# -III-

# COURSE CATALOG

## OF

## UNDERGRADUATE PROGRAMS

## SCHOOL OF ENGINEERING

***UNIVERSITY OF SCIENCE AND TECHNOLOGY***

***ZEWAIL CITY OF SCIENCE, TECHNOLOGY AND INNOVATION***

**SEPTEMBER 2023**

| Code | Description |
|---|---|
| CHEM 103 | Introduction to Chemistry for Engineers<br>Credits: 3 (2+3)<br>This course introduces engineering students to the basics of general and physical chemistry. Topics include the atomic structure and periodicity, states and characteristics of matter, chemical stoichiometry, an overview of chemical bonding and intermolecular forces, molecular structures, symmetry and molecular orbital theory, ionic solutions and electrochemistry, acid-base chemistry and pH, oxidation and reduction processes. The course includes a lab component with experiments covering the fundamentals of general and physical chemistry such as the physical and chemical properties of matter, chemical stoichiometry, and determination of empirical formulas, molecular structure, molecular shapes and molar volumes of gases, acid-base titrations, pH measurements, and oxidation-reduction reactions. |
| CIE 101 | Fundamentals of Computer Programming<br>Credits: 3 (2+3)<br>Prereq: CSCI 101<br>This course aims to provide the students with an understanding of the role of computations in solving engineering and scientific problems through introducing them to different programming paradigms. The course will focus on procedure-oriented and object-oriented programming models. Topics include primitive data types, input/output, control structures, arrays and lists, built-in and user-defined functions, classes, objects, inheritance, encapsulation, and polymorphism. By the end of the course, the students will be able to differentiate between the two design approaches. In addition, they will be able to develop high quality, working software that solves real problems using any of the two programming approaches. |
| CIE 110 | Introduction to Circuits and Electronics<br>Credits: 3 (2+3)<br>This course covers the fundamentals of electric and electronic circuits. The course introduces the techniques used to analyze circuits of different lumped elements and circuit blocks. The course starts first by introducing several electric circuit elements, including regular and dependent sources. Then it discusses how to analyze simple and complex resistive circuits through different techniques. After that energy storage elements (capacitors and inductors) are introduced. Sinusoidal sources are introduced and analyzed using phasors through different analysis methods. AC circuits power calculations are also explained. The course then introduces students to the basic electronic devices and their applications. It shortly explains the semiconductor physics and the main semiconductor devices: PN junction (diodes), BJT and MOSFET transistors. Also, some of their common applications like rectifiers, amplifiers, and logic gates are demonstrated. The course will integrate demonstrations and laboratory examples with lectures on electronics foundations. Throughout the course we will use simulation programs for analysis, design, and understanding the operation of electronic circuits. Practical experience in design, analysis, and troubleshooting will be covered. |

| Code | Description |
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| CIE 201 | Advanced Electric Circuits<br>Credits: 3 (2+3)<br>Prereq: MATH 202 AND (CIE 110 OR ENGR 210 OR ENGR 201 OR NANENG 203)<br>This course covers the formal methods of electrical circuit analysis and relevant network theorems will be covered. This includes an in-depth study of state-equation formulations and methods of obtaining them from a circuit's graph. Extensive use of the Laplace Transform for the analysis of networks will be made and it is expected that a student will have the mathematical background related to Laplace Transform techniques. The second part of the course will be devoted to the fundamentals of frequency selective circuits, network synthesis, filter approximations and frequency transformations. Different methods for passive and active filter synthesis. Computer techniques for analyzing and designing electrical circuits, using Spice as exemplary tools, will be used throughout the course. Laboratory sessions and a final group design project will provide a means of applying theoretical concepts and computer tools to solve practical problems and create useful circuit designs. |
| CIE 205 | Data Structures and Algorithm Analysis<br>Credits: 3 (2+3)<br>Prereq: CIE 101 OR CIE 202<br>This course introduces formal techniques to support the design and analysis of algorithms, focusing on both the underlying mathematical theory and practical considerations of efficiency. Introduced design approaches will be supported by some common data structures, with a focus on some advanced ones. Topics include: mathematics foundation, divided-and-conquer, dynamic programming, greedy method, NP-completeness complexity, approximation algorithms, randomized algorithms, and backtracking algorithms. In addition to some advanced data structures: Binary trees, Heaps, Priority Queues, and Huffman Coding Trees. |
| CIE 206 | Database Management System<br>Credits: 3 (2+3)<br>Prereq: CIE 101 OR CIE 202<br>The overall aim of the course is to know the basic concepts of database systems. To design and practice creating database systems using the entity-relationship model. To learn functional dependencies and practice relational model normalization. To learn and practice using SQL for relational databases programming |

| Code | Description |
|---|---|
| CIE 227 | Signals and Systems<br>Credits: 3 (2+3)<br>Prereq: MATH 102<br>This course covers the fundamentals of signal and system analysis, focusing on representations of discrete-time (DT) and continuous-time (CT) signals. The course introduces the Fourier series representation for periodic signals and the Fourier transform method for CT and DT signals. The course builds upon the representations of linear, time-invariant systems to analyze frequency domain and time domain representation of systems. Applications are drawn broadly from engineering and physics, focusing on communications, and signal processing. |
| CIE 237 | Probability and Stochastic Processes<br>Credits: 3 (2+3)<br>Prereq: MATH 201 AND (CIE 227 OR SPC 210)<br>This course introduces the theory and applications of probability and stochastic processes. It provides also an understanding of the mathematical techniques relating to random processes in the areas of signal processing, and communication. Topics include: introduction to probability, random variables and joint random variables, applications to random variables, introduction to stochastic processes, stochastic processes through linear systems, applications to stochastic processes. |
| CIE 239 | Digital Design and Computer Architecture<br>Credits: 3 (2+3)<br>This course focuses primarily on the fundamentals of digital design. The core concepts are studied at first, including data representation, binary operations, Boolean algebra, and logic simplification. Next, the design and analysis of combinational and sequential circuits is discussed, including adders, flip-flops, registers, and counters. Also, the topic of hardware description languages is gradually introduced in a learning-by-doing fashion along with a brief introduction to FPGAs. In addition, the course briefly introduces the basics of computer architecture, including the functions and design of microprocessors. To enhance the learning experience, the practical element of the course includes several hands-on labs and a term project. |
| CIE 247 | Digital Signal Processing<br>Credits: 3 (2+3)<br>Prereq: CIE 227<br>This course begins with a discussion of the analysis and representation of discrete-time signal systems, including discrete-time convolution, difference equations, the z-transform, and the discrete-time Fourier transform. Emphasis is placed on the similarities and distinctions between discrete-time. The course proceeds to cover digital network and nonrecursive (finite impulse response) digital filters. Digital Signal Processing concludes with digital filter design and a discussion of the fast Fourier transform algorithm for computation of the discrete Fourier transform |

| Code | Description |
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| CIE 249 | Computer Architecture and Assembly Language<br>Credits: 3 (2+3)<br>Prereq: CIE 239<br>The objective of this course is to explain how computers are designed and how they work. Students are introduced to modern computer principles using a typical processor. They learn how efficient memory systems are designed to work closely with the processor, and how input/output (I/O) systems bring the processor and memory together with a wide range of devices. The course emphasizes system-level issues and understanding program performance. Topics include Harvard and Von Neumann microprocessors architectures, instruction sets, X86 and ARM assembly language, internal data representation, computer arithmetic, processor datapath and control, memory hierarchy, I/O devices and interconnects, CISC and RISC architectures, and an introduction to DSP architecture and GPUs. |
| CIE 302 | Operating Systems<br>Credits: 3 (2+3)<br>Prereq: (CIE 205 OR BMS 328)<br>This course explores the field of computer operating systems, emphasizing basic operating systems (OS) concepts and design principles. While stressing the fundamental principles behind them, the idea is to learn not only what operating systems are and how they work today, but also why they are designed the way they are and how they are likely to evolve in the future. This course will cover fundamental OS material such as scheduling and synchronization, threads, memory management, file system, protection, and security. Topics: •Threads and Processes •Concurrency and Synchronization •Scheduling •Virtual Memory •I/O •Disks, File systems •Protection and Security •Virtual machines |
| CIE 317 | Machine Learning<br>Credits: 3 (2+3)<br>Prereq: CIE 205 AND ( CIE 237 OR CIE 327 OR (MATH 301 AND MATH 201) )<br>Machine learning is one of the most powerful tools that is used for data-driven decision making. Topics covered include: training and evaluating machine learning models, model selection, regression, classification, clustering, and dimensionality reduction. Selected applications in data mining, predictive analytics, and pattern recognition. |
| CIE 318 | Control Systems<br>Credits: 3 (2+3)<br>Prereq: CIE 247 OR CIE 442<br>This course introduces the analysis and design of continuous-time and discrete-time feedback control systems. Topics include the properties and advantages of feedback systems, time-domain and frequency-domain performance measures, stability, PID control, the root locus method, frequency-domain design, and an introduction to state space methods. |

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| CIE 328 | Electromagnetic Fields and Waves I<br>Credits: 3 (2+3)<br>Prereq: PHYS 104 AND MATH 102<br>This course covers the fundamentals of Electromagnetic Fields and waves. The course starts by introducing the math tools required to understand the electromagnetic model. Then, it introduces fundamental electrostatic quantities and laws, discussing several methods to solve electrostatic problems such as the image method and Laplace and Poisson's equations. After that steady state current problems are introduced and magnetostatic fundamental quantities and laws are discussed. Magnetostatic problems and their solutions are presented. Further, the time varying fields and Maxwell's equations, wave equations and time harmonic fields are discussed and explained. The course ends with the plane electromagnetic waves propagation in different lossless and lossy materials, introducing the electromagnetic power and poynting vector. Throughout the course the student is presented by Maxwell's equations, constitutive relations and boundary conditions, in different media. |
| CIE 337 | Communications Theory and Systems<br>Credits: 3 (2+3)<br>Prereq: CIE 237 OR CIE 327<br>The course introduces the concept of information measurement through Shannon's information theory. The course also introduces technical concepts, principles, models, management, and foundational logic of information and communication systems such as coding, error correction, channel noise, distortion, communication protocols, and communication standards. The course examines history, current trends, and future of ICT. Review of global ICT standards and regulations. |
| CIE 338 | Electromagnetic Fields and Waves II<br>Credits: 4 (3+3)<br>Prereq: CIE 328 AND MATH 302<br>This course covers the fundamentals of Electromagnetic waves. The course starts by reviewing the plane electromagnetic waves propagation in different lossless and lossy materials. Then the course shows how EM waves behave at different materials interfaces when incident normally or obliquely. Then the course introduces the analysis and design of electromagnetic waves applications: Transmission Lines, Wave Guides, Cavity Resonators, and Antennas. |
| CIE 347 | Information Theory and Coding<br>Credits: 3 (2+3)<br>Prereq: CIE 237 OR CIE 327<br>This course covers fundamentals of information theory and coding, including entropy, average mutual information, channel capacity, block codes and convolutional codes. Topics covered also include asymptotic equipartition property, entropy rates of a stochastic process, data compression, channel capacity, differential entropy, and the Gaussian channel. |

| Code | Description |
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| CIE 349 | Embedded Systems<br>Credits: 3 (2+3)<br>Prereq: (CIE 249 OR CIE 439) AND CIE 302<br>Embedded systems are computing devices capable of interacting with the “real world”, executing dedicated functions within a larger mechanical or electrical system, often with real-time computing constraints. The course covers the basic features of Microcontrollers organization of typical 8 bit and advanced ARM embedded microcontrollers. Digital I/O Control and interfacing, typical sensors for embedded applications, A/D and D/A Converters. Timers and counters, Pulse Width Modulation, H-bridge, DC motor control, Stepper motor control. Serial communications, SPI, I2C, CAN bus, Wi Fi, and Iot interfacing. Embedded systems Integrated Development Environments IDE. Introduction to real-time operating systems RTOS, and Robotics Operating Systems (ROS). |
| CIE 357 | Digital and Wireless Communications<br>Credits: 3 (2+3)<br>Prereq: CIE 337<br>Digital and Wireless communications course is an in-depth senior level Communications course for undergraduate students. This course covers signal space representation of signals and Gram-schmidt orthogonalization procedure. It also covers digital passband shift keying systems, including Amplitude Shift Keying, Phase Shift Keying, Quadrature Amplitude Modulation and Frequency Shift Keying. The course also studies the calculation of error probabilities for various digital communication systems as well as union bounds. In this course, the characteristics of wireless communication channels and the concept of multipath fading as well as statistical descriptions of such channels are also covered. |
| CIE 367 | Computer Networks<br>Credits: 3 (2+3)<br>Prereq: CIE 237 OR CIE 327<br>Computer networks is a fundamental course that introduces the concept of networking. It provides the basic concepts of computer networks, their performance metrics. The OSI layer model as well as the TCP/IP model are covered. The course also covers the fundamentals of switching and routing. Protocols of the data link layer, the network layer and the transport layer are discussed. Ethernet protocol for LANs is covered in this course, as well as WiFi as an example for wireless networks. |

| Code | Description |
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| CIE 399 | Introduction to Applied Software Development<br>Credits: 1 (0+3)<br>Prereq: CIE 205 AND CIE 206<br>The aim of this course is to introduce the students to the fundamentals of contemporary software development. The course helps the students to gain core software development skills which can be applied to a variety of challenges and to experience and apply sound professional practices of software development. Students will learn how to design, develop, and evaluate software that implements commercially realistic but manageably small software requirements. The course uses the project-based learning strategy where students work on a project over the entire semester. They will be engaged in solving a real-world problem and will demonstrate their knowledge and skills by creating a software product for a real customer enabling them to develop deep content knowledge as well as critical thinking, collaboration, creativity, and communication skills. |
| CIE 402 | Antennas Engineering<br>Credits: 3 (2+3)<br>Prereq: CIE 338<br>This course explores the theory and practice of antenna engineering, including a range of popular antenna types, applications and electromagnetic properties from basic to state-of-the-art. Study a wide spectrum of frequencies from 300 kHz to 550 GHz, with primary emphasis in the MF, HF, VHF, UHF and microwave regions. Examine communications, radar, commercial and military applications. Discuss related topics, such as radomes, antenna materials, computer modeling of antennas, antenna noise and antenna measurement techniques. |
| CIE 404 | Cloud Computing Technology<br>Credits: 3 (2+3)<br>Prereq: CIE 302 AND (CIE 367 OR CIE 447)<br>This course provides a foundation for cloud computing infrastructure and modern data centers. It has a theoretical and practical component and hands-on activity on the various cloud services. It introduces the students to the concepts of virtualization in computing, storage, and networking and the popular hypervisors. The different service models, Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) are also introduced. The course also addresses the economics and pricing models of cloud computing and security challenges related to the cloud. The course introduces the students to Cloud-native applications, containers, and serverless computing. Moreover, the popular cloud computing systems and the various cloud services offering like Storage, Infrastructure, Compute, and Data are discussed. The course has hands-on cloud programming and a capstone project. |

| Code | Description |
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| CIE 412 | Propagation and Channel Modeling<br>Credits: 3 (2+3)<br>Prereq: CIE 402<br>This course discusses radiowave propgation and channel modeling for wireless indoor/outdoor/V2V applications. The courses covers topics such as Radio Wave Propagation for the Wireless Channel, Shadowing and Multipath, Path-Loss, Channel Models, MIMO Channels, Antenna-Channel Interaction Characterization, System-Specific Propagation Channels (indoors/outdoors/V2V...), Channel Measurement Techniques, Channel Estimation,Statistical Inference and Model Selection, and Future Developments in Wireless Communication Channels |
| CIE 413 | Bioinformatics for Engineers<br>Credits: 3 (2+3)<br>Prereq: BIOL 102 AND (CIE 317 OR CIE 417) AND (CIE 237 OR CIE 327 OR MATH 301)<br>The role of biological research has been transformed significantly due to the vast amount of data produced in genomics related research. The aim of this course is to introduce the students to the recent research field of bioinformatics. The topics covers in this course include the areas of computer science that play an important role in bioinformatics such as software, data mining, high-performance computing, mathematical models and infrastructure for high-throughput automated biological experiments. Other topics include existing methods for analyzing genomes, sequences and protein structures. The course provides hands-on approach to the field of bioinformatics. |
| CIE 416 | Satellite Communications System<br>Credits: 3 (2+3)<br>Prereq: CIE 437<br>This course provides an in-depth introduction to geostationary Earth orbit (GEO) satellites and their use in broadcasting services, as well as low Earth orbit (LEO) satellites and their use in telecommunications, covering practical existing satellite networks such as IRRIDIUM, Globalstar and Starlink. The course will cover also link budget calculations and multiple access techniques used in satellite systems, based on relevant standards. In addition, the course includes topics related to interference in satellite systems and the calculation of the carrier to interference ratio for various types of interference. Moreover, the course studies the practices of planning satellite networks. For LEO telecommunication satellite systems, the course covers the topics of inter-satellite communication links, handoff, Doppler effect, spotbeams, Doppler-based multiple access and design considerations for satellite clusters regarding the numbers of satellites and orbits in such clusters. |

| Code | Description |
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| CIE 418 | Communications Circuits<br>Credits: 3 (2+3)<br>Prereq: CIE 320 AND CIE 301<br>This course is an introduction to concepts associated with the wireless transmission and reception of analog modulated signals. It provides sufficient background in theory, devices, and circuits employed in radio communication systems, which enables the students to design, build and test basic communication circuitry. In particular, this course introduces fundamental principles of wireless RF communications, AM, FM, and PM modulation, demodulation and spectra, and frequency shifting and mixing. Practical linear and nonlinear circuits for a heterodyne radio receiver are studied, including RF/IF amplifiers, matching networks, oscillators, mixers, modulators, and demodulators. |
| CIE 419 | Computer Vision<br>Credits: 3 (2+3)<br>Prereq: CIE 317 OR CIE 417<br>This course provides an introduction to the field of computer vision. Some of the topics covered in the class are: Image and Camera Fundamentals, Fourier Transform and Convolution, Image enhancement, Image Segmentation, Image Feature Extraction, Object recognition, Stereo-vision, Motion analysis, and latest topics in computer vision. |
| CIE 420 | Robot and Machine Vision<br>Credits: 3 (2+3)<br>Prereq: CIE 419 AND CIE 442<br>This course addresses the industrial use of vision for automatic inspection, process control and robot guidance. The course addresses the usage of computer vision technique to increase the robot's ability to physically affect the environment. It involves controlling the motion of a robot by using the feedback of the robot's position as detected by a vision sensor. The course teaches how to use and select the hardware components of a machine vision system, and implement machine vision tasks and inspections using Arduino or equivalent system. The students will apply their knowledge of computer vision to create a vision system to program a robotic arm to perform a simple, visual task. |
| CIE 427 | Big Data Analytics<br>Credits: 3 (2+3)<br>Prereq: CIE 206 AND (CIE 317 OR CIE 417)<br>The course is designed to give the students in-depth knowledge of the Big Data framework using Hadoop and Spark. They will learn the principles of HDFS, YARN, and MapReduce. They will learn to use Pig and Hive to process and analyze large datasets stored in the HDFS and to use Sqoop and Flume for data ingestion. They will be introduced to HBase, a distributed column-oriented database to use when require real-time read/write random access to very large datasets. They will learn real-time data processing using Spark, understanding parallel processing in Spark, and using Spark RDD optimization techniques and SparkML. |

| Code | Description |
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| CIE 436 | Electromagnetic Remote Sensing: Engineering Principles and Techniques<br>Credits: 3 (2+3)<br>Prereq: (CIE 247 OR CIE 442) AND CIE 338<br>This course covers the physical principles involved in remote sensing of Earth's environment and their implementation in engineering systems. The topics covered include: the fundamentals of electromagnetic wave propagation, scattering by matter, effects of propagation media, passive and active sensing systems, remote sensing platforms, data processing, and systems integration. Concepts important for the design and analysis of remote sensing systems will also be covered |
| CIE 438 | RF and Microwave Engineering<br>Credits: 3 (2+3)<br>Prereq: CIE 338<br>This course introduces the design and analysis of active and passive radio frequency and microwave circuits. It prepares? the students for careers in RF and Microwave Engineering; and for working on projects related to antennas and propagation, RF electronics, and optical communication systems. Topics include introduction to microwave systems; microwave network analysis; and impedance matching and tuning. After that the course discusses microwave passive and active devices. |
| CIE 448 | IoT Systems Engineering<br>Credits: 3 (2+3)<br>Prereq: (CIE 349 OR CIE 408) AND (CIE 367 OR CIE 447)<br>This is an applied project-based course in which the students learn to build an IoT system for a particular application. The students will get introduced to state-of-the-art IoT standards. The students shall apply the engineering design principles starting from gathering the project requirements, iterative analysis and design, up to the level of the final implementation and field testing. The final product should meet the requirements and constraints. The students shall work in teams to build the different IoT subsystems including embedded hardware and software, communications, application software, and data analysis. The students will also learn the fundamentals of software engineering and use them in the software development required for the IoT project. |
| CIE 449 | Wireless Sensor Networks and IoT<br>Credits: 3 (2+3)<br>Prereq: (CIE 357 OR CIE 437) AND (CIE 367 OR CIE 447)<br>In this elective course, the students will be introduced to the concept of the Internet of Things (IoT). The course starts with introducing wireless sensor networks (WSN) as a key player in IoT. The basics and applications of wireless sensor networks are presented. The course studies the wireless communication technologies suitable for WSN. Medium access control protocols as well as routing protocols for WSN are covered. The course also covers the network management models for WSN, as well as performance and traffic management. In addition, the course will introduce the most common operating systems used for WSN and IoT applications. |

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| CIE 450 | Robotics: Transformations, Kinematics, and Dynamics<br>Credits: 3 (2+3)<br>Prereq: CIE 318<br>Introduction, history, types and applications of robots; Manipulation using single and multi-robots; Rigid body motion, Rigid body transformations, Homogeneous representation; Velocity of a rigid body, Manipulator kinematics, and Forward kinematics; Manipulator workspace, General solutions to inverse kinematics problems, End-effector velocity and forces; Robot dynamics and control, Lagrange's equations, Dynamics of a two-link planar robot; Redundant and parallel manipulators; Tools for robotics analysis and simulation. |
| CIE 451 | Mechatronics Engineering<br>Credits: 3 (2+3)<br>Prereq: CIE 450<br>This course provides an overview of robot mechanisms, dynamics, and intelligent controls. Topics include planar and spatial kinematics, and motion planning; mechanism design for manipulators and mobile robots, multi-rigid-body dynamics, and 3D graphic simulation; Control design, actuators, and sensors; Multi-robot systems; Data communication and wireless networking; Task modeling, human-machine interface, and embedded software. Students will design and build working robotic systems with multiple sensors, actuators, mechanisms and computer systems connected with a data communication bus. |
| CIE 452 | Advanced Computer Architecture<br>Credits: 3 (2+3)<br>Prereq: CIE 439 OR CIE 249<br>Fundamentals of computer design; quantifying cost and performance; instruction set architecture; program behaviour and measurement of instruction set use; processor datapaths and control; pipelining, handling pipeline hazards; memory hierarchies and performance; I/O devices |
| CIE 453 | Natural Language Processing<br>Credits: 3 (2+3)<br>Prereq: CIE 317 OR CIE 417<br>This course provides an introduction to the field of Natural Language Processing. Some of the topics covered in the class are Text Similarity, Part of Speech Tagging, Parsing, Semantics, Question Answering, Sentiment Analysis, and Text Summarization. The course includes programming assignments in Python. |

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| CIE 454 | Computer Arithmetic<br>Credits: 3 (2+3)<br>Prereq: CIE 205<br>Arithmetic is the science of handling numbers and operating on them. This course is about the arithmetic done on computers. To fulfill its purpose, there is a need to describe the computer representations of the different numbers that humans use and the implementation of the basic mathematical operations such as addition, subtraction, multiplication and division. These operations can be implemented in software or in hardware. The focus of this class is to introduce the hardware aspects of computer arithmetic. The enhancements to improve the usual performance metrics (speed, area, and power) are discussed and the students are expected to use them in their projects. |
| CIE 455 | Neural Networks and Deep Learning<br>Credits: 3 (2+3)<br>Prereq: CIE 317 OR CIE 417<br>This course provides an intoduction to deep Learning, how to build efficient neural networks, and how to apply deep learning to applications. Topics covered in this course include convolutional networks, RNNs, LSTM,GAN, Adam, Dropout, and more. Students will be able to build, train and apply fully connected deep neural networks. They will study the key parameters in a neural network's architecture and learn how to implement efficient neural networks. They will work on case studies from autonomous driving, image generation, natural language processing, and more. They will master the theory and practice the ideas. |
| CIE 456 | Speech Analysis, synthesis, and recognition<br>Credits: 3 (2+3)<br>Prereq: (CIE 317 OR CIE 417) AND CIE 442<br>This course provides an introduction to speech analysis, synthesis and recognition. The course introduces the production of human speech, vocal tract, the hearing system, the units of speech, methods of analysis for speech signals, speech recognition technology, and computerized speech synthesis. It provides a basic understanding of multidimensional techniques for speech representation and classification methods. Students will learn to express the speech signal in terms of its time domain and frequency domain. They will learn to derive expressions for simple features used in speech classification applications. Topics include Introduction to speech processing, time-frequency analysis, spectral analysis, speech Modeling , Linear Predictive Analysis, pitch Extraction, Human Auditory System, Speech Enhancement, Clustering and Gaussian Mixture models, Speaker Recognition, Hidden Markov models and Neural networks, and speaker and speech recognition. |

| Code | Description |
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| CIE 457 | Statistical Inference and Data Analysis<br>Credits: 3 (2+3)<br>Prereq: CIE 237 OR CIE 327<br>The aim of this course is to provide a thorough treatment of some major topics in statistical inference and data analysis. The course focuses on a solid knowledge of statistical inference methods, and the practical application of these methods using programming to analyze and learn from data. The course starts with exploratory data analysis. The sampling distribution concept is then introduced along with an introduction to inferential statistics. Practical statistical inference topics are then covered in more detail including estimation, confidence intervals, and hypothesis testing. The course then proceeds to a more thorough coverage of frequentist and Bayesian inference topics and theories. Finally, the course will cover an introduction to probabilistic machine learning. |
| CIE 458 | Fundamentals of Artificial Intelligence<br>Credits: 3 (2+3)<br>Prereq: CIE 205 AND (CIE 237 OR CIE 327 OR MATH 301)<br>The course addresses key concepts underlying intelligent systems, which are increasingly deployed in consumer products and online services. Topics include problem solving, state-space representation, heuristic search techniques, game playing, constraint satisfaction problems, Markov decision process, and reasoning under uncertainty. These concepts will be examined in the design of intelligent agents in the context of several applications. |
| CIE 459 | Parallel and Distributed Computing<br>Credits: 3 (2+3)<br>Prereq: (CIE 249 OR CIE 439) AND CIE 205<br>This course covers a broad range of topics related to parallel and distributed computing, including parallel and distributed architectures and systems, parallel and distributed programming paradigms, parallel algorithms, and scientific and other applications of parallel and distributed computing. |
| CIE 460 | Software Engineering Fundamentals<br>Credits: 3 (2+3)<br>Prereq: (CIE 205 OR BMS 328) AND CIE 206<br>This course covers the fundamentals of software engineering, including understanding system requirements, finding appropriate engineering compromises, effective methods of design, coding, and testing, team software development, and the application of engineering tools. The course will combine a strong technical focus with a capstone project providing the opportunity to practice engineering knowledge, skills, and practices in a realistic development setting with a real client. |

| Code | Description |
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| CIE 461 | Automata and Compiler Design<br>Credits: 3 (2+3)<br>Prereq: CIE 302<br>The purpose of this course is to acquaint the student with an overview of the theoretical foundations of computer science from the perspective of formal languages and to introduce them to the principles and practices in the design of compilers. The course covers formal language, regular Expressions, Finite Automata and conversion of regular expressions to Finite Automata. Students study applications of Finite Automata to lexical analysis. The course includes the study of context Free grammars and parsing as well as the semantics such as Syntax directed translation, Intermediate code, translation of simple statements and control flow statements. Topics such as symbol table, storage organization, storage allocation strategies, code optimization principal and optimization techniques are also discussed in the course. Other topics are also covered in the course such as machine dependent code generation, object code forms, generic code generation algorithm and the DAG representation for Blocks. |
| CIE 464 | Computer Graphics<br>Credits: 3 (2+3)<br>Prereq: (CIE 205 OR BMS 328)<br>This course provides introduction to computer graphics algorithms, software and hardware. Topics include: ray tracing, the graphics pipeline, transformations, texture mapping, shadows, sampling, global illumination, splines, animation and color. |
| CIE 465 | Visualization<br>Credits: 3 (2+3)<br>Prereq: CIE 464<br>This course provides an overview about the state of the art in information visualization. It teaches the process of producing effective visualizations that take the needs of users into account. Among other topics, the course covers: Data analysis algorithms that enable extraction of patterns and trends in data Major temporal, geospatial, topical, and network visualization techniques Discussions of systems that drive research and development. |

| Code | Description |
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| CIE 467 | Mobile Communications Technologies<br>Credits: 3 (2+3)<br>Prereq: (CIE 357 OR CIE 437) OR CIE 428<br>In this course, students will apply the concepts of digital communications as well as the characteristics of wireless communications on mobile communication systems. The course introduces the cellular concept, frequency reuse and channel allocation techniques. The course also covers mobility management issues, including the various types of handover. The course studies interference in cellular systems, methods to mitigate it and its effects on the system capacity. Students will learn the concepts of trunking and grade-of-service. In this course, students will also learn about the various multiple access techniques and their effect of the system capacity. In addition, the course covers system architectures for second, third and fourth generation mobile communication systems, and the requirements of each of these generations as well as standard systems that fulfill such requirements. By the end of the course, students will learn about the key enabling technologies of the fifth generation systems and proposed methods in literature to reach the requirements of the standardization bodies. |
| CIE 470 | Introduction to Quantum Computation and Quantum Information<br>Credits: 3 (2+3)<br>Prereq: MATH 201<br>Quantum information and quantum computation are newborn sciences that benefit from the quantum-mechanical nature to launch the next huge revolution of information and communications technology. In quantum information and quantum computation, elementary quantum systems like photons and subatomic systems are used to build fascinating quantum devices and protocols superior to the traditional classical ones. On that scale, instead of the binarized classical information unit (the bit), quantum mechanics offers another more featured unit; the quantum bit (qubit), that supports coherent superposition (and interference) and thereby can take an infinite number of values. In this course, we will attempt to cover the fundamentals of Quantum computation and quantum information. We will shed light on some of the famous quantum protocols such as quantum teleportation, quantum superdense coding, quantum key distribution, quantum privacy amplification, quantum error correction. We will study possible quantum-circuit implementations. |

| Code | Description |
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| CIE 474 | Distributed Systems<br>Credits: 3 (2+3)<br>Prereq: (CIE 367 OR CIE 447) AND CIE 459<br>The course addresses the main principles underlying distributed systems: processes, communication, naming, synchronization, consistency, fault tolerance, and security. The course covers the building blocks for a study of distributed systems, and addressing the characteristics and the challenges that must be addressed in their design: scalability, heterogeneity, security and failure handling. The course also covers issues and solutions related to the design and the implementation of distributed applications. Students will be familiar with some of the main paradigms in distributed systems: object-based systems, file systems, web-based and coordination-based systems. Students will be able to design and develop distributed systems and applications. |
| CIE 477 | Cognitive Radio Systems<br>Credits: 3 (2+3)<br>Prereq: CIE 357 OR CIE 437<br>This course introduces the students to the concept of spectrum sharing and its use in cognitive systems. The course covers the concept of cognitive radio, the reasons it evolved and the methods it is applied. The course includes the general structure of cognitive systems. It then details the types of spectrum sensing and their techniques. This includes the calculations of missed detection and false alarm probabilities. The course then covers the topic of spectrum management. The course also covers the aspects of game theory that are used in spectrum management in cognitive radio. In addition, the course includes the design of prototype cognitive radios using USRPs. |
| CIE 478 | Advanced Wireless Communication Systems<br>Credits: 3 (2+3)<br>Prereq: CIE 357 OR CIE 437<br>In this senior-level undergraduate communications course, the students are introduced to the advanced concepts of wireless communication systems. The course starts with the fundamentals of cellular systems used in mobile communications including the concepts of frequency reuse, handover, channel assignment, radio planning and optimization, etc. The course then covers multicarrier techniques such as orthogonal frequency division multiplexing/multiple access (OFDM/A) and its applications in 4G, 5G mobile systems, WiFi, etc. The course also covers spread spectrum communication techniques including direct sequence spread spectrum and frequency hopping spread spectrum. Multiple access techniques are studied, including code division multiple access (CDMA) and its application in 3G mobile systems. Other multiple access techniques used in wireless communication systems are also studied. Finally, the course covers the concepts of diversity and equalization to address the impairments of wireless communication channels. |

| Code | Description |
|---|---|
| CIE 481 | Information Security and Encryption<br>Credits: 3 (2+3)<br>Prereq: CIE 237 OR CIE 327<br>This course introduces the fundamentals of information security, with a focus on modern practices that are used in protecting the information at rest and in transit. The concept of security services is first discussed. Then, the course discusses selected topics in information security, including encryption, access control mechanisms, IoT security, network security, physical security, security management and risk assessment. The practical element of the course includes several lab activities, research discussions and a final research report. |
| CIE 482 | Cryptography<br>Credits: 3 (2+3)<br>Prereq: MATH 308 AND (CIE 237 OR CIE 327)<br>This course provides a foundation of applied cryptography, enabling the students to grasp its importance in the field of information security. Topics include steganography, block and stream ciphers, secret-key encryption, public-key encryption, cryptographic hash functions, message authentication codes, digital signatures, certificates and authentication protocols, cryptanalysis techniques, and key management. Also, the course covers principles of number theory, necessary for the study of cryptographic algorithms and cryptanalysis. The practical element of the course includes several lab activities and a final project. |
| CIE 491 | Selected Topics in Networks and Communications Systems<br>Credits: 1-3<br>Selected topics of interest of faculty and major students, not covered elsewhere in the curriculum. The course can be repeated for credit more than once on the condition that course topics are different |
| CIE 492 | Selected Topics in Electromagnetics and Remote Sensing<br>Credits: 1-3<br>Selected topics of interest of faculty and major students, not covered elsewhere in the curriculum. The course can be repeated for credit more than once on the condition that course topics are different |
| CIE 493 | Selected Topics in Artificial Intelligence and Big Data Analytics<br>Credits: 1-3<br>Selected topics of interest of faculty and major students, not covered elsewhere in the curriculum. The course can be repeated for credit more than once on the condition that course topics are different |
| CIE 494 | Selected Topics in High Performance Computing and Visualization<br>Credits: 1-3<br>Selected topics of interest of faculty and major students, not covered elsewhere in the curriculum. The course can be repeated for credit more than once on the condition that course topics are different |

| Code | Description |
|---|---|
| CIE 495 | Selected topics in Robotics<br>Credits: 1-3<br>Selected topics of interest of faculty and major students, not covered elsewhere in the curriculum. The course can be repeated for credit more than once on the condition that course topics are different |
| CIE 497 | Selected topics in Communications and Information Engineering<br>Credits: 1-3<br>Selected topics of interest of faculty and major students, not covered elsewhere in the curriculum. The course can be repeated for credit more than once on the condition that course topics are different |
| CIE 498 | Senior Design Project I<br>Credits: 1 (0+3)<br>Prereq: Completed 102 credit hours toward satisfying the degree requirements, and during the last two semesters<br>Students must undertake an independent major senior design project during the last two terms of their program. The purpose of the project is to demonstrate students' abilities to practice in their chosen area of expertise, using knowledge gained from their academic and industrial training experiences. The first part of the project will include problem identification, generation and selection of solutions and time management. Incorporation of technical and economic issues in the solution for the project will be required. Requirements include: proposal, progress report, and a final report containing recommendations for part two of the project. |
| CIE 499 | Senior Design Project II<br>Credits: 3 (0+9)<br>Prereq: CIE 498<br>A continuation of CIE 498. The final design of the major senior design project proposed in CIE 498 will be undertaken. The purpose of this phase of the project is to carry out a detailed technical design of the solution proposed in CIE 498. Requirements of this part of the two-term project include a final report. Students will present their thesis project at the graduation seminar orally or in a poster session. |
| CSCI 101 | Introduction to Computer Science<br>Credits: 2 (1+3)<br>In this course, students identify how various forms of data are represented digitally, how the major hardware components store and operate on such data, and how software is developed to control these systems. Students learn the basics of computational problem solving, algorithm design and analysis, and data structures. The course will also include an introduction to computer programming to maximize the depth of experience in designing and writing computer programs by teaching the students how to write programs using Python programming language. In the end of the course, the students should be able to use the computer to solve the problems they face in other university's courses by writing efficient Python programs. |

| Code | Description |
|---|---|
| ENGL 152 | Effective Speaking and Composition<br>Credits: 2 (2+0)<br>Prereq: ENGL 004 if the student was placed in ENGL 003 or ENGL 004 after the English placement exam<br>The focus of the course is twofold; the first part of the course introduces the meaning and strategies of rhetoric; it aims to enhance the students' skills in identifying, comprehending, evaluating, and producing different elements and types of written arguments. This entails developing the rhetorical analysis skills and instilling deeper insights to develop solid arguments while addressing a variety of audiences. The students will further demonstrate an understanding of various types of audiences, explicit and implicit purposes, and positive/negative/neutral tones constituting a rhetorical situation. Throughout the first half of the semester, students will practice critical thinking, reading, and writing; they will develop research skills in which they will identify and evaluate primary and secondary sources that include different types of evidence to support their own stance towards a controversial topic. Using the enhanced critical thinking and argumentation skills, the second part of the course aims to instill the public speaking skills that are now of incremental significance whether in the scientific field or for marketing purposes. The focus of the second part of the course will be enabling the students to deliver different types of speeches in different settings, for different purposes, and addressing different audiences. |
| ENGL 153 | Scientific Writing<br>Credits: 2 (2+0)<br>Prereq: ENGL 152<br>In designing this course, the main priority was to enhance the required skills needed in scientific research design and writing; accordingly, the course takes students through a step-by-step process to identify and avoid wordy writing, integrate scientific collocations in writing, understand the different scientific approaches, identify different types of scientific articles, critically review a scientific article, synthesize different valid and reliable sources, write a full-fledged research grant proposal, avoid plagiarism by applying summarizing/paraphrasing techniques and using an acknowledged documentation style and deliver an effective poster presentation. |
| ENGR 102 | Introduction to Engineering Design<br>Credits: 2 (1+3)<br>Introduction to profession teamwork and effective functional meetings. Problem solving procedure: problem definition, generation of solutions, decision analysis methodology, solution implementation, assessment of implementation. Engineering design process. Computer modeling and heuristics for problem solving. Hands-on real life and team–based engineering design project: customer requirements, conceptual design, prototyping, functional testing, preparation of operational manual. Communicating design outcomes. Organization of the work and design notebook. Reverse engineering and design projects. Principle of project commercialization. |

| Code | Description |
|---|---|
| ENGR 105 | Engineering Thermodynamics<br>Credits: 3 (2+3)<br>Prereq: PHYS 103<br>Thermodynamics is concerned with the study of heat and work, and the transfer of energy from one form to another in physical and chemical transformation. The main topics are The first law and basic concepts, volumetric properties of pure fluids, Heat effects, the second law of thermodynamics, Thermodynamics properties of fluids, Applications of thermodynamics to flow processes, and Cycles. |
| ENGR 121 | Engineering Drawing<br>Credits: 2 (1+3)<br>This course introduces students to the graphical communication and visualization tools used by engineers. The course covers the use of instruments and computer-aided drafting packages for producing engineering drawings. Topics include the use of instruments, line types, lettering, drawing scale, geometrical constructions, principles of orthographic projection, pictorial drawing, sectional views, auxiliary views, dimensioning, and dawing standards and conventions. |
| ENGR 201 | Circuits and Electronics<br>Credits: 3 (3+0)<br>Prereq: PHYS 104 AND MATH 102<br>The course introduces the components of a lumped electrical circuits and the laws and theories used for circuit analysis. Both DC, transient and AC steady state analyses will be covered for passive circuits. Active circuits will be analyzed only in DC. The course will use CAD tools such as Spice to enhance the practical capabilities of the student. |
| ENGR 207 | Fluid Mechanics<br>Credits: 3 (2+3)<br>Prereq: MATH 102 AND PHYS 103<br>Fluid properties; Fluid statics; Bernoulli equation; Fluid kinematics; Energy equation; Finite control volume analysis; Dimensional analysis; Viscous flow in pipes; Flow around immersed bodies. |
| ENGR 333 | Industrial Training<br>Credits: 2 (0+120)<br>Prereq: Completed 80 credit hours toward satisfying the degree requirements<br>The main objective of industrial training is to enable engineering students a real life engineering workplace to earn practice skills. It is typically in the summer after the students complete their third year. For a minimum of 120 working hours, the students receive a training from industrial companies, research institutions, consultancy offices, government ministries, and NGO or foreign research institute related to their field of specialization. The student, supervised by the training organization, has to submit at the end a technical report to his/her Program. The course is graded as “PASS” or “FAIL”. |

| Code | Description |
|---|---|
| ENGR 346 | Heat Transfer<br>Credits: 3 (2+3)<br>Prereq: (ENGR 105 OR PHYS 203) AND MATH 202<br>This course illustrates the fundamental principles and laws of heat transfer by conduction, convection, and radiation to explore the implications of these principles for system behavior; to formulate the models necessary to analyze and design heat transfer systems. |
| ENV 104 | Chemistry for Environmental Engineers<br>Credits: 3 (2+3)<br>Prereq: CHEM 103<br>This course covers the fundamental principles of Chemistry for environmental engineers. Topics include environmental organic and inorganic compounds in our environment including their stability, reactions, kinetics, equilibria and thermodynamics. The lab is designed to include analysis/measurements of some environmentally sound molecules, their solubility and solubility product, partition coefficient, separation of ions from their mixtures and removal of some pollutants from environmental samples. |
| ENV 120 | Microbiology and Environmental Health<br>Credits: 2 (1+3)<br>This course provides students with a conceptual and experimental background in environmental microbiology and environmental health. The course covers introduction on microbiology; growth and control of microorganisms in the environment; characterization and identification of microorganisms in the environment; biofilms and its control; transmission and persistence of microorganisms in various environments such as water, air, soil, and industrial settings; use of microorganisms in biodegradation, bioremediation, and fermentation. The laboratory component of the course covers basic aspects of microbiology and environmental health, including techniques for detecting, identifying and quantifying microorganisms in the environment, their survival in environmental media, and their removal and destruction by technological measures. |
| ENV 204 | Environmental Engineering Chemistry<br>Credits: 3 (2+3)<br>Prereq: ENV 104<br>This course covers topics in analytical chemistry with applications to the environment: Classification of pollutants and their methods of measurements including classical and instrumental techniques. The course includes an overview of air, water, and soil pollution and their control. The Practical is designed to include analysis of water and wastewater parameters such as pH, TDS, TSS, COD, BOD and Oil and grease. It also includes analysis of some air and soil quality parameters. |

| Code | Description |
|---|---|
| ENV 207 | Material and Energy Balances<br>Credits: 3 (2+3)<br>Prereq: ENGR 105 OR PHYS 203<br>This course covers the fundamental principles and applications of the conservation of mass and energy and develops the skills needed to apply these principles to engineering problems. It includes methods of formulating and analyzing mass and energy balances in unit operations with the goal of minimizing waste and assessing material and environmental impact. |
| ENV 219 | Climate Dynamics<br>Credits: 2 (2+0)<br>Prereq: ENV 207<br>The course gives an introduction to physical climatology in order to better understand climate variations in the past, present, and future. Topics include the physical principles governing the global energy budget; the role of atmosphere and ocean circulations; interactions between the different components of the climate system; the physical mechanisms for climate change; natural climate variability; and possible effects of anthropogenic climate change. |
| ENV 224 | Ecology for Environmental Engineers<br>Credits: 3 (3+0)<br>This course covers ecological processes at organism, population, community, and ecosystem levels. Topics include characteristics of the physical environment, adaptation and natural selection, population growth, species interaction, community structure and dynamics, ecosystem energetics, decomposition and nutrient cycling, biogeochemical cycles, terrestrial ecosystems, aquatic ecosystems, and coastal and wetland ecosystems. |
| ENV 230 | Phase Equilibria for Engineers<br>Credits: 3 (2+3)<br>Prereq: ENGR 105 OR PHYS 203<br>Review of basic thermodynamics and development of the laws of thermodynamics into working equations. Covers fundamental property relations, enthalpy calculations, residual properties, vapor-liquid equilibrium of ideal and non-ideal systems, equations of state, activity coefficient models, chemical reaction equilibrium and solid-liquid and solid-vapor adsorption equilibria. |
| ENV 250 | Hydraulic Engineering<br>Credits: 3 (2+3)<br>Prereq: ENGR 207 AND ENGR 121<br>Hydraulic analysis of steady-state pressurized flow in pipelines, branched pipes, and pipe networks; pumping systems: pump types, pump characteristic curve, pipeline system curves, operating point, selection of single, parallel, and series pumps, cavitation; quasi-steady flow in pressurized systems with tanks; free-surface flow in open and closed conduits: uniform flow, rapidly-varied flow, gradually-varied flow; flow measurements in open channels; culvert design. |

| Code | Description |
|---|---|
| ENV 257 | Reactions Engineering<br>Credits: 3 (2+3)<br>Prereq: ENV 207<br>Review of stoichiometry and chemical kinetics; Isothermal operation and design of ideal reactors, including batch; semi-batch; continuous stirred tank reactor (CSTR), plug flow reactors (PFR), packed bed reactor (PBR); CSTRs and PFRs combinations; Multiple reactions; Yield and selectivity; Optimal operation of reactors; Special reactors; Temperature effects in non-isothermal reactors. |
| ENV 302 | Environmental Laws and Policies<br>Credits: 2 (2+0)<br>This course covers principles of environmental legislation; Egyptian environmental laws and regulations; and obligations under related international conventions. Appropriate and realistic environmental management models through environmental law and regulations are presented and evaluated to support the idea of sustainable development via environmental law. |
| ENV 306 | Engineering Hydrology<br>Credits: 3 (2+3)<br>Prereq: ENV 250 AND MATH 301<br>This course introduces students to the fundamental surface and subsurface hydrologic processes as well as hydrologic engineering applications. Topics include the hydrologic cycle, water balance, precipitation, evaporation, evapotranspiration, infiltration, runoff generation, flood routing, fundamental principles of groundwater flow in aquifers, and well hydraulics. |
| ENV 320 | Water Treatment Engineering<br>Credits: 3 (2+3)<br>Prereq: ENV 204 AND ENV 250<br>The course provides theoretical background and practical expertise in the field of surface and groundwater treatment. The topics include water demand and water resources options, surface and groundwater characteristics, design of water intake, treatment units and processes such as coagulation, flocculation, clarification, filtration, adsorption, disinfection and oxidation. |
| ENV 322 | Wastewater Treatment Engineering<br>Credits: 3 (2+2)<br>Prereq: ENV 120 AND ENV 204<br>The course topics include characterization of municipal and industrial wastewater (quantity and quality); physical, chemical, and biological processes necessary for designing, operating, controlling, and managing wastewater treatment plants; and the principles of process selection to meet effluent discharge requirements in a cost-effective manner. |

| Code | Description |
|---|---|
| ENV 323 | Municipal Solid Waste Management<br>Credits: 3 (2+2)<br>Prereq: ENV 207<br>This course covers municipal solid waste characteristics, storage and collection, transfer and transport, separation and processing, recycling, composting, incineration, and sanitary landfilling. |
| ENV 325 | Mass Transfer Operations<br>Credits: 3 (2+3)<br>Prereq: ENGR 346 AND ENV 230<br>This course studies selected important topics for environmental mitigation such as mass transfer theory and mechanisms, stage and continuous gas-liquid contacts, absorption and stripping, hydrodynamics of plate and packed columns, simple and continuous distillation. Students will learn a quantitative framework to design different processes related to environmental mitigation measures. |
| ENV 327 | Hazardous Waste Management<br>Credits: 2 (2+0)<br>Prereq: ENV 323<br>This course provides an overview of treatment and disposal of hazardous municipal and industrial waste, including design and economic analysis. Topics include regulatory aspects, resource conservation and recovery overview, classification and characterization of hazardous waste, hazardous waste facility operation, generators of hazardous waste, fate and transport of contaminants in the subsurface, toxicology and quantitative risk assessment, pollution prevention and waste minimization, landfill disposal, treatment processes, and disposal methods. The course covers different case studies of hazardous waste management. |
| ENV 328 | Sampling and Monitoring of Environmental Pollutants<br>Credits: 2 (2+0)<br>Prereq: ENV 204<br>This course outlines the sampling process of the environmental pollutants from various sources. Also, the course covers the advanced instrumentation techniques for chemical analysis, on-line and off-line methods of measurements for air and exhaust gases such as carbon, nitrogen, and sulphur oxide and respirable and suspended particulate matter. Other topics include water, wastewater, soil, and indoor sampling and analysis. |
| ENV 359 | Bioprocess Engineering<br>Credits: 3 (2+2)<br>Prereq: ENV 120 AND ENV 257<br>Study of the engineering concepts for biological conversion of raw materials to food, pharmaceuticals, fuels, and chemicals. The course covers enzyme kinetics and technology, bioreaction kinetics, design, analysis, and control of bioreactors and fermenters, and downstream processing of bioreaction products. Moreover, the course emphasizes the production of energy and fuels from biomass. |

| Code | Description |
|---|---|
| ENV 367 | Environmental Impact Assessment<br>Credits: 3 (3+0)<br>Prereq: ENV 302<br>The course is intended to present the students with up-to-date information on the principles of Environmental Impact Assessment and its application at different levels and in different projects. The course is designed to be practical in nature. For this purpose, the course is divided in the EIA principles, case studies with an on-hand application and computer application in the EIA studies. The students will be able at the end of the course to apply the EIA concepts on real life cases. During the course students will do exercises on how to carry out an EIA study and write up an EIA report. The course main objectives are to have the student familiar with EIA Principles, know and apply computer applications used in EIA studies, and present and make a case study. |
| ENV 380 | Urban Water Systems Design<br>Credits: 3 (2+3)<br>Prereq: ENV 306 AND ENV 320<br>This course covers planning, design, hydraulic analysis, operation, and maintenance of water transport and distribution systems, wastewater collection systems, and stormwater drainage systems; introduction to hydraulic design of pump stations; transient analysis and protection methods for pipelines; use of professional software packages for hydraulic analysis and design of urban water systems. |
| ENV 411 | Process Synthesis and Simulation<br>Credits: 3 (2+3)<br>Prereq: ENV 325<br>The course aims to provide fundamentals and methods of process synthesis and simulation, which are required for design of chemical and environmental processes. The course covers introduction to process design, process synthesis, process simulation, and preliminary plant design. In addition, the students will learn mechanical design of process equipment, cost estimation, and profitability analysis of chemical processes. Moreover, students will practice the use of process simulation as a tool for the analysis and the conceptual design of chemical and environmental processes. |
| ENV 412 | Sustainability for Engineers<br>Credits: 2 (2+0)<br>Prereq: ENV 302 AND SCH 262<br>Exploration of concepts to think innovatively about achieving sustainability in the engineering domain by introducing the three aspects of sustainability, namely, economic, environmental, and social. Topics include definition(s) of sustainability, main engineering sustainability challenges (e.g., water, energy, climate, and materials), pollution generation and prevention, identification and understanding of best practices, development of sustainability models for engineers, and sustainability assessment tools (e.g., life cycle assessment). |

| Code | Description |
|---|---|
| ENV 415 | Water and Wastewater Treatment Lab<br>Credits: 1 (0+3)<br>Prereq: ENV 320 AND ENV 322<br>This laboratory course provides and refreshes the basic knowledge of process technology, water chemistry, and microbiology involved in water and wastewater treatment. Students will be trained practically on various process technologies. They will study mass balance analysis, reactor models, mixing in reactors, kinetics, mathematical description of chemical and biological reactions in reactors. The course aims to build practical skills for application in various cases of water and wastewater engineering. |
| ENV 416 | Environmental Chemical Unit Operations Lab<br>Credits: 1 (0+3)<br>Prereq: ENV 257 AND ENV 325<br>The lab provides the students with the practical skills of different environmental chemical unit operations to understand the design principles. The laboratory covers mass transfer, separation and chemical reaction engineering concepts. Students will perform experiments on educational equipment to acquire physical data for new systems and test the influence of the parameters affecting the system. |
| ENV 419 | Introduction to Integrated Water Resources Management<br>Credits: 3 (3+0)<br>Prereq: ENV 306<br>This course introduces the concept of Integrated Water Resources Management (IWRM). The course discusses the following topics: definition of management functions and decision making processes in IWRM; tools for water resources management; water and irrigation management at the watershed level (water policy and governance aspects; operation of irrigation at the main-distribution-system scale (irrigation system distribution components, irrigation scheduling); operation of irrigation at the on-farm scale (identification of soil types and their soil-water holding capacity, definition of crop evapotranspiration rates and determination of crop and irrigation water requirements, soil-water balance and yield response to water); irrigation water use efficiency at different scales; introduction to water economics (water values, basic functions and characteristics of water markets, unit costs of water and cost recovery in water utilities, role of the public and private sectors in water supply; water pricing in agriculture, urban water pricing and regulation); basics of water policy and legislation; water institutions and administration; transboundary water management and international water law. |

| Code | Description |
|---|---|
| ENV 430 | Urban Development and Environmental Planning<br>Credits: 3 (3+0)<br>Prereq: ENV 302<br>The course covers basic principles in urban planning with an emphasis on environmental sustainability in the context of a developed or developing economy. Topics include land and water utilization, transport, infrastructure planning, waste and recycling, and impacts on local and global environments. Topics also include green buildings and smart infrastructure. A systems approach integrating the physical, urban, and social environment is emphasized. Means of incorporating environmental regulations and risk management into planning approaches are covered. |
| ENV 434 | Safety and Risk Analysis<br>Credits: 3 (3+0)<br>Prereq: MATH 301 AND ENV 325<br>This course provides a study of the fundamentals of process safety. It includes toxicology, industrial hygiene, source models, fires and explosions, hazard identification, risk assessment, accident investigations, and process safety management |
| ENV 440 | Advanced Separation Processes<br>Credits: 3 (2+2)<br>Prereq: ENV 325<br>The aim of this advanced course is to deepen and extend knowledge and understanding of separation by equilibrium and rate processes. New separation methods such as adsorption, membrane, ionic separation, and others are introduced. Multicomponent effects on equilibria and transport will be discussed. Throughout the course emphasis is placed on problem solving, design, and illustrative worked examples. |
| ENV 446 | Water Desalination<br>Credits: 3 (3+0)<br>Prereq: ENV 320 AND ENV 440<br>Theoretical and practical aspects of seawater/brackish water desalination technologies, including thermal-based (MSF, MED, VC) and membrane-based (RO, NF, ED/EDR) desalination processes; process design and system performance; fouling, scaling (including bio-fouling) and cleaning; product water quality and post-treatment. |
| ENV 451 | Industrial Bioprocesses<br>Credits: 3 (3+0)<br>Prereq: ENV 359<br>This course provides a comprehensive understanding of the industrial bioprocesses field. It covers topics such as renewable resources, design of biorefineries, process integration, techno-economic analysis, and environmental impact of biorefineries. In addition, the course provides an overview of the main chemicals produced by bioprocesses, with applications in the food, healthcare, fuel, and fine chemical industries. The course provides students with an up-to-date knowledge of upstream and downstream processing steps for industrial bioprocesses. |

| Code | Description |
|---|---|
| ENV 454 | Life Cycle Assessment<br>Credits: 3 (3+0)<br>Prereq: ENV 302<br>The course provides students with knowledge about Life Cycle Assessment (LCA), a framework for evaluation of the environmental footprint of various systems and technologies, as well as application of LCA on various energy, product, and transport technologies and systems. The course gives the students insight about methodology for the different phases of an LCA (goal definition and scoping, inventory analysis, impact assessment and interpretation), methodology for simplified LCA, LCA software tools and databases, critical review of an LCA study, application areas of LCA, and LCA limitations. |
| ENV 456 | Coastal Environmental Management<br>Credits: 3 (3+0)<br>Prereq: ENV 219<br>This course covers engineering problems dealing with waves, currents, their interactions, their effects on the coastline and man-made interventions, spanning from short (storms) to decadal scales (affected by climate change). Topics include coastal hydrodynamics and processes; short-term and long-term wave climate; sediment transport and morphology; tidal currents; coastal numerical modelling; coastal vulnerability within a sustainable framework; beach management strategies; and climate change effect on the coast. |
| ENV 458 | Energy from Biomass and Waste<br>Credits: 3 (3+0)<br>Prereq: ENV 359<br>The course deals with the production of energy from different types of wastes through thermal, biological, and chemical routes. It will also introduce fundamental principles and practical applications of biomass to renewable energy processes, including anaerobic digestion of agricultural and industrial wastes for biogas and hydrogen production, bioethanol production from starch and lignocellulosic materials, biodiesel production from plant oils, and conversion of biomass and waste materials for renewable energy production. |
| ENV 459 | Environmental Remote Sensing<br>Credits: 3 (3+0)<br>Prereq: PHYS 104 AND ENV 219<br>The course covers the principles of remote sensing, general concepts, data acquisition procedures, data analysis and role of remote sensing in terrain investigations for environmental engineering practices. Data collection from airborne and satellite platforms will be emphasized. Photographic and non-photographic sensing methodologies will be covered as well as manual and computer assisted data analysis techniques for site investigations and examination of ground conditions. |

| Code | Description |
|---|---|
| ENV 460 | Water-Quality Engineering in Natural Systems<br>Credits: 2 (1+3)<br>Prereq: ENV 204 AND ENV 306<br>This course focuses on modelling of fate and transport processes in aquatic systems including rivers, streams, lakes, and groundwater aquifers. Design of effective remediation measures is also discussed. |
| ENV 461 | Soil and Groundwater Remediation<br>Credits: 3 (3+0)<br>Prereq: ENV 204 AND ENV 306<br>This course deals with the theoretical principles and practical engineering methodologies associated with the remediation of contaminated soil and groundwater. Topics to be considered are as follows: industrial and agricultural contamination of soil and groundwater; potential hazards to human health and the environment; planning and legislative issues in land-use change and redevelopment; site investigation; site hydrogeology; soil gas and vapour tests; modelling of underground pollutant transport; remediation options; selection of options; formal ranking procedures; design and implementation; health and safety and environmental protection issues; and post project monitoring plan. |
| ENV 470 | Air Quality and Pollution Engineering<br>Credits: 3 (2+3)<br>Prereq: ENV 219<br>The course covers discussion of local versus global air pollution, combustion emissions, air pollution control strategies, and types and design of air pollution control equipment in indoor and outdoor environments. Also, regulations, legal and economic aspects are addressed. Sources, behavior, and fate of gaseous and particulate air pollutants are covered. Finally, principles of meteorology and atmospheric diffusion in relation to modeling pollutant transport and dispersion are detailed. |
| ENV 475 | Industrial Reaction Engineering<br>Credits: 3 (3+0)<br>Prereq: ENV 257 AND ENV 325<br>The course builds on students' core knowledge of reaction engineering and is designed to give an advanced insight into the design, optimization, and operation of real reaction vessels used in different industries. Particular emphasis is given to chemical kinetics and transport phenomena, review of elements of reaction kinetics, rate processes in heterogeneous reacting systems, design of fluid-fluid and fluid-solid reactors, scale-up and stability of chemical reactors and residence time analysis of heterogeneous chemical reactors. |

| Code | Description |
|---|---|
| ENV 497 | Selected Topics in Environmental Engineering<br>Credits: 3 (3+0)<br>Prereq: Depends on the selected course topics<br>Selected topics of interest to environmental engineering faculty and senior students, not covered elsewhere in the curriculum. The course can be repeated for credit more than once on the condition that course topics are different. |
| ENV 498 | Senior Design Project I<br>Credits: 1 (0+3)<br>Prereq: Completed 102 credit hours toward satisfying the degree requirements, and during the last two semesters<br>Students must undertake an independent Senior Design Project in Environmental Engineering in the last two semesters after completing at least 102 credit hours toward satisfying the degree requirements. The purpose of the project is to demonstrate students' abilities to perform in an Environmental Engineering capacity in their chosen area of expertise, using knowledge gained from their academic and internship experiences. The first phase of the Senior Design Project (ENV 498) includes problem identification, generation and selection of solutions, and time management. Incorporation of technical, environmental, social, political, and economic issues in the solution for the project is required. A basic requirement of the proposed solution is that it must be compatible with the principles of sustainability. |
| ENV 499 | Senior Design Project II<br>Credits: 3 (0+9)<br>Prereq: ENV 498<br>The second phase of the Senior Design Project (ENV 499) is a continuation of ENV 498. In this phase, students carry out a detailed design of the solution proposed in ENV 498. |
| MATH 101 | Calculus I<br>Credits: 3 (2+2)<br>Calculus I course discusses the definite integral, applications of definite integrals to different physical problems (area, volume, surface area and arc length), calculus of important transcendental functions (Natural Logarithms, Exponential functions, Inverse Trigonometric functions, Hyperbolic functions), techniques of integrations, Numerical Integration and Improper integrals, and methods for solving first order differential equations. |
| MATH 102 | Calculus II<br>Credits: 3 (2+2)<br>Prereq: MATH 101<br>Calculus II course discusses convergence and divergence of sequences and series, power series, Taylor series, Binomial series, parametric equations, polar coordinates, lines and planes in space, functions of several variables, partial derivatives, multiple integrals, cylindrical and spherical coordinates, line integrals and work, integrals on vector fields. |

| Code | Description |
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| MATH 201 | Linear Algebra and Vector Geometry<br>Credits: 3 (2+2)<br>In this course, students are introduced to systems of simultaneous equations and the use of matrices to describe multidimensional spaces, matrix algebra, vector spaces and bases sets, eigenvalues and eigenvectors. The course covers the following topics: Systems of linear equations, matrix algebra, vector spaces and Bases, eigenvalues and eigenvectors, orthogonality and least squares, applications. |
| MATH 202 | Ordinary Differential Equations<br>Credits: 3 (2+2)<br>Prereq: MATH 102<br>This course demonstrates the usefulness and importance of using differential equations as mathematical models for real world problems that emerged in science and engineering. The course covers the following topics: first order, second order and higher order ordinary differential equations, modeling and applications, a system of linear differential equations with constant coefficients, numerical methods, Laplace transform, series solutions to DEs, Fourier series, and an introduction to partial differential equations. |
| MATH 203 | Introduction to Discrete Mathematics<br>Credits: 1 (0+2)<br>This course demonstrates the usefulness and importance of using discrete mathematics as mathematical tools for real world problems that emerged in science and engineering. The course covers the following topics: Proofs, mathematical induction, recursion. Efficient exponentiation and multiplication Greatest common divisor, Euclid algorithm. Prime numbers, modular arithmetic, Fermat Little theorem. Public-key cryptography, RSA. Counting, the binomial theorem, elementary probability theory. Generating random numbers with their factorization. Elementary graph theory: connectivity, trees, planarity. De Bruijn sequences and Gray codes |

| Code | Description |
|---|---|
| MATH 301 | Probability and Statistics<br>Credits: 3 (2+2)<br>Prereq: MATH 102<br>This course introduces the students to the basic concepts of probability and statistics that can be used in many engineering fields and in particular in the analysis of experimental data. The examples and exercises emphasize applications in engineering as general and space, physics, chemical, and mineral resources in particular. MINITAB will be used during tutorial Lab. The course covers the basic tools for the collection, analysis, and presentation of data in all areas of engineering. Emphasis on principles of mathematical statistical reasoning, underlying assumptions, and careful interpretation of results is considered. Topics covered include: Tools for describing central tendency and variability in data; random variables, their distributions, expectations and correlations, methods for performing inference on population means and proportions via sample data; statistical hypothesis testing and its applications to group comparisons; ANOVA; correlation, and regression. While there are some formulae and computational elements to the course, the emphasis is on interpretations and concepts. |
| MATH 302 | Partial Differential Equations and Complex Analysis<br>Credits: 3 (2+2)<br>Prereq: MATH 202<br>One of the fundamental mathematical tools used in studying systems that change over time and space is partial differential equations (PDEs). They are widely used in diverse areas of engineering, physical sciences, biology, economics and finance. The course first introduces some special functions that usually appear in the solutions of PDEs such as Bessel and Legendre functions. Some theoretical concepts about the Sturm-Liouville problem are discussed. It also introduces solutions of PDEs using different methods such as separation of variables, integral transforms and Green's function for both homogeneous and non-homogeneous cases. It also provides solutions to higher order PDEs. In the complex analysis part, the following topics are covered: analytical functions, Cauchy-Riemann equations, contour integrals, Cauchy's integral formulas, Taylor and Laurent series, the calculus of residues, the evaluation of contour integrals and inverse Laplace transform and conformal mappings and their applications in solving PDEs. |

| Code | Description |
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| MATH 306 | Numerical Analysis<br>Credits: 3 (2+2)<br>Prereq: MATH 201 AND MATH 202<br>Numerical methods are techniques by which mathematical problems are formulated so that they can be solved with arithmetic operations. Although there are many kinds of numerical methods, they have one common characteristic: they invariably involve large numbers of tedious arithmetic calculations. It is little wonder that with the development of fast, efficient digital computers, the role of numerical methods in engineering problem solving has increased dramatically in recent years. The course will develop numerical methods aided by technology (programming using Matlab) to solve algebraic, transcendental, and differential equations, and to calculate derivatives and integrals numerically. It also shed a light on curve fitting, including regression and interpolation models, and linear programming. The course will also develop an understanding of the elements of error analysis for numerical methods and certain proofs. The course will further develop problem solving skills needed in engineering and science. |
| MATH 404 | Linear and Non-linear Programming<br>Credits: 3 (2+2)<br>Prereq: MATH 102<br>The goal of this course is to help the student develop efficient algorithms to solve linear and nonlinear optimization problems especially convex optimization. The course explores the optimality conditions, duality and sensitivity analysis, algorithms include simplex methods, gradient and conjugate gradient methods, Newton and Quasi-Newton methods and interior-point methods. |
| MATSCI 201 | Fundamentals of Materials Science and Engineering<br>Credits: 3 (3+0)<br>Prereq: CHEM 101<br>This course introduces students to the fundamentals of structure and mechanical properties of materials. Topics covered include structure of metals, ceramics, composites, polymers. Imperfections in solids and grain size and diffusion mechanisms in solids. This course also covers mechanical properties like elasticity, hardness, tensile properties, stress, strain and sheer in solids. Pathways to strengthen solids, deformation mechanisms, failure due to fracture, fatigue, and creep. Lab sessions that will focus on the following will be included: Mechanical testing (Tensile, Compressive, Hardness, and Impact tests); Metallographic sample preparation; Diffusion in liquids; and Solidification of alloys and phase diagrams development for simple alloys. |

| Code | Description |
|---|---|
| NANENG 112 | C/C++ Programming Lab<br>Credits: 1 (0+3)<br>Prereq: CSCI 101<br>This course introduces the student to object-oriented programming through a study of the concepts of program specification and design, algorithm development, and coding and testing using a modern software development environment. Students learn how to write programs in an object-oriented high-level programming language. Topics covered include fundamentals of algorithms, flowcharts, problem solving, programming concepts, classes and methods, control structures, arrays, and strings. Throughout the semester, problem solving skills will be stressed and applied to solving computing problems. Weekly laboratory experiments will provide hands-on experience in topics covered in this course. |
| NANENG 171 | Materials and Chemistry for Nanoelectronics<br>Credits: 2 (1+3)<br>Prereq: CHEM 103<br>This course will introduce students to nanotechnology, nanoelectronics and nanodevices engineering. It is an introduction to key topics in nanotechnology illustrated with original scientific literature; the methods used for the synthesis of the nanoscale materials and for the nanofabrication from 'top-down' lithography approaches to 'bottom-up' self-assembly and nanopatterning. The experimental techniques that can be used to study and characterize the nanoscale materials and phenomena behind it; material properties at the nanoscale; introduction to physics and chemistry needed to understand nanoscale phenomena and material properties. introduction to silicon semiconductor industry and silicon wafer production from sand which are the fundamentals in manufacturing the electronic "chips" that shape almost every aspect of our lives. |
| NANENG 202 | Digital Logic<br>Credits: 3 (2+3)<br>This course introduces the concepts of the design and implementation of digital circuits. The students will be introduced to different numbering systems as well as logic gates family. The Boolean Algebra will also introduced to simplify logic circuit design. Analysis and Synthesis of Combinational Circuit, Sequential Circuits, Registers and Counters, Sequential Circuits with Programmable Logic Devices.<br>Laboratory experiments will be used to reinforce the theoretical concepts discussed in lectures. The lab experiments will involve the design and implementation of digital circuits. Emphasis is on the use computer aided tools in the design, simulation, and testing of digital circuits. All concepts are implemented as well using System Verilog. |

| Code | Description |
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| NANENG 203 | Electric Circuits<br>Credits: 3 (2+3)<br>Prereq: PHYS 104 AND MATH 102<br>Introduction to theory, analysis and design of electric circuits. Voltage, current, power, energy, resistance, capacitance, inductance. Kirchhoff's laws node analysis, mesh analysis, Thevenin's theorem, Norton's theorem, steady state and transient analysis, AC, DC, phasors and Introduction to the concept of impulse response and frequency analysis using the Laplace transform, and introduction to 3-phase circuits. |
| NANENG 205 | Physics of Semiconductors<br>Credits: 3 (3+0)<br>Prereq: PHYS 224 AND MATH 202<br>The course will apply fundamental solid-state physics concepts to a specific material class, namely semiconductors, to identify its electronic properties. The course starts by reviewing quantum mechanical concepts, followed by Kronig-Penny model and band theory, energy gaps, and effective mass. This is followed by Fermi-Dirac and Maxwell-Boltzmann carrier statistics, density of states, Fermi level and doping, and electron-hole concentrations calculations. Basic conduction mechanisms such as drift-diffusion equation, mobility, conductivity, generation-recombination, lifetime, excess carriers injection, thermionic emission and metal-semiconductor contacts are discussed. |
| NANENG 211 | Electrical Power Circuits and Machines<br>Credits: 2 (1+3)<br>Prereq: NANENG 203<br>This course begins by covering the fundamentals of Electrical Machines principles, DC machines, Ac generators and power transformer. The course will introduce the concept of three phase circuits and standards for selecting wires and cables sizing. Students will learn about the concept of electrical protection and earthing systems. The course also covers the applications of power devices in Electric Vehicles and power electronics. The course will demonstrate the applications of Brushless DC Motor and Drives. |

| Code | Description |
|---|---|
| NANENG 212 | Applied Digital Control<br>Credits: 3 (2+3)<br>Prereq: NANENG 112 AND MATH 202<br>This course introduces the analysis and design of continuous-time, discrete-time feedback control systems, DC motor<br>modeling and digital control design of DC motor position control system. Topics include the properties and advantages of<br>feedback systems, time-domain performance, stability, PID control and state-space methods. Also, convert from continuous<br>to discrete systems, transient, steady-state responses and stability analysis in the z-plane. By using simulation tools, learn<br>how to design and implement different practical control systems to achieve the target performance of the system to be<br>controlled. More-hands experience is expected in this course including system identification and analysis of practical system using<br>Matlab and Arduino as a data acquisition. Practical digital control implementation of DC motor position control using<br>microcontrollers. |
| NANENG 218 | Thermofluids for Nanoelectronics<br>Credits: 2 (1+3)<br>Prereq: MATH 202<br>This course introduces the basics of fluid mechanics and heat transfer, and the interaction of fluids with heat. The course has an applied nature, where it emphasizes the use of these concepts in nanoelectronics, such as heat sinks, self heating in integrated circuits, flow and heat transfer aspects of furnaces and Chemical Vapor Deposition (CVD), or during silicon processing from melts. |
| NANENG 222 | Electronic Circuit Design<br>Credits: 3 (2+3)<br>Prereq: NANENG 203<br>The course first starts by explaining the basic operation of basic devices such as diodes, BJTs and FETs, from a simplified point of view. Basic DC and load-line analysis of these devices is explained, followed by AC analysis and small circuit models. This course covers basic building blocks in electronic systems, such as amplifiers, current mirrors, digital switches and inverters. Application of basic circuit theory to analyze these simple sub-systems is implemented |

| Code | Description |
|---|---|
| NANENG 231 | Electromagnetics<br>Credits: 3 (3+0)<br>Prereq: PHYS 203 AND MATH 202<br>This course covers electromagnetic forces and fields and their sources. Maxwell's equation in vacuum: The integral and differential forms; boundary and continuity conditions; static and dynamic problems; plane waves; the quasistatic field equations.Electro-quasistatics: Potential; Poisson's and Laplace's equations; the superposition integrals; boundary value problems in Cartesian, cylindrical and spherical coordinates; electro-mechanical systems and equivalent circuits; numerical solutions. Magneto-quasistatics: The vector potential and gauge theory; Biot-Savart superposition integral; boundary value problems; induced fields and potentials; self and mutual induction; magneto-mechanical systems and equivalent circuits. Fields in matter: Conduction and charge relaxation, polarization and magnetization; physical models; field equations and constitutive relations; solution techniques; examples for quasistatic electro- and magneto-mechanical systems. Electromagnetic energy: Pointing's theorem; energy balance in static and quasistatic problems; exchange of mechanical and electromagnetic energy. Electro-dynamics: The sinusoidal steady state and introduction to electromagnetic waves. |
| NANENG 301 | Micro/Nano Fabrication Techniques<br>Credits: 3 (2+3)<br>Prereq: NANENG 171<br>The course provides an in-depth understanding of electronic device fabrication steps. Focus is on developing knowledge of the process design, the device different fabrication techniques and the experimentation related to CMOS manufacturing. Both concepts and practical aspects are covered. Cleanroom processes and fabrication techniques are aimed to be learned through lectures in class, then in the Lab and educational cleanroom. In addition, students will design a process flow using a commercial TCAD tool. |
| NANENG 303 | Computer Architecture and Design<br>Credits: 2 (1+3)<br>Prereq: NANENG 202<br>The objective of this course is to explain how computers are designed and how they work. Students are introduced to modern computer principles using a typical Reduced Instruction Set Processor (RISC). The course emphasizes system-level issues and understanding program performance. Topics include instruction sets, assembly language, internal data representation, computer arithmetic, processor datapath and control, execution pipelines, memory hierarchy, and I/O devices. Stends implement parts of the processor microarchitectures using Verilog and implement actual assembly language instructions on development boards. |

| Code | Description |
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| NANENG 308 | Solid State Devices<br>Credits: 3 (2+3)<br>Prereq: NANENG 205<br>This course covers crystal structures, band gap theory, ionic equilibrium theory, fundamentals of carrier transport, compound semiconductors III-V. This course will make special emphasis on the properties of various types of junctions (p-n junctions, heterojunctions, metal-semiconductor junctions) leading to various electronic devices such as field effect transistors (FETs), metal oxide-semiconductor FETS (MOSFETs), high electron mobility transistors (HEMTs), etc. Short Channel effects and nanoscale phenomena will be emphasized throughout the course and their impact on device modeling in analog and digital circuits. |
| NANENG 313 | Educational Cleanroom Lab<br>Credits: 1 (0+3)<br>Prereq: NANENG 301<br>Students will implement the fabrication techniques and processes studied in NANENG 301 using the cleanroom facilities. This includes chemical cleaning, oxidation, diffusion, etching, plasma sputtering and projection lithography, and end by process integration of simple CMOS test structures. |
| NANENG 315 | MEMS Design and Fabrication<br>Credits: 3 (2+3)<br>Prereq: NANENG 301 AND NANENG 313<br>This course introduces nanotechnology engineering students to state-of-the-art micro / Nano fabrication technologies in a combination of theory, simulation, device fabrication and device characterization in modern laboratory facilities. The course covers basic MEMS/NEMS fabrication technologies, various transduction mechanisms such as piezoelectric, thermoelectric, thermionic, piezoresistive, etc. In addition, the theory of operation of few sensors will be covered this will include infrared detectors, radiation sensors, rotation and acceleration sensors, flow sensors, pressure and force sensors, and motion sensors. |
| NANENG 323 | Analog Integrated Circuit Design<br>Credits: 3 (2+3)<br>Prereq: NANENG 222 AND NANENG 212<br>The subject of this course is the analysis and design of analog CMOS integrated circuits. Simple modelling techniques are used to gain a better understanding of the functions of the circuits. Intuitive design methods, quantitative performance measures and practical circuit limitations are emphasized. Circuit performance is predicted by means of both hand calculations and computer simulations. The course contains a review of device modelling, dc and small signal properties of single- and multi-stage amplifiers, followed by the study of biasing circuits, current mirrors, and active loads, differential pairs and operational amplifiers. Next, frequency response characteristics of amplifiers will be examined. |

| Code | Description |
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| NANENG 325 | ASIC and FPGA Design<br>Credits: 3 (2+3)<br>Prereq: NANENG 204<br>This course covers comprehensive theoretical understanding as well as hands-on practical experience of the digital design flow, including the design optimization, hardware description languages (VHDL/Verilog Coding), commercial Field Programmable Gate Arrays (FPGAs) architectures, the physical implementation steps in digital custom Application Specific Integrated Circuits (ASICs) design, as well as synthesis algorithms. Students will earn invaluable experience to professionally work with state-of-the-art design tools for both FPGA and ASIC design flow through several hardware implementation assignments. The implementation platform is Xilinx Spartan 6 board, which will be used throughout the course. Moreover, students will design a ready for-fabrication ASIC tape-out as a final project in this course. |
| NANENG 335 | Introduction to Photonics<br>Credits: 3 (3+0)<br>Prereq: PHYS 203<br>Course description: Introduction to light interaction with the material, Fresnel equations, Dielectric mirrors, optical waveguiding, optical fibers, light dispersion, control of light polarization. COMSOL® and Lumerical FDTD software are used throughout the course to demonstrate and simulate different devices. |
| NANENG 361 | Communications Theory and Systems<br>Credits: 3 (2+3)<br>Prereq: MATH 301<br>The course introduces the concept of information measurement through Shannon's information theory. The course also introduces technical concepts, principles, models, management, and foundational logic of information and communication systems such as coding, error correction, channel noise, distortion, communication protocols, and communication standards. The course examines history, current trends, and future of ICT. Review of global ICT standards and regulations. |
| NANENG 406 | Modeling of Nanodevices<br>Credits: 3 (2+3)<br>Prereq: (NANENG 408 OR NANENG 308) AND MATH 306<br>The course studies limitations of conventional bulk MOSFETs and related device structures . After that, physics background on Silicon-on-insulator FET technology, Double-gate and FinFETs, Physics of the Multigate MOS System, nanowires, and Tunnel FETs Different approaches for semiconductor device modeling and simulation are taken. Both classical and quantum mechanical modelling techniques of charge and electron transport are studied. Simulation using TCAD EDA tools of 3D device structures, as well as development of Verilog-A based compact models, are practiced in lab sessions. |

| Code | Description |
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| NANENG 410 | Real-Time Embedded System and Microcontroller Design<br>Credits: 3 (2+3)<br>Prereq: NANENG 204 AND NANENG 112<br>Due to its vital role in almost all application domains, such as ground and air/space vehicles, robots, buildings and even human bodies, as well as telecommunication systems and devices, real-time computing (RTC) has become an essential discipline in the field of computer science and engineering. The new emerging concept of cyber-physical system (CPS) is also rooted at real-time computing. This course is intended to cover principles and foundations (not case studies or applications) of real-time computing, which are based on three attributes: timeliness, reliability/safety, and environmental interface. These three attributes are strongly coupled with each other by a single precious resource, time, which is, in turn, dictated by limited resources, electric energy, space and weight. In this course, students will be exposed to the state-of-art (both analytical and experimental) research and development related to all these three attributes and their interplay. |
| NANENG 416 | VLSI Design Lab<br>Credits: 2 (1+3)<br>Prereq: NANENG 323 AND NANENG 325<br>The students will implement the full design flow for ASIC tapeout, including analog, mixed signal and digital structures, uptil the IO pads. Focus will be on advanced mixed signal design and postlayout simulation, as well as methodology for behavioral modeling and co-simulation of Analog and Digital blocks. The course will include 1 weekly lecture, as well as 3 hours of VLSI lab, using state-of-the-art EDA tools. Using FPGA as emulators for RTL is also included |
| NANENG 419 | Introduction to Artificial Intelligence<br>Credits: 2 (1+3)<br>Prereq: MATH 301 AND NANENG 112<br>In this course you will learn what Artificial Intelligence (AI) is, explore use cases and applications of AI, understand AI concepts and terms like machine learning, deep learning and neural networks. Topics include problem solving, state-space representation, heuristic search techniques, game playing, knowledge representation, logical reasoning, automated planning, reasoning under uncertainty, decision theory and machine learning. These concepts will be examined in the design of intelligent agents in the context of several applications. |

| Code | Description |
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| NANENG 424 | Photovoltaics and Photonic Devices<br>Credits: 3 (2+3)<br>Prereq: NANENG 308<br>The course is introduction to the principles, design and application of semiconductor photonic devices including photovoltaic, photodiodes, light-emitting diodes, laser diode and optical Fibers. Light interaction with semiconductors, quasi-Fermi levels, and light absorption are discussed. The course identifies the various kinds of semiconductor materials used in photonic devices, different generations of solar cell materials and structures, in addition to basic characterization techniques required for photovoltaic devices and the factors that limit the power conversion efficiency. It also explains the most common specifications of photodiodes, LEDs, and laser diodes. |
| NANENG 430 | Principles of Microwave and Waveguides<br>Credits: 3 (3+0)<br>Prereq: SPC 312 OR NANENG 231<br>Review of transmission line and Use of Smith Chart for admittance. Field analysis of different type of metallic waveguides. TEM, TM and TE Waves. Parallel plate and rectangular waveguides. Waveguide modes of a coaxial line. Circular metallic waveguide. Dielectric slab waveguides, surface waves, Stripline, Planar guiding structures: microstrip, coplanar lines etc. Microwave network analysis. Scattering parameters. ABCD matrix. Two-port networks. The course will also cover design of passive microwave elements such as divider, couplers, and filters and will also introduce the design of active transistor amplifier. |
| NANENG 431 | Computational Photonics<br>Credits: 3 (2+3)<br>Prereq: MATH 306 AND NANENG 112<br>This course covers many of the most popular methods used in modern computational modeling of photonic devices. These methods include transfer matrix method, finite-difference frequency-domain, finite-difference time-domain, beam propagation method, plane wave expansion method, and finite element method and optimization. The students will demonstrate a rich and deep understanding of computational electromagnetics, including formulation and implementation of several specific methods. |
| NANENG 435 | Nanophotonics<br>Credits: 3 (2+3)<br>Prereq: NANENG 335 OR NANOSC 413<br>This course is intended undergraduate students in Nanotechnology and Nanoelectronics program. In this course, broad range of topics in the physics and engineering of nanophotonics will be covered. In particular, a detailed discussion on the modeling and simulations of many silicon on insulator devices, photonic crystal devices, plasmonic and metamaterials will be introduced. |

| Code | Description |
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| NANENG 436 | Advanced MEMS Design and Fabrication Techniques<br>Credits: 3 (2+3)<br>Prereq: NANENG 315<br>Utilizing the previous knowledge obtained about microfabrication techniques and MEMS structures to build complete MEMS devices. Throughout the course the students learns how to use various transduction mechanisms to achieve sensors for different physical quantities such as pressure, acceleration, infrared radiation, etc. In addition, the students get hand on experience for finite element multi-physics modeling packages that enables full simulation of various types of MEMS devices. Beside the design rules for some processes such as polyMUMPs and developing the mask layouts of some examples according to it |
| NANENG 437 | Organic Electronics and Photovoltaics<br>Credits: 3 (2+3)<br>Prereq: NANENG 301 AND NANENG 205<br>The course gives an overview of organic electronic and optoelectronic devices. It begins with a review of electronic structure of single organic molecules as a guide to the electronic behaviour of organic aggregates. Various relevant material phenomena are reviewed; including topics from photophysics (absorption and emission of light, excited states, radiative and non-radiative transitions), intermolecular charge transport mechanisms (hopping, disorder), charge injection and transport models, and energy transfer processes. Their applications in light emitting devices, solar cells, thin film transistors, photodetector and imaging photoreceptors, etc. are discussed. |
| NANENG 438 | CMOS Nanofabrication<br>Credits: 3 (2+3)<br>Prereq: NANENG 301 AND NANENG 313<br>This course addresses several advanced techniques and fabrication process flows for nanodevices, including the materials used. Topics include Metal/High-k process integration, Atomic Layer Deposition (ALD), metal-organic CVD, advanced optical lithography practices such Optical Proximity Correction (OPC) and Resolution Enhancement Techniques (RET), resists and Anti-Reflection Coating (ARC), copper interconnects, IC packaging, deep RIE. The course will implement the techniques used to develop process test mask, Process Development Kits (PDKs), and TCAD simulations for SPICE parameter extraction. |
| NANENG 439 | Advanced Digital ASIC Design<br>Credits: 3 (2+3)<br>Prereq: NANENG 325<br>This course will focus on the Hardware Description Language (HDL): Verilog and VHDL, Professional Verilog Coding for Synthesis, Verification Techniques, FPGA Architectures, Digital System Design with Xilinx FPGAs, ASIC Digital Design Flow (from Verilog to the actual Chip tape-out), Synthesis Algorithms, Power Dissipation, Power Grid and Clock Design, and Fixed-point Simulation Methodology. The course will be around 30% theoritical and 70% hands on on the design tools for the FPGA and the ASIC flows. |

| Code | Description |
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| NANENG 440 | Nanofabrication Vacuum and Equipment Tech<br>Credits: 3 (2+3)<br>Prereq: NANENG 301<br>This course focuses on the broad spectrum of processing approaches involved in "top down", "bottom up", and hybrid nanofabrication. The majority of the course details a step-by-step description of the equipment, facilities processes and process flow used in today's device and structure fabrication. Students learn to appreciate processing and manufacturing concerns including safety, process control, contamination, yield, and processing interaction. The students design process flows for micro- and nano-scale systems. In addition, the students will be included in the process of designing such equipment and using vacuum inside these equipment. More hands on are expected in this course including automation of the nano-fabrication equipment as well. |
| NANENG 441 | Testing, Verification and Reliability<br>Credits: 3 (2+3)<br>Prereq: NANENG 325<br>Basic theory, techniques for testing digital circuits and systems. Design techniques for fault tolerant and early diagnosable systems. Test generation for combinational and sequential logic circuits, checking experiments. Gate level fault simulation, and its application to diagnosis. Design techniques using static and dynamic redundancy for reliable systems. Design for testability (DFT) including full and partial internal scan and boundary Scan. Memory test, delay test and at speed testing. Built In Self Test (LBIST, MBIST). Reliability basics its relation to accelerated testing. |
| NANENG 442 | Devices and VLSI for Smart Power ICs<br>Credits: 3 (2+1)<br>Prereq: NANENG 308<br>Smart Power Integrated Circuits and discrete power devices are becoming major components in systems like Electric Vehicles (EV), energy conversion, battery charging systems, as well as mobile handset transmitters. Smart power ICs are a special category of VLSI systems requiring special layout and process fabrication techniques, in which relatively high voltage and high current drives are integrated with regular low voltage mainstream IC technology. These ICs in turn drive higher power discrete components such as IGBTs and Power MOSFETs, needed to drive motors and controls in systems like electric vehicles. The analysis of these ICs and devices requires modeling and simulation under harsh temperature conditions. In this course, students will get introduced to the fundamentals of power electronic devices operation, with focus on the main power devices including power diodes, LDMOS and IGBTs with the modelling and simulation using TCAD tools. Such devices are the building components for several control circuits that will be discussed including inverters and DC-DC converters, with the discussion of the role of these circuits in electric vehicles. Also an insight about the fabrication process integration of power devices in the regular CMOS process, in addition to the layout. |

| Code | Description |
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| NANENG 445 | RF/Mixed Signal ICs<br>Credits: 3 (2+3)<br>Prereq: NANENG 323<br>In this course, you will learn about design of basic building blocks in radio frequency (RF) integrated circuits. RF circuits constitute the basis of modern communication systems. Designing RF circuits requires an in depth knowledge of transistor operation and high frequency analog circuit design concepts. This course will start from the fundamentals of RF microelectronics such as the noise, linearity, matching and move subsequently to basic communication systems. Next, passive devices such as inductors, capacitors for RF designs will be reviewed. After a detailed discussion of noise calculations in analog and RF circuits, the course will analyze the key building blocks in RF circuits, namely low noise amplifiers (LNA), mixers, oscillators, phase locked loops (PLLs), frequency synthesizers, and power amplifiers. Finally, IC and PCB layout considerations for RF circuits which are crucial for high RF performance will be inquired. |
| NANENG 446 | Optical MEMS<br>Credits: 3 (2+3)<br>Prereq: NANENG 315<br>This course aims at providing students with essential concepts about optical MEMS. Topics covered include: Fabrication and testing concepts for optical MEMS, different optical systems on-chip, chip testing and characterization, optical transducers and sensors, optofluidics, Lab-on-a-chip and μTAS (Micro Total Analysis Systems), advanced topics in coupling between different domains such as optical forces. Several practical experiments for optical systems will be demonstrated. |
| NANENG 447 | Physical Design and EDA Algorithms<br>Credits: 3 (2+3)<br>Prereq: NANENG 112 AND NANENG 325<br>Beginning with a general introduction to VLSI design flow and Electronic Design Automation (EDA) tools, the course mainly focuses on VLSI physical design (layout). It covers partitioning, placement, floor planning, routing (global and detailed), and compaction. We will discuss why and how to partition a design process into sub-problems and will study how to design good algorithms to solve each of those sub-problems. The course will also introduce numerical methods for large scale simulation of electronic analog/mixed signals using SPICE, compact models and matrix solution. |
| NANENG 448 | Mixed Signal and Low Power VLSI<br>Credits: 3 (2+3)<br>The goal of this course is to provide the students with in-depth study of advanced mixed-signal integrated circuits such as ADCs/DACs, switched-capacitor circuits, variable gain amplifiers, filters, PLL. If time permits, the instructors will provide an overview of analog circuits for biomedical applications, specifically design techniques of neural recording amplifiers for Brain-Computer Interfaces. |

| Code | Description |
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| NANENG 449 | Microfluidics and Biochips<br>Credits: 3 (2+3)<br>Prereq: BIOL 101 AND NANENG 301 AND (NANENG 218 OR ENGR 218 OR ENGR 207N OR ENGR 207)<br>Introduction to Microfluidics: Advantages of microfluidics, Types of microfluidic platforms, different applications. Particle manipulation on the microscale: Electrophoresis, Dielectrophoresis, Magnetophoresis, Optical tweezers. Microfabrication Technology: micromachining of silicon and polymeric chips, fabrication techniques. Components of Microfluidic Devices: miniaturized Systems, actuators, pumps, valves, micro-mixers, sensors, readout circuits, microfluidic chamber. Biodetection Techniques: optical, impedance, Flow Cytometry and Cell Sorting. Lab-on-CMOS (Biochips): advantages, parts, fabrication, applications and packaging. |
| NANENG 497 | Selected topics in Nanotechnology Eng.<br>Credits: 3 (3+0)<br>Selected coverage of topics specializing in different fields in nanotechnology and nanoscience e.g., modern quantum devices, spin-devices, junctionless devices, tunneling based device, predictive technology models. Printed electronics and their applications in solar cells, photovoltaics, lab-on-chip and other applications, biosensors. |
| NANENG 498 | NANENG Senior Design Project 1<br>Credits: 1 (0+3)<br>Prereq: Completed 102 credit hours toward satisfying the degree requirements, and during the last two semesters<br>NANENG Senior Design Project 1 |
| NANENG 499 | NANENG Senior Design Project 2<br>Credits: 3 (0+9)<br>Prereq: NANENG 498<br>NANENG Senior Design Project 2 |
| PHYS 103 | Introduction to Classical Mechanics for Engineers<br>Credits: 3 (2+3)<br>This course introduces students to the classical Newtonian formalism for mechanics, including kinematics, conservation of energy and momentum, Newton's laws of motion, force diagrams, friction, centripetal and centrifugal force, rotational motion and angular momentum, gravitation and periodic motion. The course includes a laboratory to conduct experiments on the course topics involving data collection and reporting, and error analysis. |

| Code | Description |
|---|---|
| PHYS 104 | Introduction to Electromagnetism for Engineers<br>Credits: 3 (2+3)<br>Prereq: PHYS 103<br>This course covers classical electromagnetism, from electric charges and Coulomb's law to Maxwell's equations, including Gauss' law; Ohm's Law; magnetic fields and forces; and electromagnetic induction. The course includes a laboratory to conduct experiments on the course topics involving data collection and reporting, and error analysis. |
| PHYS 203 | Introduction to Thermodynamics, Wave Motion and Optics for Engineers<br>Credits: 3 (2+3)<br>Prereq: PHYS 103<br>This course concludes the introduction to classical physics, with modules in thermodynamics (thermal physics, ideal gases entropy and the first and second laws), wave mechanics (interference, standing waves, and sound), optics (geometric optics), and fluid mechanics (buoyancy and the continuity equation). The course includes a laboratory to conduct experiments on the course topics involving data collection and reporting, and error analysis. |
| PHYS 224 | Introduction to Modern Physics for Engineers<br>Credits: 3 (2+3)<br>Prereq: PHYS 104<br>This course introduces the basic concepts of quantum mechanics including wave-particle duality, de Broglie wavelength and the Schrodinger equation and the Uncertainty Principle, along with an introduction to special and general relativity and atomic physics. The course will describe the key experimental observations such as the photoelectric effect, blackbody radiation and the Michelson-Morley experiment. The course includes a laboratory to conduct experiments on the course topics involving data collection and reporting, and error analysis. |
| REE 101 | Renewable Energy Systems<br>Credits: 3 (2+3)<br>In this course, students will learn about the operation and performance of a series of renewable energy technologies, including grid-connected wind turbines, photovoltaic systems, and solar hot water systems. A selection of such systems will be used to introduce students to energy engineering calculations and the availability of renewable energy sources. Emphasis will be placed on selecting and evaluating renewable energy equipment for given applications and integrating renewable energy sources into production, distribution and end-use systems. |
| REE 122 | Introduction to Manufacturing Processes<br>Credits: 3 (2+3)<br>The course introduces the major Production methods that include: Metal Casting, Metal Forming, Metal Joining Processes, Machining and Machine Tool Operations, Principles and applications of nontraditional machining, Metrology and Inspection, Powder Metallurgy, processing Polymers and Composites. |

| Code | Description |
|---|---|
| REE 202 | Mechanics of Materials<br>Credits: 3 (2+3)<br>Prereq: MATH 102 AND PHYS 103<br>This course introduces the concepts of stresses in materials of elementary structures due to the axial, twisting, sheering, and bending loading. |
| REE 203 | Advanced Circuits Design<br>Credits: 3 (2+3)<br>Prereq: ENGR 201 AND MATH 202<br>This course is based on deep understanding of aspects in active analog filter design students are equipped with the knowledge and skills to design, and to be in a good position to undertake further self-study as required. This course is conducted with theoretical study and design project practice. It covers the theory and design of active and passive analog filters including the followings: Fundamental concepts in circuit theory: network functions, characteristic frequencies; Types of filter: lowpass, bandpass, etc; Review of operational amplifiers; Design of first and second order filters using operational amplifiers; Cascade design; Typical filters: Butterworth, Chebyshev, etc; Frequency transformations in design; Sensitivity, etc. |
| REE 208 | Engineering Dynamics<br>Credits: 3 (2+3)<br>Prereq: MATH 102 AND PHYS 103<br>Basics of engineering dynamics. Kinematics of motion using vectors. Motion of projectiles. Kinetics: Newton's laws of motion. Momentum, Work and Energy conservation principles. Angular momentum and the motion of rigid bodies in the plane |
| REE 218 | Mechanical Vibrations<br>Credits: 3 (3+0)<br>Prereq: REE 208<br>This course will introduce the student to the concepts of mechanical vibration applied to single degree of freedom systems, multiple degree of freedom systems and continuous structures including bars, beams, cables, and shafts. Then the student will be introduced to the concepts of vibration damping and control. |
| REE 302 | Machine Design<br>Credits: 3 (1+6)<br>Prereq: REE 202 AND REE 122<br>Introduction to Conceptual Design: design considerations, uncertainty, and reliability. Materials in design: material selection process, material failure limits. Loading and stress analysis, stiffness, and stress concentration. Fatigue failure of ductile and brittle materials. Analysis of combined loading: Goodman diagram. Design of machine elements: shaft design, bearings, gears, and flexible machine elements. |

| Code | Description |
|---|---|
| REE 306 | Advanced Thermodynamics<br>Credits: 3 (3+0)<br>Prereq: ENGR 105<br>The course introduces advanced concepts and applications of engineering thermodynamics. The course starts by a general review on the first law and second law of thermodynamics as well as entropy. This is followed by exergy and second law analysis and the relation to real-life processes. Then, thermodynamic cycles (gas power cycles, vapor and combined cycles and refrigeration cycles) with practical considerations are discussed in details. Psychrometry and gas mixture engineering will be then studied leading to a study of chemical reactions of hydrocarbon fuels, first law analysis of reacting systems (including the analysis of enthalpy of formation), heat of reaction (including the study of adiabatic flame temperature). |
| REE 310 | Control Systems<br>Credits: 3 (3+0)<br>Prereq: MATH 202<br>This course studies dynamic systems encountered in a variety of Renewable Energy and Power Plants systems. It will look at the modelling of such systems and the response of these systems to inputs, initial conditions and disturbances. It is of particular interest to analyse systems obtained as interconnections (e.g., feedback) of two or more other systems. In addition, the design of control systems that ensure desirable properties (e.g., stability, performance) of the interconnection with a given dynamic system using different design techniques will be studied. |
| REE 311 | Electric Machines<br>Credits: 3 (3+0)<br>Prereq: REE 203<br>This course begins by covering the fundamental theory of power converters and electrical machines, including energy storage and conversion; force and emf production; coupled circuit analysis of systems with both electrical and mechanical inputs; the electromechanical theory (magnetic systems, torque and force generation, multi-phase analysis); AC machines; and control mechanisms. The course also covers applications to specific control systems, including those being used in renewable energy systems. |

| Code | Description |
|---|---|
| REE 315 | Power Plant Technology<br>Credits: 3 (3+0)<br>Prereq: REE 306<br>This course provides a comprehensive overview of power plant fundamentals and the challenges and advantages of major electrical power generation unit types. A review of the principles of thermodynamics as well as the theory and design of fossil, nuclear, hydro, solar, and wind generation systems and related equipment will be addressed. Maintenance and operational requirements and special concerns involved in each type of generation are addressed. Options for future generation systems and the related advantageous choices each holds for future sources of electricity for Egypt will be studied. Research reports on the subject matter and sub-topics related to power generation are required of participants in this course. |
| REE 317 | Aerodynamics<br>Credits: 3 (3+0)<br>Prereq: ENGR 207<br>This course extends fluid mechanic concepts from Unified Engineering to the aerodynamic performance of wings and bodies in sub/supersonic regimes. Generally it four components: subsonic potential flows, including source/vortex panel methods; viscous flows, including laminar and turbulent boundary layers; aerodynamics of airfoils and wings, including thin airfoil theory, lifting line theory, and panel method/interacting boundary layer methods; and supersonic and hypersonic airfoil theory. |
| REE 319 | Power Systems<br>Credits: 3 (3+0)<br>Prereq: REE 311<br>This course is an introduction to urban, suburban and rural electrical distribution systems, and the analysis of power flow in circuits and large systems. Topics will include power system control, power system stability, distribution transformers, estimation of load, load characteristics, groundings, earthing of distribution transformer, earthing resistance, earthing practice in L.V. networks, power factor, and fundamentals of illumination engineering. |
| REE 320 | Advanced Control Systems<br>Credits: 3 (3+0)<br>Prereq: REE 310<br>This course will teach fundamentals of control design and analysis using state-space methods. This includes both the practical and theoretical aspects of the topic. We will introduce the design of feedback control systems as applied to a variety of systems. Topics include the properties and advantages of feedback systems. By the end of the course, you should be able to design controllers using state-space methods and evaluate whether these controllers are robust to some types of modeling errors and nonlinearities. |

| Code | Description |
|---|---|
| REE 321 | Power Electronics<br>Credits: 3 (3+0)<br>Prereq: REE 203<br>The course will demonstrate the basics of power semiconductor devices including: Principle of operation -Characteristics and modeling of power diodes, IGBTs, and power MOSFETs. The course will also cover the analysis of Phase controlled converters, DC/DC converters, single phase and three phase inverters. The analysis of these converters will include circuit analysis, circuit simulation, continuous mode of operation, dynamic modeling, and controller design for closed loop operation. Applications in power systems and renewable energy fields will be demonstrated. |
| REE 403 | Renewable Energy Law and Economics<br>Credits: 2 (1+2)<br>In response to depleting natural resources and heightened environmental awareness, many countries are now seeking to redefine their energy mix. Several energy sources are available: coal and oil, natural gas, and a variety of renewable energy sources such as solar and wind and biomass. The selection and achievement of the energy mix that best meets core energy-related concerns: reliability, security, affordability, fairness, and sustainability poses complex not only technical but also legal and economic questions. This course introduces the students to questions of legal regulation of the energy market and to the art and science of evaluating various energy generation proposals from a realistic, market, point of view. |
| REE 425 | Thermal Solar Energy<br>Credits: 3 (3+0)<br>Prereq: REE 315<br>This course provides a comprehensive overview of Thermal Solar Energy fundamentals and its different application for heating, steam production and power generation. Different solar concentration technologies and equipment regarding the collectors, receivers and the working fluid will be addressed. Lectures will cover commercial and emerging Thermal Solar Energy technologies and cross-cutting themes, including conversion efficiencies, loss mechanisms, characterization, manufacturing, systems, reliability, life-cycle analysis, and risk analysis. |
| REE 428 | Energy Storage<br>Credits: 3 (3+0)<br>Prereq: REE 315<br>The hydrogen economy has been proposed as an alternative to hydrocarbons as the main source of energy for economic and societal needs. This course explores the vision and principles behind the concept of the hydrogen economy and the technologies that are being applied or proposed to produce and store hydrogen, including fuel cells, types of rechargeable batteries, lithium-ion battery technology, and methods of chemical and physical storage. |

| Code | Description |
|---|---|
| REE 429 | Smart Grid<br>Credits: 3 (3+0)<br>Prereq: REE 319<br>This course will introduce the main aspects of integrating renewable power plants into power systems. The challenges facing the increase of the renewables penetration level in the power system will be covered including for example the frequency and voltage stability. The students will be exposed to the grid code requirements for renewable power integration established by system operators to maintain the acceptable operation of the power system. The course will also introduce the concepts of distributed generation and smart micro-grids to demonstrate the challenges facing the operation and control of such systems. Finally, the electrical design of renewable power plants and the needed studies to show grid code compliance will be demonstrated. |
| REE 430 | Rotor Aerodynamics<br>Credits: 3 (3+0)<br>Prereq: REE 317<br>The course considers the design of wind turbine rotors. The main emphasis will be on horizontal axis wind turbines. Extension of the theory to other types of machines such as tidal generators and vertical axis wind turbines will be briefly discussed. The course covers basic aerodynamic theory including blade element momentum theory and its corrections. The course also covers the calculation of blade loads, and the preliminary sizing of the blade structure. The modelling of wind resources using statistical methods is addressed at multiple time and length scales. The students are able by the end of the course to analyse wind turbine rotors and predict their torque and power characteristics and their structural integrity. |
| REE 432 | Photovoltaic Systems<br>Credits: 3 (3+0)<br>Prereq: REE 321<br>In this course, students learn about the fundamentals of photoelectric conversion: charge excitation, conduction, separation, and collection. Lectures cover commercial and emerging photovoltaic technologies and cross-cutting themes, including conversion efficiencies, loss mechanisms, characterization, manufacturing, systems, reliability, life-cycle analysis, and risk analysis. Some of the course will also be devoted to discussing photovoltaic technology evolution in the context of markets, policies, society, and environment. |
| REE 434 | Wind Energy Systems<br>Credits: 3 (3+0)<br>Prereq: REE 319<br>This course introduces the basic science behind the meteorology of wind; extraction of energy from wind, and physical wind modeling. In addition, the course covers the design and development of wind plants, with emphasis on wind turbine aerodynamics and design, and applications to wind farm and wind energy grids. |

| Code | Description |
|---|---|
| REE 470 | Computer-Aided Design and Engineering<br>Credits: 3 (2+3)<br>Prereq: REE 302<br>This course allow the student to have hands on experience on computer aided design (CAD) for mechanical engineering applications, it employs commercial software such as solidWorks, ANSYS, COMSOL, for developing 3D models, professional mechanical drawings. The student will also learn to utilize finite element analysis and computational fluid dynamics techniques to analyze design performance and drive design enhancements. |
| REE 479 | Mechanical System Design<br>Credits: 3 (3+0)<br>Prereq: REE 208<br>Kinematics fundamentals: planar and spatial mobility. Design and dynamic force analysis of mechanisms. Design of mechanical power transmission systems. Design of flywheel energy storage systems and gyroscopes. |
| REE 480 | Sustainable Energy Development<br>Credits: 2 (1+3)<br>This class assesses current and potential future energy systems, covering resources, extraction, conversion, and end-use technologies, with emphasis on meeting regional and global energy needs in the 21st century in a sustainable manner. Instructors and guest lecturers will examine various renewable and conventional energy production technologies, energy end-use practices and alternatives, and consumption practices in different countries. Students will learn a quantitative framework to aid in evaluation and analysis of energy technology system proposals in the context of engineering, political, social, economic, and environmental goals. Students taking the graduate version, Sustainable Energy, complete additional assignments. |
| REE 481 | Carbon Dioxide Sequestration<br>Credits: 2 (1+3)<br>Prereq: PEU 311 OR ENV 346<br>This course covers the technologies used for carbon dioxide disposal and the engineering issues concerned with their implementation, as well as the resultant economic and environmental impacts. It also covers the physical and chemical properties of carbon dioxide and carbon containing materials; fluid and non-aqueous phase equilibria; hydrates; and compressor design and operation. The course introduces students to the natural carbon cycle and the effects of human intervention within the context of present and future carbon management strategies. The course also discusses how plants can be used to sequester carbon. |

| Code | Description |
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| REE 482 | Renewable Resources Management<br>Credits: 2 (1+3)<br>Prereq: REE 429<br>This course focuses on the management of soil, water, plants, and animals as renewable natural resources in an integrated ecosystem context; and practices used to protect water, wood, forage, wildlife and other renewable resources and to mitigate the adverse impacts of energy and land-use on the environment. The course introduces sustainable practices in forestry and agriculture as sources for bioenergy carriers. |
| REE 483 | Geothermal Energy<br>Credits: 2 (1+3)<br>Prereq: REE 315<br>This course starts with the structure and composition of the earth and how heat is transferred, generated and stored naturally. It also introduces plate tectonic theory. The course then covers the layout, design and operation of geothermal systems, including heat pumps and ground source heat systems; pond and lake-based systems; ground heat exchanger configurations; building heating and cooling loads; soil thermal conductivity; pressure drop calculations; pump, and fluid selection; and air and debris purging. |
| REE 484 | Modeling and Control of Voltage Source Converters<br>Credits: 2 (1+3)<br>Prereq: REE 321<br>In this course the fundamentals of the different renewable power generation technologies will be demonstrated. The course will cover the commercially available technologies for wind power and solar power. The focus will be put on the dynamics and control of such systems to demonstrate the interaction between the different components of the generator system. One major building block in these systems is the voltage source converter and therefore emphasis will be put on the modeling, dynamics and control of such a power electronics based system. This course can be considered as the application of the fundamentals taught in the electric machines course (REE405) and the power electronics course (REE420) for renewable power generation. |
| REE 485 | Applications of Voltage Source Converters<br>Credits: 2 (1+3)<br>Prereq: REE 484<br>In this course the fundamentals of the different renewable power generation technologies will be demonstrated. The course will cover the commercially available technologies for wind power and solar power. The focus will be put on the dynamics and control of such systems to demonstrate the interaction between the different components of the generator system. One major building block in these systems is the voltage source converter and therefore emphasis will be put on the modeling, dynamics and control of such a power electronics based system. This course can be considered as the application of the fundamentals taught in the electric machines course (REE405) and the power electronics course (REE420) for renewable power generation.” |

| Code | Description |
|---|---|
| REE 486 | Hydroelectric, Tidal and Wave Energy<br>Credits: 2 (1+3)<br>Prereq: REE 470<br>This course covers water hydraulics and principles of fluid statics, the hydrologic cycle and hydrodynamics as applied to hydropower generation. The conservation of energy principle is used to establish the conditions that need to be considered in the selection of a hydropower generation system. Analysis of hydraulic head, flow rates and power; river discharge and flow duration curves; turbine selection and efficiency; and planning and design issues are also covered. |
| REE 487 | Bio Fuels and Bio Mass<br>Credits: 2 (1+3)<br>Prereq: REE 315<br>This course covers the chemistry and biochemistry of various forms of biofuel technologies, such as biomass, biodiesel, biomethane, bioethanol and biohydrogen; bioenergy systems; direct biomass combustion and co-firing; gasification and pyrolysis; wood biomass energy; grass energy; and algae biofuel. The course also assesses the sustainability, and environmental and economic impact of each form. |
| REE 488 | Hydrogen Systems<br>Credits: 2 (1+3)<br>Prereq: REE 315 AND REE 321<br>The course covers the principles and challenges involved in the production, transport, conversion and storage of hydrogen as energy storage medium. |
| REE 489 | Nuclear Energy<br>Credits: 2 (1+3)<br>Prereq: REE 315 AND REE 470<br>This course is intended to understand the engineering design of nuclear power plants using the basic principles of reactor physics, thermodynamics, fluid flow and heat transfer. Lectures will include the following: Reactor designs, Thermal analysis of nuclear fuel, Reactor coolant flow and heat transfer, Power conversion cycles, Nuclear safety and Reactor dynamic behavior. |
| REE 490 | Electric Power Generation, Distribution and Utilization<br>Credits: 2 (1+3)<br>Prereq: REE 319<br>This course is an introduction to urban, suburban and rural electrical distribution systems, and the analysis of power flow in circuits and large systems. Topics will include power system control, power system stability, distribution transformers, estimation of load, load characteristics, groundings, earthing of distribution transformer, earthing resistance, earthing practice in L.V. networks, power factor, and fundamentals of illumination engineering. |

| Code | Description |
|---|---|
| REE 491 | Renewable Energy Economic Analysis and Feasibility Study<br>Credits: 2 (1+3)<br>Prereq: REE 403<br>This course prepares students for the systematic evaluation of the costs and benefits associated with proposed technical projects. Concepts include the “time value of money” and the methods of discounted cash flow; engineering costs and cost estimates; interest and equivalence; present worth, cash flow, and rate of return analysis; uncertainty in future events; depreciation; inflation; and replacement analysis. |
| REE 492 | Energy Conservation and Efficiency<br>Credits: 2 (1+3)<br>Prereq: REE 319<br>This course provides students with a foundation level of understanding of electrical energy use and losses, introduces the tools required for electrical energy analysis and management, and presents case studies of latest industry practice in energy efficiency improvements. This course also focuses on providing state-of-the-art knowledge of energy efficiency management strategies and technology options for improving electrical energy utilization in the residential, commercial and industrial sectors where special attention is given to process optimization, energy conservation and waste energy recovery. |
| REE 493 | Turbine Blade Design<br>Credits: 2 (1+3)<br>Prereq: REE 430<br>The course considers the design of turbine blades. The main emphasis will be on horizontal axis wind turbines. Extension of the theory to other types of machines such as tidal generators and vertical axis wind turbines will be briefly discussed. The design of a turbine blade is a multidisciplinary problem that involves: aerodynamics, structures and materials, and control. Moreover some understanding of the characteristics of wind (in the case of wind turbines), or water currents (in the case of tidal machines) is prerequisite. The course covers basic aerodynamic theory including blade element momentum theory and its corrections. The course also covers the calculation of blade loads, and the preliminary sizing of the blade structure. The modelling of wind resources using statistical methods is addressed at multiple time and length scales. The students are able by the end of the course to analyse wind turbine blades and predict their torque and power characteristics and their structural integrity. |

| Code | Description |
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| REE 494 | Special Topics in Adv Thermal Systems<br>Credits: 2 (1+3)<br>Prereq: REE 425<br>The course introduces fundamental concepts and applications of solar thermal energy conversion. The course starts by a general introduction on solar radiation, solar geometry, irradiance models and meteorological data analyses. Techniques of measuring solar radiation are also included. This is followed by studies and analyses of different types of solar collection systems (non-concentrating and concentrating collectors) and the relation to applications. Finally, some attractive applications are introduced; solar water heating systems, solar cooling and dehumidification systems, solar thermal desalination systems and solar food drying systems. |
| REE 495 | Electric Vehicles<br>Credits: 2 (1+3)<br>Prereq: REE 321<br>This course considers the design and control of power converters in electric drive vehicles. The course includes an overview of system architectures and covers system-level dynamic modelling and control using MATLAB/Simulink at levels appropriate to determine requirements and validate the performance of switched-mode power converters in the vehicle system. Analysis, modelling and design of switched-mode power converters in electric-drive vehicle systems are then covered, including battery DC-DC converters, battery management electronics, motor drive inverters and battery chargers. |
| REE 496 | Selected Topics in Renewable Energy Engineering<br>Credits: 1-3<br>Selected topics of interest of faculty and major students, not covered elsewhere in the curriculum. The course can be repeated for credit more than once on the condition that course topics are different |
| REE 498 | Senior Design Project I<br>Credits: 1 (0+3)<br>Prereq: Completed 102 credit hours toward satisfying the degree requirements, and during the last two semesters<br>Students must undertake an independent Renewable Energy Engineering design or experimental project during the last two terms of their program. The purpose of the project is to demonstrate students' abilities to practise in a Renewable Energy Engineering capacity in their chosen area of expertise, using knowledge gained from their academic and employment experiences. The first part of the project (REE498) will include problem identification, generation and selection of solutions and time management. Incorporation of technical, social, political and economic issues in the solution for the project will be required. A basic requirement of the proposed solution is that it must be compatible with the principles of sustainability. Requirements include: proposal, progress report, and a final report containing recommendations for part two of the project. |

| Code | Description |
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| REE 499 | Senior Design Project II<br>Credits: 3 (0+9)<br>Prereq: REE 498<br>As a continuation of REE498, the final design of the major Renewable Energy Engineering project proposed in REE498 will be undertaken. The purpose of this phase of the project is to carry out a detailed technical design of the solution proposed in REE498. A final report that covers all activities carried out in this two-term project is a must. |
| SCH 261 | Engineering Project Management<br>Credits: 2 (2+0)<br>This course introduces the students to fundamentals of engineering project management with case studies from real life. Topics include phases of engineering project management, participants' responsibilities, knowledge areas, processes, tools, integration of project activities, types of organizations and types of contracts, leadership skills, time value of money, feasibility studies, business case, project charter, scope management, time management, CPM and PERT based scheduling, cost management, and strategic project management. |
| SCH 262 | Engineering Project Economics<br>Credits: 2 (2+0)<br>This course aims at providing students with the essential concepts of Engineering Project Economics. Topics covered include: making economic decisions, engineering costs and cost estimating, interest andequivalence, common interest formulae, present worth analysis, rate of return analysis, inflation and price change. The course also introduces macro- and micro- economic factors that affect small and medium size engineering projects. |
| SCH 263 | Engineering Ethics and Safety<br>Credits: 2 (2+0)<br>An engineer makes ethical decisions that has moral and physical implications on a daily basis. The course covers ethical, environmental, and safety issues surrounding engineering projects. It provides a foundation for thinking about and recognizing the ethical, and legal dimensions of a variety of professional settings. The course familiarizes the students with current ethical debates in a range of fields. Topics will include: conflicts of interest and objectivity, intellectual property, and ethical decision making. The second part of the course will cover safety issues, risk assessment and how engineers should handle hazards, in relation to national and international safety regulations. |

| Code | Description |
|---|---|
| SCH 264 | Introduction to Entrepreneurship and Small Business Management<br>Credits: 2 (2+0)<br>The course is designed to provide preliminary guidance for entrepreneurs to understand business nature, spot business opportunities, conduct market research, make a marketing plan and put pricing strategies of products, work on financial aspects of the business plans, and create business plans. |
| SPC 101 | Introduction to Aerospace Engineering<br>Credits: 2 (2+0)<br>This course is intended as an introduction to the topics of Aerospace Engineering and Flight Mechanics. It lays the foundations for understanding the relationship between different aerospace subsystems; aerodynamics, control, structure, and propulsion. |
| SPC 206 | Advanced Thermodynamics<br>Credits: 3 (2+3)<br>Prereq: ENGR 105<br>The course introduces advanced concepts and applications of engineering thermodynamics. The course starts by a general review on the first law and second law of thermodynamics as well as entropy. This is followed by exergy and second law analysis and the relation to real-life processes. Then, thermodynamic cycles (gas power cycles, vapor and combined cycles and refrigeration cycles) with practical considerations are discussed in details. Psychrometry and gas mixture engineering will be then studied leading to a study of chemical reactions of hydrocarbon fuels, first law analysis of reacting systems (including the analysis of enthalpy of formation), heat of reaction (including the study of adiabatic flame temperature). |
| SPC 210 | Control Systems<br>Credits: 3 (2+3)<br>Prereq: MATH 202<br>This course will introduce the student to the concepts of mechanical vibration applied to single degree of freedom systems, multiple degree of freedom systems and continuous structures including bars, beams, cables, and shafts. Then the student will be introduced to the concepts of vibration damping and control. |
| SPC 228 | Engineering Dynamics<br>Credits: 3 (2+3)<br>Prereq: MATH 102 AND PHYS 103<br>Basics of engineering dynamics. Kinematics of motion using vectors. Motion of projectiles. Kinetics: Newton's laws of motion. Momentum, Work and Energy conservation principles. Angular momentum and the motion of rigid bodies in the plane |

| Code | Description |
|---|---|
| SPC 238 | Mechanical Vibration<br>Credits: 3 (2+3)<br>Prereq: SPC 228<br>This course will introduce the student to the concepts of mechanical vibration applied to single degree of freedom systems, multiple degree of freedom systems and continuous structures including bars, beams, cables, and shafts. Then the student will be introduced to the concepts of vibration damping and control. |
| SPC 302 | Advanced Control Systems<br>Credits: 3 (2+3)<br>Prereq: SPC 210<br>This course will teach fundamentals of control design and analysis using state-space methods. This includes both the practical and theoretical aspects of the topic. We will introduce the design of feedback control systems as applied to a variety of systems. Topics include the properties and advantages of feedback systems. By the end of the course, you should be able to design controllers using state-space methods and evaluate whether these controllers are robust to some types of modeling errors and nonlinearities. |
| SPC 304 | Orbital and Space Flight Mechanics<br>Credits: 2 (2+0)<br>Prereq: SPC 218 OR SPC 228 OR REE 208<br>This course covers the fundamentals of astrodynamics, focusing on the two-body orbital initial-value and boundary-value problems with applications to space vehicle navigation and guidance for lunar and planetary missions, including both powered flight and midcourse maneuvers. Other topics include celestial mechanics, Kepler's problem, Lambert's problem, orbit determination, multi-body methods, mission planning, and recursive algorithms for space navigation. Selected applications from the Apollo, Space Shuttle, and Mars exploration programs are also discussed. |
| SPC 307 | Aerodynamics<br>Credits: 3 (3+0)<br>Prereq: ENGR 207<br>This course extends fluid mechanic concepts from Unified Engineering to the aerodynamic performance of wings and bodies in sub/supersonic regimes. Generally, it four components: subsonic potential flows, including source/vortex panel methods; viscous flows, including laminar and turbulent boundary layers; aerodynamics of airfoils and wings, including thin airfoil theory, lifting line theory, and panel method/interacting boundary layer methods; and supersonic and hypersonic airfoil theory. |

| Code | Description |
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| SPC 315 | Thin-Walled Structures<br>Credits: 3 (2+3)<br>Prereq: SPC 202<br>This course introduced intermediate concepts in structural analysis as applied to aerospace vehicles. The use of energy principles to solve structural problems as well as the application of the concepts of the theory of elasticity are introduced. The course will describe techniques used to analyze and design complex cross section of wings and bodies of aerospace vehicles. |
| SPC 322 | Machine Design II<br>Credits: 3 (2+3)<br>Prereq: REE 302<br>Introduction to geometric dimensioning and tolerance specification, Design of machine elements: joints and fasteners, welded joints, gears, Clutches, brakes, couplings, flexible machine elements. Case study. |
| SPC 327 | Analog and Digital Electronics<br>Credits: 3 (2+3)<br>Prereq: ENGR 201<br>Circuit analysis fundamentals. Analog and digital microelectronic circuits and systems. Operational amplifiers, diodes, BJT, FETs. Frequency response, feedback circuits and amplifiers under large signals. Digital circuits combinational and sequential - Bipolar and MOS families. (includes lab) |
| SPC 332 | Flight Dynamics and Control<br>Credits: 3 (2+3)<br>Prereq: SPC 302<br>This class includes a brief review of applied aerodynamics and modern approaches in aircraft stability and control. Topics covered include static stability and trim; stability derivatives and characteristic longitudinal and lateral-directional motions; and physical effects of the wing, fuselage, and tail on aircraft motion. Control methods and systems are discussed, with emphasis on flight vehicle stabilization by classical and modern control techniques; time and frequency domain analysis of control system performance. |
| SPC 337 | Gas Dynamics<br>Credits: 3 (2+3)<br>Prereq: ENGR 105 AND ENGR 207<br>The course begins with the basics of compressible fluid dynamics, including governing equations, thermodynamic context and characteristic parameters. The next large block of lectures covers quasi-one-dimensional flow, followed by a discussion of disturbances and unsteady flows. The second half of the course comprises gas dynamic discontinuities, including shock waves and detonations, and concludes with another large block dealing with two-dimensional flows, both linear and non-linear |

| Code | Description |
|---|---|
| SPC 412 | Digital Control<br>Credits: 2 (2+0)<br>Prereq: SPC 302<br>In modern control system controllers are often implemented using digital devices. This is demonstrated by the widespread use of microcontrollers in industrial applications. The use of digital devices requires the introduction of finite sampling of continuous (analogue) signals. Moreover, finite precision and quantization effects need to be considered. In this course, students are introduced to the basic concepts and methods of digital control systems. The course starts by a discussion of discrete time systems and their relation to analogue systems and introduces the z-transform as the corresponding tool to the usual Laplace transform used in continuous system analysis. This is followed by a detailed discussion of the stability of discrete systems using stability tests, root loci and frequency domain criteria. The design of digital systems is connected to standard methods of design in analogue systems. Finally state space models of discrete systems and their controllability and observability are discussed and standard state space controller introduced. Applications to aircraft and space systems are used throughout the course to illustrate the concepts and methods. |
| SPC 413 | Attitude Determination and Control<br>Credits: 2 (2+0)<br>Prereq: SPC 228<br>Vector kinematics are applied to translation and rotation of rigid bodies. Newtonian and Lagrangian methods are used to formulate and solve equations of motion. Additional numerical methods are presented for solving rigid body dynamics problems. Examples and problems describe applications to aircraft flight dynamics and spacecraft attitude dynamics. |
| SPC 414 | Optimal Control<br>Credits: 2 (2+0)<br>Prereq: SPC 302<br>An introduction to optimal control theory. The course starts by a discussion of calculus of variations. This is followed by a review of variational methods in mechanics (Lagrange equations, Hamilton's equations and the Hamilton-Jacobi equations). This sets the stage for an exposition of optimal control of dynamical systems using dynamic programming and Pontryagin's maximum principle. The primary application will be to linear state space systems for which optimal control indicates the necessity of full state feedback. Finally, optimal estimation is considered to cover cases where noise or other reasons necessitate estimating the system states. |

| Code | Description |
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| SPC 417 | Gas Turbine Engines<br>Credits: 3 (2+3)<br>Prereq: SPC 206 AND SPC 337<br>This course presents aerospace propulsive devices as systems, with functional requirements and engineering and environmental limitations along with requirements and limitations that constrain design choices. Air-breathing engines are covered, at a level which enables rational integration of the propulsive system into an overall vehicle design. Mission analysis, fundamental performance relations, and exemplary design solutions are presented. |
| SPC 418 | Control Systems Design for Autonomous Vehicles<br>Credits: 2 (2+0)<br>Prereq: SPC 302<br>This course covers the fundamentals of autonomous vehicle design and control, whilst enabling the students to specialize in appropriate subject areas via optional modules and an individual research project. The different subject areas include autonomous airborne vehicles, which have numerous existing and potential applications including search and surveillance, mapping crop-spraying, environmental and weather monitoring. Autonomous ground vehicles have very diverse applications such as factory automation and mine clearance. The course will utilize the fundamentals of design of feedback control systems. Properties and advantages of feedback systems. Time-domain and frequency-domain performance measures. Stability and degree of stability. Root locus method, Nyquist criterion, frequency-domain design, and some state space methods. Strong emphasis on the synthesis of full classical and digital controllers, towards full vehicle autonomy. Application to a variety of aerospace systems, hands-on experiments using underwater and airborne robotic systems. |
| SPC 419 | Turbomachinery<br>Credits: 2 (2+0)<br>Prereq: SPC 337<br>The course principles are based on a synergized foundations between thermodynamics and fluid mechanics. In the course, the energy transfer mechanisms and theory of operation of the design point analysis and off-design performance are covered. The preliminary designs of compressors and turbines for gas turbine engines are considered with an emphasis on the matching process of their operating conditions. |

| Code | Description |
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| SPC 420 | Low Speed Aerodynamics<br>Credits: 2 (2+0)<br>Prereq: SPC 307<br>For most practical aerodynamic and hydrodynamic problems, the classical model of a thin viscous boundary layer along the surface, surrounded by a mainly inviscid flow, is the cornerstone of design practice. This approach is particularly useful in the area of low speed aerodynamics where compressibility effects are minimal and the complex phenomena associated with shock waves and their interaction with viscous layers are absent. The success of the approach depends on the ability to solve the inviscid flow efficiently to obtain the pressure distribution over the body which is then impressed upon the viscous layers. The subsequent calculation of the flow in the viscous layers (whether it is laminar or turbulent) would furnish estimates of the skin friction experienced by the body. The interaction between the inviscid flow and the viscous layers is also a source of pressure drag. This course gives a detailed account of the governing equations of low speed flows both in the inviscid flowfield and the viscous layers and develops the numerical schemes needed for their individual solutions and their interaction mechanisms. |
| SPC 424 | Spacecraft and Space System Design<br>Credits: 2 (2+0)<br>This design course focuses on the analysis and design of complex space systems, including mission analysis, space environment interactions, trajectory design, mission geometry, ground system and spacecraft subsystem architecture and design. Particular emphasis will be given to the principle design aspects of communication, power, guidance and navigation, avionics and attitude subsystems. Student teams will be responsible for designing a satellite or space platform from conception to critical design review. |
| SPC 426 | Experimental Aerodynamics<br>Credits: 2 (1+3)<br>Prereq: SPC 307<br>The purpose of this course is to introduce the student to different aerodynamic testing strategies along with the measurement techniques for pressure, forces, moments, and velocities associated with low-speed wind tunnel testing. The course prepares the student to plan, design, and conduct experiments then analyze, evaluate, and present experimental data. |

| Code | Description |
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| SPC 428 | Mechatronics and Robotics<br>Credits: 2 (2+0)<br>Prereq: SPC 210<br>This course presents an overview of robotics in practice and research with topics including vision, motion planning, mobile mechanisms, kinematics, inverse kinematics, and sensors. In course projects, students construct robots that are driven by a microcontroller, with each project reinforcing the basic principles developed in lectures. Students nominally work in teams of three: an electrical engineer, a mechanical engineer, and a computer scientist. This course will also expose students to some of the contemporary happenings in robotics, which includes current robot lab research, applications, robot contests and robots in the news. |
| SPC 435 | Aerospace Communication Systems<br>Credits: 3 (2+3)<br>Prereq: CIE 237 OR CIE 327<br>The Aerospace Communications Systems course aims at introducing the students to the fundamentals of telecommunication systems in general, with applications from the aerospace industry. Topics covered in this course include: the building blocks of communication systems, various amplitude modulation, frequency modulation and phase modulation techniques. The course also covers the sampling theorem, pulse modulation,<br>uniform and non-uniform quantization, and pulse code modulation. The course also includes an introduction to the general characteristics of communication channels, and their effect on aerospace communications. |
| SPC 436 | Computational Fluid Dynamics<br>Credits: 2 (2+0)<br>Prereq: MATH 306<br>The course is an introductory course to computational fluid dynamics for undergraduate students. Finite difference method will be used to solve different type of Partial Differential Equations (PDEs) that descript different fluid dynamics and heat transfer problems. Several model equations will be considered for finite difference discretization, stability and error analysis. Solution schemes and boundary conditions treatment will be selected based on the PDEs classification. Scalar form of Navier-Stokes (NS) equations will be solved along with two-dimensional incompressible NS equations. |

| Code | Description |
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| SPC 439 | Aircraft Conceptual Design<br>Credits: 2 (2+0)<br>The conceptual design of aircraft focuses on system level analysis and sizing of aircraft to meet stringent mission requirements. This is particularly important given the recent trends towards limiting carbon footprint and noise levels generated by air flight. The design approach works by integrating new technologies and systems with traditional and advanced configurations. The sizing procedure would consider the usual disciplines of aircraft design: materials and structures, control and avionics, propulsion systems and foremost aerodynamic configuration. The course makes airworthiness compliance ensuring designs satisfy the safety requirements of certification authorities- is a central concern in developing the course material. The students will be exposed to a systematic approach of sizing aircraft systems and selecting components based on a combination of airworthiness requirements, detailed system modelling and empirical correlations gleaned from analysis of existing aircraft in the same class. At the conclusion of the course students will be able to specify mission requirements, satisfy airworthiness regulations and come up with a complete baseline concept for an aircraft. |
| SPC 446 | Advanced Materials for Aerospace Struct<br>Credits: 2 (2+0)<br>Prereq: SPC 315<br>This course will introduce the students to the modeling of composite materials starting from the micromechanics of materials through the mechanics of plies and the composite plates. Then the student will be introduced to the concepts of smart structures through an introduction to piezoelectric materials, shape memory alloys and magnetorheological fluids. |
| SPC 447 | Advanced Aerospace Structures<br>Credits: 2 (2+0)<br>Interaction of electromagnetic waves with natural surfaces. Scattering of microwaves, microwave and thermal emission from atmospheres and surfaces, and sensors and associated technology, including sensor design, new observation, techniques, ongoing developments, and data interpretation. (includes lab). |

| Code | Description |
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| SPC 460 | Non-Linear Control<br>Credits: 2 (2+0)<br>Prereq: SPC 302<br>The objective of this course, is to present the fundamentals of modern nonlinear control. Classical techniques such as phase plane analysis and the describing function methods are treated, because of their continued practical importance. The scope of the course is quite broad. This is in order to show the multidisciplinary role of nonlinear dynamics and control. In particular, nonlinear control, and Lyapunov stability theory is provided. The objective of the stability analysis is to determine the system behavior without solving the differential, or difference equations modeling the system. In fact, the Lyapunov theory is used as a unifying medium for different types of dynamical systems analyzed. Finally, an introduction to the design of nonlinear control systems design using sliding mode control and nonlinear feedback control will be presented. |
| SPC 470 | Computer-Aided Design and Engineering<br>Credits: 3 (2+3)<br>Prereq: REE 302<br>This course allow the student to have hands on experience on computer aided design (CAD) for mechanical engineering applications, it employs commercial software such as solidWorks, ANSYS, COMSOL, for developing 3D models, professional mechanical drawings. The student will also learn to utilize finite element analysis and computational fluid dynamics techniques to analyze design performance and drive design enhancements. |
| SPC 477 | Airports and Airlines Management<br>Credits: 2 (2+0)<br>The course is intended to familiarize the student with the international aviation system and community. Aviation as an industrial sector requires both pieces of knowledge of the airlines and airport regulations. The course provides an introduction to aviation engineering know-how along with basic management skills of global airlines and airports. |
| SPC 497 | Selected topics in Aerospace Engineering<br>Credits: 1-3<br>Selected topics of interest of faculty and major students, not covered elsewhere in the curriculum. The course can be repeated for credit more than once on the condition that course topics are different |

| Code | Description |
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| SPC 498 | Senior Design Project I<br>Credits: 1 (0+3)<br>Prereq: Completed 102 credit hours toward satisfying the degree requirements, and during the last two semesters<br>Students must undertake an independent Aerospace Engineering design project during the last two terms of their program. The purpose of the project is to demonstrate students' abilities to practice in an Aerospace Engineering capacity in their chosen area of expertise, using knowledge gained from their academic and employment experiences. The first part of the project (SPC 498) will include problem identification, generation and selection of solutions and time management. Incorporation of technical, ecological, social, political and economic issues in the solution for the project will be required. Requirements include: proposal, progress report, and a final report containing recommendations for part two of the project. |
| SPC 499 | Senior Design Project II<br>Credits: 3 (0+9)<br>Prereq: SPC 498<br>A continuation of SPC 498. The final design of the major Aerospace Engineering project proposed in SPC 498 will be undertaken. The purpose of this phase of the project is to carry out a detailed technical design of the solution proposed in SPC 498. Requirements of this part of the two-term project include a final report |