**ELECTRICAL AND COMPUTER ENGINEERING**

# CURRICULUM

**Professional Master's Diploma**

**DIPLOMA REQUIREMENTS**

| | **PMDip Energy and Innovation** | **Credits** |
|---|---|---|
| EE8901 | Smart Grids | 1 |
| EE8902 | Demand Management, Conservation | 1 |
| EE8903 | Energy Use and Storage | 1 |
| EE8904 | Electricity Markets | 1 |
| EE8905 | Diploma Project | Pass/Fail |

**Master of Applied Science**

| **DEGREE REQUIREMENTS** | | **Credits** |
|---|---|---|
| Master's Thesis | | (Milestone) |
| EE8010 | Master's Research Seminar in ELCE | |
| Five Elective credits from Table A | | 5 |

**Master of Engineering**

| **DEGREE REQUIREMENTS** | **Credits** |
|---|---|
| Master's Project* | (Milestone) |
| Eight Elective credits from Table A** | 8 |

*students may apply to substitute 2 courses for the project.
** With the permission of the Program Director, a student may substitute up to 2 courses from Table B

**Doctor of Philosophy**

| **DEGREE REQUIREMENTS** | | **Credits** |
|---|---|---|
| Candidacy Examination | | (Milestone) |
| Dissertation | | (Milestone) |
| EE9010 | PhD Research Seminar in ELCE | |
| Four Elective credits from Table A | | 4 |
| (Only one elective credit may be a Directed Studies course) | | |

**ELECTIVES**

| | | **Credits** |
|---|---|---|
| **TABLE A** | | |
| EE8102 | Statistical Inference | 1 |
| EE8103 | Random Processes | 1 |
| EE8104 | Adaptive Signal Processing | 1 |
| EE8105 | Digital Signal Processing I | 1 |
| EE8107 | Digital Communications | 1 |
| EE8108 | Multimedia Processing & Comm | 1 |
| EE8109 | Wireless Communications I | 1 |
| EE8111 | Digital Signal Processing II | 1 |
| EE8114 | Optical Commun & Networks | 1 |
| EE8121 | Wireless Networks | 1 |
| EE8122 | Opto-electronic Devices | 1 |
| EE8123 | Radio Frequency Circuits Syst. | 1 |
| EE8124 | 5G Wireless Communications and IoT | 1 |
| EE8202 | Digital Image Processing I | 1 |
| EE8204 | Neural Networks | 1 |

| | | |
|---|---|---|
| EE8205 | Embedded Computer Systems | 1 |
| EE8208 | Arch Synth & Des of Dig Sys | 1 |
| EE8209 | Intelligent Systems | 1 |
| EE8212 | Digital Image Processing II | 1 |
| EE8213 | Computer Network Security | 1 |
| EE8214 | Computer Systems Modelling | 1 |
| EE8215 | Human Computer Interaction | 1 |
| EE8216 | Computer Networks | 1 |
| EE8217 | Reconfigurable Computing Sys | 1 |
| EE8218 | Parallel Computing | 1 |
| EE8219 | Arch of Field-Prgr Gate Arrays | 1 |
| EE8220 | Advanced Digital Filters | 1 |
| EE8221 | Systems-on-Chip Design | 1 |
| EE8222 | Advanced Data Engineering | 1 |
| EE8223 | Deep Learning | 1 |
| EE8225 | IOT Analytics | 1 |
| EE8226 | Sustainability Engineering | 1 |
| EE8227 | Secure Machine Learning | 1 |
| EE8228 | Neural Information Processing and Retrieval | 1 |
| EE8229 | Distributed and Cloud Computing | 1 |
| EE8230 | Machine Learning for Engineers | 1 |
| EE8301 | Linear System Theory | 1 |
| EE8401 | Computer Methods Pwr Sys Analysis | 1 |
| EE8403 | Adv Topics in Power Systems | 1 |
| EE8405 | Power Sys Stability & Control | 1 |
| EE8407 | Power Converter Systems | 1 |
| EE8408 | Switch Mode Power Supplies | 1 |
| EE8409 | Electromagnetic Theory | 1 |
| EE8410 | Power Electronics | 1 |
| EE8416 | Modeling and Control of Power-Electronic | 1 |
| EE8417 | Vector Control of Rotating Machines | 1 |
| EE8418 | Antenna Theory and Design | 1 |
| EE8419 | Integration of DER | 1 |
| EE8420 | Microwave Engineering | 1 |
| EE8502 | CMOS Analog Integrated Circuits | 1 |
| EE8503 | VLSI Circuits & Sys for Comm | 1 |
| EE8504 | Adv VLSI/FPGA Sys Design & Opt Alg | 1 |
| EE8505 | Digital Systems Testing | 1 |
| EE8506 | Digital CMOS VLSI Integrated Circuits | 1 |
| EE8601 | Directed St: Electrical Engr | 1 |
| EE8603 | Sel Topics: Computer Engr I | 1 |
| EE8604 | Sel Topics: Electrical Engr I | 1 |
| EE8605 | Sel Topics: Computer Sci I | 1 |
| EE8606 | Sel Topics: Biomedical Engr I | 1 |
| EE8607 | Sel Topics: Computer Engr II | 1 |
| EE8608 | Sel Topics: Electrical Engr II | 1 |
| EE8610 | Sel Topics: Biomedical Engr II | 1 |

**TABLE B**

| | | |
|---|---|---|
| EE8901 | Smart Grids | 1 |
| EE8902 | Demand Management, Conservation | 1 |
| EE8903 | Energy Use and Storage | 1 |
| EE8904 | Electricity Markets | 1 |

**COURSE LISTING**

**Master's Thesis**
The student is required to conduct advanced research on a topic chosen in consultation with the student's thesis supervisor. The supervisory committee, and the thesis supervisor, must also approve the thesis research plan/proposal, which is presented in writing by the student. The student must submit the completed research in a thesis format to an examination committee and make an oral presentation of the research thesis, and the research results, to this committee. The examination committee will assess and grade the candidate's research thesis. Through the thesis, the student is expected to furnish evidence of competence in research and a sound understanding of the specialty area associated with the research. This is a "Milestone."

**Master's Project**
The Project may consist of an advanced design assignment, laboratory research project, analysis of research data, or an in-depth review of an approved aspect of the scientific literature. The student presents the proposed project plan in writing, which must be approved by the project supervisor, and the supervisory committee. The MEng candidate must submit two copies of the completed project report to the supervisor. An oral presentation of the project report, and results, will be arranged in a seminar format. The supervisor and another member of the supervisory committee will assess and grade the candidate's project report and the presentation. This is a "Milestone."

**Candidacy Examination**
Candidacy Examination is to ascertain a Ph.D. student's understanding of the basic theories and the recent theoretical and applies developments in his/her area of specialization, and competency to undertake research commensurate with a Ph.D. degree. It must be held within 20 months from the date of initial registration. It will consist of a 3-hour written part and a two-hour oral part, which both must be passed. This is a "Milestone."

**Dissertation**
The student is required to conduct advanced research on a topic chosen in consultation with the student's supervisor. The supervisor and supervisory committee must approve the research proposal, which is presented in writing and orally by the student. The student must submit the completed research in a dissertation format and make an oral presentation to an examination committee. The examination committee will evaluate the presentation and the dissertation. Through the dissertation, the student is expected to furnish evidence of competence in research and a sound understanding of the specialty area associated with the research. The research is expected to result in original and significant contribution to knowledge in the discipline. Pre-requisite: Candidacy Examination. This is a "Milestone."

**EE8010 Master's Research Seminar in Electrical and Computer Engineering**
This course consists of weekly seminars with emphasis on current research in the specialization fields and emerging areas of electrical and computer engineering. This course will run through Fall and Winter semesters, 1 hour/week. Presentations will be given by graduate students, faculty members, visiting scholars and guest speakers. In order to achieve a pass grade in the course, the student must attend a minimum of 75% of the seminars. Pass/Fail.

**EE8102 Statistical Inference**
This course is introduction to principles of statistical inference and estimation theory. The subjects cover fundamentals of classical parametric and nonparametric modeling, estimation theory, Hypothesis testing, Maximum Likelihood (ML) estimators, Maximum a posteriori (MAP) estimators, Bayesian estimators, Karhunen Loeve (KL) expansion, Wiener and Kalman filters, as well as selected topics such as graphical models. 1 Credit

**EE8103 Random Processes**
Probability theory: mathematical model, conditional probabilities, random variables, pdf, transformation of random variables, conditional densities, statistical averages. Random processes concept; ensemble, stationarity, ergodicity, correlation and covariance, power spectral density, calculation and measurement of AVF and PSD, Gaussian random processes, noise. Transmission of random processes through linear systems: time-invariant systems, multiple terminals, Gaussian processes, non-stationary processes. 1 Credit

**EE8104 Adaptive Signal Processing**
The course begins with a brief review of linear signals and systems. Adaptive filter algorithms such as least mean squares (LMS), recursive least squares (RLS), and recursive least squares lattice (RLSL) will be covered. Linear prediction theory, autoregressive modeling, and spectral estimation will also be discussed. The course will briefly cover advanced adaptive signal analysis techniques based on time-frequency and wavelet transforms. 1 Credit

**EE8105 Digital Signal Processing I**
The class provides an introductory treatment of the theory and principles of digital signal processing, with suitable supporting work in linear system concepts and digital filter design. More specifically, the class deals with the

following topics: general concepts of digital signal processing, continuous-time system analysis, Fourier analysis and sampled-data signals, discrete-time system analysis, discrete-time systems, infinite impulse response digital filter design, discrete and fast Fourier transforms, and general properties of the discrete Fourier transform. Background in Signals and Systems is required. 1 Credit

**EE8107 Digital Communications**
The class is intended to introduce the student to the concepts and theory of digital communications. The concepts of information, channel capacity, error probability, intersymbol interference, pulse shaping and spectrum shaping and optimum filtering are discussed. Digital multiplexing and bit stuffing, encoding, scrambling, equalization and synchronization problems are studied. Regenerative repeaters, M-ary signaling systems, basic modulation techniques - ASK, PSK and FSK; and performance characteristics of digital transmission systems are considered. 1 Credit

**EE8108 Multimedia Processing and Communications**
This course will touch some of the fundamental issues in media processing and applications. It will start with a quick look at the standards which set the baseline work for multimedia, such as MPEG-4 and MPEG-7. It will then present to the class the latest and the most important issues in multimedia, including indexing and retrieval, media coding, media transmission, human-computer interface, image and speech processing for multimedia, wireless multimedia, and more. Examples, demonstrations, and applications will also be provided. 1 Credit

**EE8109 Wireless Communications I**
This class provides an overview of wireless communications systems and fundamental analysis and design techniques. The class introduces cellular system, channel characterization for propagation losses, fading, and interference. Coding, modulation, and advanced transceiver design issues are examined. Modern mobile wireless communication system applications are reviewed.
1 Credit

**EE8111 Digital Signal Processing II**
This course covers signal processing topics such as discrete cosine transform, principal component analysis, continuous and discrete wavelet transforms, multirate filterbanks, independent component analysis, and quadratic time-frequency distributions. Applications of the above techniques in denoising, data compression, feature extraction, and source localization will also be discussed. Prerequisite: EE8105 or equivalent. 1 Credit

**EE8114 Optical Communications and Networks**
The objective of the course is to provide an in-depth understanding of light wave communication systems. Active and passive state of the art photonic devices that form the backbone of high-speed optical systems will be studied. Theoretical and practical aspects of the devices as well as the optical channel will be evaluated. Relevant issues such as analog and digital optical modulation techniques, noise sources and mechanisms, optical signal processing techniques and multiple access techniques such as DWDM (dense wavelength division multiplexing) and CDMA (code division multiple access) will also be covered. Both the guided (fiber based) and free space (optical wireless) systems will be discussed. 1 Credit

**EE8121 Wireless Networks**
This course is a moderately advanced level course on wireless networks. This course will assume necessary background knowledge in Internet Protocol (IP) networks with particular emphasis on routing, transport protocol design (congestion control and flow control), and quality of service and then build upon it. In particular, this course focuses on four major areas of wireless networks: (1) Design of different WNs including their integration, (2) Medium access control for WN, (3) Routing in WN, and (4) TCP design for WN. A discussion on applications and security is also included to introduce the students with those topics. 1 Credit.

**EE8122 Opto-electronic Devices**
This course offers a comprehensive overview of optical properties of semiconductors devices. The course begins with the transmission properties of electromagnetic wave in different media. This introduction is followed by the devices that generate light: light-emitting diodes (LEDs) and laser diodes (LDs). Topics also include optical spectra and transitions, spontaneous and stimulated emission, population inversion, carrier and optical confinements in heterostructures, etc. Some of the most popular devices such as LCD, CCD, DVD and LED will be discussed. The last part is the semiconductor photodetectors such as photoconductors, photodiodes and avalanche photodiodes. 1 Credit.

**EE8123 Radio Frequency Circuits and Systems**
This course deals with the design of CMOS circuits & systems for wireless communications. Key components include introduction of RF transceivers, impedance transformation, noise, low-noise amplifiers, mixers, frequency synthesizers, and power amplifiers. Antirequisite: ELE804 1 Credit

**EE8124 5G Wireless Communications and IoT**
The class provides an overview of 5G wireless communications systems and Internet of Things (IoT) with fundamental analysis and design techniques. The class introduces 5G cellular system, channel characterization for propagation, fading, and interference. Advanced 5G modulation and multiple access design issues may be examined. Relevant state-of-the-art communications and Iot technologies, such as localization and tracking, may also be introduced. Prerequisite: UG Digital Communications. 1 Credit

**EE8202 Digital Image Processing I**
This course starts with the introduction to digital image fundamentals, imaging geometry, and image storage formats. Simple spatial domain techniques as well as spatial frequency domain methods and digital filter design for image enhancement and restoration are discussed. Low-level image segmentation and feature extraction concepts will also be introduced. Special topics in application of image processing including remote sensing, medical imaging, etc. will be presented. 1 Credit

**EE8204 Neural Networks**
The class deals with preliminaries of artificial neural systems including fundamental concepts and models. Single layer perception classifiers and multi-layer feed forward networks, single-layer feedback networks, and associative memories are covered. 1 Credit

**EE8205 Embedded Computer Systems**
This course focuses on the design and implementation of software for embedded systems. High performance embedded system and safety critical embedded system architecture will be introduced, Fault-tolerant and reliable embedded system design techniques are also highlighted. The main topics to be covered include embedded computer organization, hardware/software codesign of embedded systems, CAD tools for hardware/software codesign, system on chip, advance concepts of real-time operating systems and real-time scheduling. The course introduces the technologies used in the design of embedded systems such as processor cores, embedded system specification languages, and software tools for hardware/software co-verification and system partitioning. The application of embedded systems for emerging networking and medical devices will also be covered. 1 Credit

**EE8208 Architectural Synthesis & Design of Digital Systems**
This course will explore the methodologies for high-level architectural synthesis and low-level logic design of digital systems and architecture-to-task optimization techniques. Topics will include: architecture overview of modern computing systems, overview of recent hardware basis for custom digital systems (FPGA and CPLD) and hardware description languages (VHDL), methodology for high-level architectural synthesis including resource scheduling and binding, and low-level logic synthesis of digital systems. Case studies on synthesis process of digital systems from functional and technical specification to electrical schematic diagram will be discussed. Students are expected to read selected papers from current research literature, learn one of hardware description languages (VHDL or Verilog) and perform a project using a commercial CAD system. 1 Credit

**EE8209 Intelligent Systems**
This course introduces the fundamental practice and underlying principles involved in the study of intelligent systems. The emphasis of the course is on a practical approach to problem solving and learning processes in the context of neural networks. In addition to theoretical, mathematical, and implementation of such systems students will get exposure to some of the popular intelligent systems tools. Applications in signal processing, pattern recognition and vision will be considered. Antirequisite: ELE888 1 Credit

**EE8212 Digital Image Processing II**
This course deals with advanced concepts in digital image processing. In particular, emphasis will be on color image processing. The concepts that will be covered include: color vision, trichromacy theory, color spaces, colour image creation/representation/storage, component colour image processing, vector colour image processing, segmentation, and colour image compression. The course will include a practical aspect by discussing applications and implementations of image processing techniques currently in use in industry. The course will have student implemented assignments and projects that will require hands-on programming, literature reviews and oral presentation. Prerequisite: EE8202 or equivalent 1 Credit

**EE8213 Computer Network Security**
This course provides a thorough understanding of technologies and methodologies in network security. It deals with the fundamental techniques used in implementing secure network communications, and forms of attacks on computer networks and approaches to their prevention and detection. Topics that are covered include Introduction to Cryptography, Virtual Private Networks (VPN), Firewalls and intrusion detection techniques. In addition, the course covers worms, viruses, and DDOS attacks and their remedies. Kerberos authentication Protocol, SSL, and anonymous communication protocols. 1 Credit

**EE8214 Computer Systems Modeling**
The objectives of this course are to study the characteristics of various analytical models of computer systems and to learn how to apply those models to analyze system performance and dependability. The modeling techniques to be covered include Poisson, renewal, Markov processes, fault trees, Petri nets and queuing networks. Examples include models of computer systems, computer networks, and wireless systems. 1 Credit

**EE8215 Human Computer Interaction**
The course is designed as an introduction to Human Computer Interaction from the perspective of human capabilities and limitations. It will provide the student with an understanding of human sensory systems and information processing models to support future work in any systems design where there is a human interface. Applications range from basic computer interfaces and web page design to semi-autonomous robotics and remote systems control to the design of complex systems such as flight simulators or other virtual environments. By the end of the course, the student will have gained knowledge in some of the essentials of cognitive human factors and information theory concepts, and an understanding of factors that affect human performance such as memory, learning, attention and reaction times. The student will be capable of specifying displays and controls to optimize overall useability and system performance outcomes. Prerequisite: CMN432, BME506, BME705, BLG601 or equiv. Antirequisite: BME802 1 Credit

**EE8216 Computer Networks**
This is an advanced course in computer networking. The course is designed to include materials relevant to the industry, for example IP QoS and TE necessary for VOIP and MPLS services. The course deals with the principles, architectures, algorithms, and protocols related to Internet, with emphasis on routing, transport protocol design, flow control and congestion control, IP Quality of Service and Traffic Engineering. It also introduces IP security. Anti-requisite: COE865 or ELE865. 1 Credit

**EE8217 Reconfigurable Computing Systems**
This course will introduce the theory and engineering design principles of the modern reconfigurable computing systems (RCS). The emphasis is on the understanding of the concepts of architecture reconfigurability, programmable logic devices and optimization of the RCS architecture to the task algorithm and data structure. It will also cover basics of the complex programmable logic devices, and FPGA organization and RCS architectures based on these devices. The survey of RCS and areas of their application will also be provided. Languages and compilers for the RSC are other aspects to be covered in this course. Course gives brief description of RCS application in DSP, video and image processing, and supercomputing. Then the specifics of RCS design will be discussed including DSP and embedded processor design flow, modular and incremental design. Synthesis, simulation and verification design tools also will be discussed in details. 1 Credit

**EE8218 Parallel Computing**
This course will introduce students to parallel computing including parallel algorithms, parallel programming and different parallel architectures. It covers the basic programming models used in parallel computers, parallel algorithms, parallel programming, the shared memory multiprocessor and NUMA multiprocessor. The Laboratory projects include parallel programming using one of the parallel models. 1 Credit

**EE8219 Arch of Field-Programmable Gate Arrays**
This course will cover the following: Modelling and Evaluation of FPGA Architectures, High-Level CAD Algorithms used in FPGA Architectural Evaluation – Synthesis, Technology Mapping and Packing Tools, Physical-Level CAD Algorithms used in FPGA Architectural Evaluation – Placement and Routing Tools, Architecture and Computer-Aided Design (CAD) Tools for Commercial FPGAs, Power Modelling and Power-Aware CAD Tools for FPGAs, Low Power FPGA Architectures and Circuit-Level Design Techniques, Dynamically Reconfigurable Architectures. 1 Credit.

**EE8220 Advanced Digital Filters**
This course will enable graduate students to pursue research in digital filters in one and more dimensions, which are applied to such diverse fields as radar, sonar, telecommunications, biomedicine and image/video processing. The students will be encouraged to develop designs and introduce their filters to novel applications. 1 Credit

**EE8221 Systems-on-Chip Design**
This course covers the advances in system-on-chip (SoC) design, hardware-software co-synthesis and network-on-chip techn ologies. It provides the advance knowledge required for design and development of embedded system on a chip and multi-core architectures. The main principles of embedded system modeling and design will be explored. Various soft processors (Nios-11, ARM) and other IP cores will be studied and SoC design tools (Quartus II, SOPC builder) will be employed in course projects. Antirequisite: COE838 1 Credit

**EE8222 Advanced Data Engineering**
The objective of this course is to familiarize students with how big data can be stored, maintained and distributed in an effective and efficient way. The course will cover noSQL, MapReduce, SQL on Hadoop, Spark, stream processing systems and main memory data processing techniques. This course will also briefly touch on topics such as semi-

structured data, semantic relations, resource description framework, querying semantic information, ontologies, reasoning and the linked open data. 1 Credit

**EE8223 Deep Learning**
A course on the theory, design, and implementation of neural networks and deep learning. The topics include multilayer neural networks, back propagation algorithm, deep learning in Convolutional neural networks, recurrent neural networks, and LSTM. 0ther state-of-the-art deep learning/AI algorithms and their applications may also be introduced. 1 Credit

**EE8225 IOT Analytics**
Internet of Things (IoT) analytics extracts important information from the vast amount of data generated by sensors and smart devices. This IoT Analytics course targets the unmet demand for these skills in every industry vertical. This course is designed to give students an overview of IoT data, state of the practice in IoT analytics, and analytics life-cycle as an end-to-end process. This course presents concepts related to data science research activities including IoT Data Management, IoT Data Modeling, Regression Models, Deep Learning, Social Data Analysis, Anomaly Detection, Machine Learning, Text Analysis. 1 Credit

**EE8226 Sustainability Engineering**
The course will cover the background on environmental issues, and will emphasize the impact and relevance of the student's field of research on these issues. Topics include the role of emerging technologies in improving environmental outcomes. Applications include energy, electronics, infrastructure, logistics, sourcing, waste, and resource management. Industry standards and best practices will be introduced including economic and social issues and effects. Materials and resource life cycles will be covered in a global context. The course content will be supported by a design and problem solving assignment, as well as a course project. 1 Credit

**EE8227 Secure Machine Learning**
This course focuses on the theories and techniques of enhancing the security and robustness of machine learning algorithms. Machine learning algorithms are increasingly used in safety critical environments such as self-driving cars and diagnostic imaging. Modern machine learning and deep learning models are shown to be vulnerable to a slight perturbation of input queries or training datasets. A number of machine learning algorithms can also expose private information about individuals. Disclosure of sensitive data not only leads to privacy breaches, but also could result in discrimination or issues of fairness. This course is designed to fill this gap and specifically covers the following topics: privacy preserving statistics and machine learning; adversarial machine learning; certified robustness; poisoning attacks and countermeasures; accountability, transparency and interpretability in machine learning, federated learning to support privacy; and considerations for trustworthy machine learning. The course is open to interested engineering graduate students with a solid undergraduate-level mathematical background. Undergraduate level knowledge of probability, statistics, algorithms and data structures, and machine learning is assumed. Familiarity with information security and deep learning would be helpful but not necessary. 1 Credit

**EE8228 Neural Information Processing and Retrieval**
This course introduces students to the cutting-edge advances in deep learning and neural networks for Information Retrieval (IR) and Information Processing (IP). Applications of IR and IP include Web search, Web advertising, machine translation, automatic question answering systems, and text summarization. This course provides students with basic knowledge to comprehend the state-of-the-art IR and IP methods based on deep learning and learn the necessary skills to design and implement their own models for IR and IP tasks. Prerequisite: UG course (e.g. ELE 888), OR a graduate course (e.g. EE8204, EE 8603, EE 8209). 1 Credit

**EE8229 Distributed and Cloud Computing**
This course covers topics related to distributed computing and cloud systems. It presents distributed system architectures; client-server and peer to peer system design; Threading and multi-process computing models; concurrency, synchronization, and inter-process communication; replication, consistency, fault tolerance and recovery. Client-server application design for web application and its full stack implementation are discussed. Web application development using Python framework on a public cloud is covered. Cloud service models; virtualization using VM and containers; their orchestration and performance issues are discussed. Case studies on public and private clouds are presented. Recent developments of multi-cloud and edge clouds are introduced. It includes a major project on the development of distributed software using Python framework and its deployment on a public cloud. Prerequisite: EE8216. Antirequisite: COE892. 1 Credit

**EE8230 Machine Learning for Engineers**
This course will provide an engineering-focused introduction to key concepts in machine learning. Theoretical concepts such as supervised, unsupervised learning, k-nearest neighbors, random

forests, convolutional neural networks, attention mechanism will be introduced. Practical applications of such concepts will be taught through implementation in Python, Pandas, Numpy, SciPy, and PyTorch. Students will also get an in-depth analysis on ethical issues in machine learning and how they affect engineering (limitations of training data, fairness and error functions). 1 Credit

**EE8301 Linear System Theory**
The main thrust of the class is to introduce an algebraic unification of finite-dimensional linear systems with emphasis on continuous and discrete dynamic systems, using an operator theoretic approach. Topics covered include transition matrices, functions of matrices, adjoint systems, weighing patterns, realizability; canonical forms; stability, minimal realization; minimum norm, and approximation problems. 1 Credit

**EE8401 Computer Methods in Power System Analysis**
Advanced topics in load flow analysis; Decoupled load flow, inclusion of high-voltage direct current links in load flow. Parameter estimation for power systems. Static state estimation. Load modeling. 1 Credit

**EE8403 Advanced Topics in Power Systems**
Basic concepts. Review of optimization techniques. Linear and non-linear programming. Pontryagin's maximum principle. Fletcher-Powell method, etc. Systems security monitoring. State estimation. Optimal power flow. Real and reactive power optimization. On-line optimization. Load dispatching. Generator scheduling, maintenance scheduling in hydro, thermal and hydrothermal systems. Some case studies. 1 Credit

**EE8405 Power System Stability and Control**
This is an advanced course in power system stability studies focused on the design of digital signal processing systems for improvement of steady state and transient power system stabilities. This course provides studies on analytical techniques and computer methods for power system stability enhancement, and digital signal processing control design and implementation of advanced power system stabilizers. 1 Credit

**EE8407 Power Converter Systems**
Principle of ac to dc converters, dc/dc and dc/ac converters, voltage and current source converters, multi-level high-power converters, pulse width modulation techniques, harmonic reduction techniques, modeling and simulation techniques, and industrial applications. 1 Credit

**EE8408 Switch Mode Power Supplies**
Flyback converters, forward converters, bridge converters, Cuk converters, pre-regulators, inrush control, start-up methods, overvoltage and undervoltage protections, foldback current limiting, output filters, transformer design, induction and choke design, current mode control, stability. 1 Credit

**EE8409 Electromagnetic Theory**
The course will cover the following: Electromagnetostatic fields, Maxwell's equations in the time domain, and in the frequency domain using Fourier integral transform, Poynting and uniqueness theorems, losses due to polarization damping forces, Helmholtz wave equation, auxiliary potential functions, reciprocity theorem. Transverse electromagnetic waves, wave polarization, reflection and transmission at interfaces, wave-transmission matrices, oblique incidence, electromagnetic radiation from fast transients, lightning-generated electromagnetic pulse. 1 Credit

**EE8410 Power Electronics**
A course on microprocessor-controlled solid state converters. Major topics include: solid state switching devices, dc-dc switch mode converters, diode & thyristor rectifiers, current & voltage source inverters, industry applications and microprocessor programming techniques. Typical control schemes for these converters will also be discussed. Important concepts are illustrated with design projects. 1 Credit

**EE8416 Modeling and Control of Power-Electronic**
This course will enable graduate students to pursue research in the area of design, modelling and analysis of static, electronic, power converters. Even though the presented methodologies are rather general and thus applicable to various types of power-electronic converters, the emphasis will be on the three-phase Voltage-Sources Converter (VSC) technology, which is widely employed in such systems as Distributed Energy Resource (DER) systems; active distribution systems and micro grids; photovoltaic (PV), and fuel-cell energy systems; Flexible AC Transmissions Systems (FACTS) ; and High Voltage DC (HVDC) transmissions. 1 Credit

**EE8417 Vector Control of Rotating Machines**
This course will enable graduate students to pursue research in the area of advanced control of rotating electric machines. The applications include regenerative industrial drives, rotating-machine-based distributed generation and energy storage systems, high-performance position-control machines, and transportation systems. The course will teach methodologies for design, parameter selection, and signal-processing and estimation techniques pertaining to advance control of rotating electric machines. 1 Credit

**EE8418 Antenna Theory and Design**
The course introduces the fundamental principles of Analysis and design of antennas. This course develops an interest for research in the area of antennas for mobile wireless and advanced communications systems. Particular topics covered are: fundamental parameters of antennas such as radiation patterns, directivity, gain, near field and far field zones, Detailed Analysis of traditional antennas such as linear wire antennas, loops, arrays and aperture antennas. 1 Credit

**EE8419 Integration of DER**
Distributed Energy Resources (DERs), such as wind, photovoltaic, and battery energy systems, are rapidly increasing in power systems. This course discusses their impacts on the power system stability and protection. It is designed to cover DER modeling and control, DERs fault ride through, microgrid control, stability, and protection, and cyber-physical security of smart grids. This course will enable graduate students to pursue research on smart grid stability. 1 Credit

**EE8420 Microwave Engineering**
Introduction to microwave technology, transmission line theory and applications, standing waves and voltage standing wave ratio (VSWR), examples of practical transmission lines, the Smith chart, power flow, transmission-line impedance matching networks, L-section lumped-element matching networks, Z, Y, S and ABCD parameters, passive microwave devices: power dividers and directional couplers, introduction to Computer Aided Design (CAD) techniques, theory and design of microwave amplifiers: FETs, BJTs, 2-port power gains, amplifier stability, design for maximum gain, specified gain, and minimum noise figure. Prerequisite: ELE 531. Antirequisite: ELE861. 1 Credit.

**EE8502 CMOS Analog Integrated Circuits**
The course deals with fundamental concepts in the design of analog CMOS circuits. Key topics include MOS device physics, I characteristics, regions of operation, small-signal model, single-transistor amplifiers, cascodes, differential voltage amplifier, frequency response of amplifiers, noise, feedback, CMOS op amps, systematic design of op amps, bandgap references, biasing circuits, voltage regulators, filter implementation in CMOS. Antirequisite ELE727. 1 Credit

**EE8503 VLSI Circuits and Systems for Communications**
An advanced course on the design of VLSI circuits for data communications over wire channels. The theoretical component has : modeling of wire channels, electrical signaling, fundamentals of serial data links, channel equalization (pre-emphasis, continuous-time linear equalization, decision feedback equalization, adaptive decision feedback equalization), clock and data recovery (frequency-locked loops, delay-locked loops, phase-locked loops, phase-tracking / phase-picking clock and data recovery), and serializers and de-serializers. The laboratory component consists of the design of a serial data link using CMOS technologies. Antirequisite: ELE863 1 Credit

**EE8504 Adv VLSI/FPGA Sys Design & Opt Alg**
The objective of this course is to introduce the fundamental principles of VLSI (Very Large Scale Integrated) circuit design and layout. This course is targeted towards an introduction to the mathematical topics of “algorithmic graph theory”, and will be followed by introductions to “computational complexity” and “general methods for Combinatorial optimization” for layout partitioning, floorplanning, placement, routing and compaction based on exact mathematical programming (linear, integer and nonlinear programming) as well as an introduction to advanced heuristic techniques (i.e. Tabu search, genetic algorithms and simulated annealing, neural networks, etc.). 1 Credit

**EE8505 Digital Systems Testing**
The course covers theory and techniques for digital systems testing and testable design. The concepts of fault modeling, fault simulation, test generation, bridging faults testing, functional testing, and logic-level diagnosis are examined. RAM testing, PLA testing, FPGA and microprocessor testing, and design for testability issues are discussed. Compression techniques, built-in self-test and self-checking circuits are considered. 1 Credit

**EE8506 Digital CMOS VLSI Integrated Circuits**
This course will provide students with various topics in the design and analysis of digital CMOS VLSI integrated circuits. Some of these topics will be discussed deeply and other moderately. The major topics to be covered are: (1) System-level and intellectual property block design methodologies, (2) MOSFET (Metal Oxide Semiconductor Field Effect Transistor) modeling and analysis, (3) Logic families such as complementary CMOS, ratioed CMOS, and dynamic CMOS, (4) Circuit characterization and performance estimation, (5) Interconnects analysis and modeling, (6) Sequential circuits design, and (7) Subsystems design and analysis. Antirequisite: ELE734 1 Credit

**EE8507 CMOS Mixed-Signal Circuits and Systems**
This course deals with CMOS mixed-mode circuits and systems. Key topics include delay-locked loops and phase-locked loops, analog-to-digital converters (flash, pipelined, and successive approximation, and delta-sigma), time-to-digital converters, all-digital phase-locked loops, simultaneous switching noise and analog/digital grounding. Antirequisite: ELE827. 1 Credit

**EE8601 Directed Studies in Electrical Engineering**
This class is available to graduate students in electrical engineering, who wish to gain knowledge in a specific area for which no graduate-level classes are offered. Students are assigned an advisor and are required to present a formal report, or take a formal examination, at the end of the class. 1 Credit

**EE8603 Selected Topics in Computer Engineering I**
This course consists of lectures, seminars, and readings covering the latest advances and research in Computer Engineering such as communications, signal processing, and computer hardware and software. The course description will be announced prior to scheduling of the course. 1 Credit

**EE8604 Selected Topics in Electrical Engineering I**
This course consists of lectures, seminars, and readings covering the latest advances and research in electrical Engineering such as electronics, electromagnetics, controls and power devices. The course description will be announced prior to scheduling of the course. 1 Credit

**EE8605 Selected Topics in Computer Science I**
This course consists of lectures, seminars, and readings covering the latest advances and research in Computer Science. The course description will be announced prior to scheduling of the course. 1 Credit

**EE8606 Selected Topics in Biomedical Engineering I**
This course consists of lectures, seminars, and readings covering the latest advances and research in Biomedical Engineering. The course description will be announced prior to scheduling of the course. 1 Credit

**EE8607 Selected Topics in Computer Engineering II**
This course consists of lectures, seminars, and readings covering the latest advances and research in Computer Engineering. The course description will be announced prior to scheduling of the course. 1 Credit

**EE8608 Selected Topics in Electrical Engineering II**
This course consists of lectures, seminars, and readings covering the latest advances and research in Electrical Engineering . The course description will be announced prior to scheduling of the course. 1 Credit

**EE8610 Selected Topics in Biomedical Engineering II**
This course consists of lectures, seminars, and readings covering the latest advances and research in Biomedical Engineering. The course description will be announced prior to scheduling of the course. 1 Credit

**EE8901 Smart Grids**
This course introduces the concept or promise of smart grids. 1 Credit

**EE8902 Demand Management and Conservation**
This course shall describe various methods for peak demand reduction and conserving energy. 1 Credit

**EE8903 Energy Storage and Use**
This course shall survey and describe new and promising technologies for energy storage. 1 Credit

**EE8904 Electricity Markets**
Energy business is driven by economics and this course shall discuss various forms of electric energy and their economic characteristics for electricity sector. 1 Credit

**EE8905 Diploma Project**
The project will focus on comprehension of new technologies and energy innovation in the context of economics, enabling diploma students to make informed decisions in their workplace. 1 Credit

**EE9010 PhD Research Seminar in Electrical and Computer Engineering**
This course consists of weekly seminars with emphasis on current research in the specialization fields and emerging areas of electrical and computer engineering. This course will run through Fall and Winter semesters, 1 hour/week. Presentations will be given by graduate students, faculty members, visiting scholars and guest speakers. In order to achieve a pass grade in the course, the student must attend a minimum of 75% of the seminars. Pass/Fail.

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