SS. 3 u.

191 **Mining and Environmental Laws.** The mining and environmental laws, policies, implementing rules and regulations. Legal and ethical issues affecting the practice of Mining Engineering. Mine safety and accident prevention. Prereq: SS. 3 u.

197 **Special Topics.** 3 u.; may be taken twice.

198 **Special Problems in Mining Engineering.** Undergraduate individual study project and written report on various subjects or problems on mining engineering. Presentation and discussion of the written reports submitted by students before the class. Subjects to be assigned by the faculty-in-charge. Prereq: SS. 3 u.

Mine and Mill Practice. 8 wks. Actual work in mine and mill. May not be waived/replaced by class work.

GRADUATE

MATERIALS SCIENCE AND ENGINEERING (MSE)[a]

201[b] **Fundamentals of Materials Science and Engineering.** Materials classification, properties and applications; principles of processing: raw materials for the Philippine industry. Prereq: COI. 3 u.

211[b] **Laboratory Module in Transmitted Light Microscopy.** Prereq: COI. 3 h. (lab) 1 u.

212[b] **Laboratory Module in Mineragraphy.** Prereq: COI. 3 h. (lab) 1 u.

213[b] **Laboratory Module in Crystallography.** Prereq: COI. 3 h. (lab) 1 u.

214[b] **Laboratory Module in Vacuum Technologies and Thin Film Deposition.** Prereq: COI. 3 h. (lab) 1 u.

215[b] **Laboratory Module in Electronic and Magnetic Measurements.** Prereq: COI. 3 h. (lab) 1 u.

216[b] **Laboratory Module in Ceramics Processing and Characterization.** Prereq: COI. 6 h. (lab) 2 u.

217 **Laboratory Module in Scanning Electron Microscopy.** Prereq: COI. 3 h. (lab) 1 u.

218 **Laboratory Module in Metallography.** Prereq: COI. 3 h. (lab) 1 u.

219 **Laboratory Module in Thermal Analysis.** Prereq: COI. 3 h. (lab) 1 u.

225[b] **X-Ray Crystallography and Spectrography.** X-ray methods for the characterization of crystal structure and determination of chemical composition. Prereq: COI. 3 u.

231[b] **Thermodynamics of Materials.** Theory of thermodynamics: applications to phase equilibria. Prereq: COI. 3 u.

233[b] **Kinetics of Materials.** Reaction rates, mechanisms, and transport phenomena in materials. Prereq: COI. 3 u.

241[b] **Physics of Solids.** Band theory of solids and lattice vibrations; electrical magnetic and optical properties. Prereq: COI. 3 u.

243 **Epitaxial Growth.** Processing and preparation of semiconducting materials and related compounds, microstructures, and devices with emphasis on the principles of epitaxial growth; in-situ analytical methods for the evaluation of growth fronts. Prereq: MSE 241. 3 u.

243.1 **Epitaxial Growth Laboratory.** Prereq: MSE 243. 6 h. (lab) 2 u.

245 **Semiconductor Characterization.** Advanced methods of evaluating semiconductor materials, microstructures and devices including electronic analysis, spectroscopy, x-ray diffraction and surface analysis. Prereq: MSE 241. 3 u.

245.1 **Semiconductor Characterization Laboratory.** Prereq: MSE 245. 6 h. (lab) 2 u.

251 **Mechanical Properties of Solids.** Mechanisms of deformation and fracture mechanics; failure of materials and strengthening mechanisms; plastic deformation processing, tools and equipment. Prereq: COI. 3 u.

253 **Heat Treatment of Ferrous and Special Alloys.** Types of ferrous alloys; interrelationships among compositions, microstructure, service requirements and mechanical properties of ferrous alloys; industrial heat treatment practices; special alloys. Prereq: COI. 3 u.

255 **Metal Casting.** Metallurgy of cast metals; unit foundry operations, sand testing and control, melting and casting practices; manufacture of special cast metals and alloys. Prereq: COI. 3 u.

265 **Ceramic Materials.** Structure and properties: synthesis and processing of ceramics; high technology and engineering applications. Prereq: MSE 241. 3 u.

266 **Polymer Materials.** Structure, properties, and synthesis of polymers; processing and conversion to plastics; applications and performance of polymers. Prereq: COI. 3 u.

267 **Surface Science.** Surfaces and interfaces; thermodynamics and electrical aspects of surfaces and interfaces; adsorption; chemisorption; catalysis; colloidal systems; applications to processing and manufacturing. Prereq: MSE 231. 3 u.

268 **Degradation of Materials.** Degradation of, and effects of the environment on metals, polymers, ceramics and composites. Prereq: MSE 231. 3 u.

271 **Physics of Liquid Crystals.** Study of anisotropic fluids: main types and properties; long and short order in nematics; principles of the main field (Maier-Saunpe) and the continuum theories, static and dynamic properties of nematics, cholesterics and smectics; applications of liquid crystals. Prereq: COI. 3 u.

271.1 **Liquid Crystals Laboratory I.** Characterization of LCs: optical microscopy; refractometry; uv-vis-ir spectrophotometry; FTIR; differential scanning calorimetry. Prereq: MSE 271. 6 h. (lab) 2 u.

[a] *Joint offering with the College of Science*

[b] *Six (6) units of Laboratory Modules in MSE (i.e., MSE 211-219) are required*

271.2 **Liquid Crystals Laboratory II.** Synthesis of LCs; fabrication of polymer dispersed liquid crystals (PDLC) fabrication; characterization and applications in simple LC devices. Prereq: MSE 271.1. 6 h. (lab) 2 u.

275 **Advanced Physics of Solids I.** Fundamental principles of the physics of solids: periodic structure, lattice waves, electron states; static properties of solids; electron-electron interaction; dynamics of electrons in solids. Prereq: MSE 241. 3 u.

276 **Advanced Physics of Solids II.** Transport and optical properties of solids, Fermi surface, magnetism, superconductivity, amorphous and disordered systems. Prereq: MSE 275. 3 u.

281 **Dislocation Theory.** Foundations of dislocation theory; dislocation movements, forces, interactions; role of dislocations in strengthening mechanisms in solids. Prereq: MSE 241. 3 u.

282 **Composite Materials.** Basic mechanics and materials science of important modern composite materials; structure and properties of fibers, matrices and final composites. Prereq: COI. 3 u.

283 **Semiconductor Materials and Processes.** Substrate materials preparation; physics of semiconductors; device fabrication technologies; packaging and encapsulation. Prereq: MSE 241. 3 u.

283.1 **Semiconductor Device Fabrication Laboratory.** Prereq: MSE 283. 6 h. (lab) 2 u.

285 **Electron Microscopy.** Techniques for transmission and scanning electron microscopy; secondary and back-scattered electron imaging; microchemical and microstructural analysis. Prereq: MSE 217. 5 h. (2 lec, 3 lab) 3 u.

286 **Powder Technology.** Problems associated with forming powders into shapes; powder characterization; processes of sintering and vitrification; operations of grinding, finishing and coating. Prereq: MSE 241. 3 u.

287 **Crystal Growth.** Application of thermodynamics and phase diagrams to crystal growth; segregation; nucleation; techniques and choice of method for a specific material. Prereq: MSE 231. 3 u.

287.1 **Crystal Growth Laboratory.** Prereq: MSE 287. 6 h. (lab) 2 u.

296 **Graduate Seminar.** Prereq: COI. 1 u.

298 **Special Problems.** Prereq: COI. 3 u.

300 **MS Thesis.** Prereq: Consent of Thesis Adviser. 6 u.

400 **PhD Dissertation.** Prereq: Passing of the Candidacy Examination. 12 u.