Master of Science in Electrical Engineering
Program code: 061010

INTRODUCTION

The Department of Electrical Engineering (College of Engineering and Petroleum) offers a Master of Science Program in **Electrical Engineering**. Degree requirements include either thesis or non-thesis options. The objective of the program is to demonstrate individual accomplishment of high professional and academic standard. At present research is being carried out in the following general areas: Power Systems, Electrical Machines, Control Systems, Microwave Integrated Circuits, Microwave Solid State Devices, Communication, Radar and Multidimensional Digital Signal Processing. English is the Language of instruction and research. The program offers both thesis and non-thesis options.

According to the University Council decision dated 4/2/2007, Thesis students admitted with effect from September 2007 are exempted from the comprehensive examination.

PROGRAM REQUIREMENTS

33 (33) TOTAL COURSE CREDITS(non-thesis option in Parenthesis)

6 (6) CORE COURSES (3 credits each)

Student choose 6 credits from the following courses:

0600-503 Statistical Concepts in Engineering
0600-504 Numerical Analysis and Computation
0600-507 Mathematical Optimization
0600-508 Random Variables and Stochastic Processes
0600-512 Advanced Engineering Mathematics I
0600-513 Advanced Engineering Mathematics II

12 (15) SUBDISCIPLINE COURSES (3 credits each)

Student chooses 12 credits (for thesis option) or 15 credits (for non-thesis option) from the following subdisciplines courses:

0610-510 Lumped Systems Theory
0610-520 Advanced Computational Electromagnetics
0610-521 Microwave Circuits and Measurements
0610-522 Antenna Theory and Design
0610-523 Electromagnetic Guided Waves and Applications
0610-524 Advanced Topics in Networking
0610-525 Digital Multimedia Compression
0610-526 Mobile Networking
0610-527 Data and Network Security
0610-528 Wireless Communication Networks

0610-530 Solid State Electronics
0610-531 Microwave Devices
0610-532 Integrated Electronics
0610-537 Introduction to VLSI Design
0610-538 Computer Aided Design for VLSI
0610-539 Optical Electronics
0610-541 Rotating Machine Dynamics
0610-542 Power Electronics
0610-543 Power Electronics Modeling and control
0610-551 Power Engineering Analysis
0610-552 Protective Relaying
0610-553 Optimization and Economic Operation of Power Systems
0610-554 Electrical Transients in Power Systems
0610-555 High Voltage Engineering
0610-559 Special Topics in Power Engineering
0610-571 Fault Tolerant Control
0610-573 System Identification
0610-574 Real-Time Computer Control
0610-575 Large Scale Systems
0610-576 System Optimal Control Theory
0610-577 Nonlinear Systems
0610-578 Computer Controlled Processes
0610-579 Special Topics in Systems Engineering
0610-581 Communication Theory
0610-582 Spread Spectrum and Code Division Multiple Access
0610-583 Information Theory
0610-584 Communication Systems
0610-585 Two-Dimensional Signal Processing
0610-586 Detection of Signal in Noise
0610-587 Terrestrial and Space Communication Systems
0610-588 Optical Fiber Communication Systems
0610-589 Special Topics in Communications
0610-590 Special Topics in Electronics
0610-536 Solar Cells
0610-540 Renewable Energies in Electrical Systems

6 (9) FREE ELECTIVE COURSES

A maximum of 3 credits hours (thesis students) and 6 credits hours (project students) of graduate courses can be taken from:

- Area of Engineering (Core and elective)
- Area of Science
- Area of Joint Graduate Programs (Engineering/Science Specialization)

with the approval of the graduate program director before registering for the course.

Crosslisted Courses

The student is not allowed to register two crosslisted courses in the same semester. In case a student completes two crosslisted courses in different semesters, only the first course will be calculated towards the degree.

Course Title (Computer Engineering)	Course Title (Electrical Engineering)
0612-575 Advanced Topics in Computer Networks	0610-524 Advanced Topics in Networking
0612-502 Digital Image Processing	0610-525 Digital Multimedia Compression
0612-574 Mobile Networking	0610-526 Mobile Networking
0612-576 Modern Cryptography and Network Security	0610-527 Data and Network Security
0612-573 Wireless Communication Systems	0610-528 Wireless Communication Networks
0612-572 Principles of VLSI Digital	0610-537 Introduction to VLSI Digital

9 (3) COMPULSORY COURSES

0610-592 Seminar (0)
0610-593 Project (3) (non-thesis option only)
0610-597 Thesis (0)
0610-598 Thesis (0)
2000-599 Thesis (9)

COURSE DESCRIPTION

0610-510: LUMPED SYSTEMS THEORY
CR: 3

Basic methods of modern system theory. Time domain techniques for both linear and nonlinear systems. Characterisation of both continuous and discrete time linear systems in the time and frequency domain. stability, controllability and observability for linear and nonlinear systems.

0610-520: ADVANCED COMPUTATIONAL ELECTROMAGNETICS: FDTD
CR: 3

Finite differences representations of Maxwell's equations, Numerical dispersion and numerical stability, Source implementations, Absorbing boundary conditions, High-order schemes and other recent advances in FDTD, Practical applications.

0610-521: MICROWAVE CIRCUITS AND MEASUREMENTS
CR: 3

Scattering parameters representation of microwave circuits, directional couplers, microwave junctions, attenuators, phase shifters, circulators, filters, microstrip lines. Techniques of microwave measurements.

0610-522: ANTENNA THEORY AND DESIGN
CR: 3

The far-field integrals, resiprocity, directivity. Radiation patterns of dipoles and loops. Radiation patterns of horn and slot antennas. Linear arrays: analysis and synthesis. Self impedance and mutual impedance of dipoles. The design of feeding structures for antenna elements. Reflectors and lenses.

0610-523: ELECTROMAGNETIC GUIDED WAVES AND APPLICATIONS
CR: 3

Waveguides with metallic boundaries, Mode orthogonality, Modal expansion Excitation by simple sources. Constant impedance wall waveguides. The corrugated waveguide as a low crosspolar radiator. Waveguides with imperfect walls: The earth Ionosphere guide and the Tunnel Guide as examples of natural waveguides. Dielectric waveguides: i) The Optical Fiber Guide, ii) Millimeter waveguides. The Microstrip line and the Coplanar Waveguide: Characteristics of single and coupled lines. Numerical methods for waveguide analysis.

0610-524: ADVANCED TOPICS IN NETWORKING
CR: 3

Networking overview, Protocols, Multimedia issues, Packet switching networks, Intelligent Networks, Ad-hoc and Sensor Networks, Mobile Networking, and current trends in high speed networking.

0610-525: DIGITAL MULTIMEDIA COMPRESSION
CR: 3

Basics of lossless compression techniques, Universal coding schemes, Dictionary based LZ algorithms, Arithmetic coding, Lossless image compression, G3/G4 facsimile coding, JBIG standard, Scalar and Vector quantization. Lossy image and audio compression, Predictive coding, Transform coding, Subband coding, Multimedia compression standards, JPEG2000, H.263 and variants, MPEG-1,2 and 4.

0610-526: MOBILE NETWORKING
CR: 3

Introduction and Fundementals, Medium Access Control Protocols, Cellular Networks, Wireless Internet, 4G and beyond Systems, and Pervasive Networking.

0610-527: DATA AND NETWORK SECURITY
CR: 3

Introduction to networks and information theory, Cryptography, Network security modeling, IP security, E-business security, Network management security, System security, Firewalls, and Current trends in network security.

0610-528: WIRELESS COMMUNICATION NETWORKS
CR: 3

Introduction to wireless communication principles, the cellular concept-system design issues, signal propogation and link budgets for wireless links, communication over fading channels, modulation, multiplexing, and multiple access techniques, channel coding for wireless systems, equalization and diversity, wireless communication networks and standards.

0610-530: SOLID STATE ELECTRONICS
CR: 3

Crystallographic properties of semiconductors, Physical models of the atom including the Quantum model, atomic structure and periodic table, Energy bands, charge carriers and excess carriers in semiconductors, Fermi-Dirac statistics, Basic semiconductor equations, Optical absorption, Quantitative theory of semiconductor devices: 1. PN Junction diodes, 2. Bipolar Junction Transistors, 3. MOS transistors, including steady state and transient analysis, high frequency properties, charge control model, Special devices such as photo-diodes, Schottky diodes, CCDs, etc..

0610-531: MICROWAVE DEVICES
CR: 3

Varactor diodes, parametric amplifiers, pindiodes, transferred electron devices. Transit time devices, IMPATTS, BARITTS, travelling wave tubes, klystrons, magnetrons, MESFET, harmonic multipliers.

0610-532: INTEGRATED ELECTRONICS
CR: 3

Models for Integrated-circuit active devices. Basic Integrated circuit building blocks. Bipolar MOS and BICMOS operational amplifiers. Design and Analysis. Frequency response of Integrated circuits. Nonlinear analog circuits. Noise in integrated circuits.

0610-537: INTRODUCTION TO VLSI DESIGN
CR: 3

Design and implementation of CMOS digital circuits including: The inverter (complexity, static, dynamic, power, delay, scaling effects). Combinational logic gates and arithmetic building blocks (static, dynamic, cascading, power, choice of logic family). Sequential logic circuits and memories (static, dynamic, non-bistable), RAM ROM. PLAS, Introduction to stick diagrams, to symbolic layout rules and to use layout editors. A silicon CMOS design project leading to a complete layout of a digital block designed and simulated using L-edit tools is an integral part of the course.

0610-538: COMPUTER AIDED DESIGN FOR VLSI
CR: 3

Mixed analog and digital simulation techniques. Symbolic layout and compaction techniques. Simulated annealing Verification methods. Logic and high level synthesis. Managing design complexity.

0610-539: OPTICAL ELECTRONICS
CR. 3

Fundamentals of quantum electronics. Modulation of light. Photoemitters and detectors. Display devices. Theory of Laser Oscillators, specific Laser Systems. Semiconductors Lasers; theory and applications.

0610-541: ROTATING MACHINE DYNAMICS
CR: 3

Applications of dynamic network theory to electromechanical energy conversion problems. Linear transformations; power invariant transformations, the generalized rotating machine; dynamic and steady-state response of machines.

0610-542: POWER ELECTRONICS
CR: 3

Thyristor equivalent circuit, static and dynamic characteristics, Power transistors. DC Choppers, Pulse width modulated inverts. Resonant Pulse Converters, Power Supplies, DC drives, AC drives, Protection of devices and circuits.

0610-543: POWER ELECTRONICS MODELING AND CONTROL
CR: 3

Direct power conversion circuit averaging state-space average models, linear and piecewise linear models, design of voltage-mode and current mode regulators, sliding-mode control applications, modeling electric machines, the theory of field orientation and vector control in high performance AC motor drives, application of the above techniques in practice; case studies.

0610-551: POWER ENGINEERING ANALYSIS
CR: 3

Multiwinding power transformers design features, the n-winding ideal transformer, 3-phase auto transformers, the transformer as a control device. High voltage direct current transmission HVDC: General aspects and comparison with AC transmission converter circuits, analysis of bridge converters, converter charts, harmonics and filters, ground return. Reactive power control. Reactive power control: Load compensation, steady state reactive power control in transmission System, effect on power system. Dynamics, static compensatory, series capacitors, syn. condensers, reactive power coordination. Power system harmonics, sources, system response to harmonics, harmonic pollution in networks, methods of analysis, standards and limits.

0610-552: PROTECTIVE RELAYING
CR: 3

Fundamentals of instrumentation. Design and operation of protective schemes for equipment in generation, transmission and distribution circuits. Analysis of abnormal system conditions requiring relay operation.

0610-553: OPTIMIZATION AND ECONOMIC OPERATION OF POWER SYSTEMS
CR: 3

Relevant factors in power system operation. Theory of optimization under equality and inequality constraints, computational methods and application to generation scheduling.

0610-554: ELECTRICAL TRANSIENTS IN POWER SYSTEMS
CR: 3

Simple switching transients. Abnormal transients. Transients in 3-phase circuits. Electromagnetic phenomena of importance under transient conditions. Traveling waves on lines. Lighting. Behaviour of windings under transient conditions. Protection against transient over voltages. Transients in integrated power networks. Computer aids to the calculation of transients.

0610-555: HIGH VOLTAGE ENGINEERING
CR: 3

Ionization and decay processes, electric breakdown in gases, liquid and solid dielectric, generation of high DC, AC and impulse voltages, measurement of high voltage.

0610-559: SPECIAL TOPICS IN POWER ENGINEERING
CR: 3

An upper division of graduate technical elective treating topics in Electrical Power Engineering not included in other Electrical Power Engineering courses.

0610-571: FAULT TOLERANT CONTROL
CR: 3

Fault tolerant control deals with the control of a system where fault and system changes may occur. First, a diagnosis of the system faults or changes are derived. Then, the controller is reconfigured or redesigned based on the information from the diagnosis. The course covers model-based Fault Diagnosis methods, Actuator and Sensor Fault-tolerant control design, passive and active Fault-tolerant control systems, redundancy in Fault-tolerant control systems, and case studies.

0610-573: SYSTEM IDENTIFICATION
CR: 3

The identification of linear dynamic systems. Problem formulation. Review of classical techniques and their limitations. Least squares techniques and their variations as applied to the transfer function and state space description of linear discrete time systems. Recursive techniques and Kalman filters. The maximum likelihood estimators. Mode and structure identification. Diagnostic methods. State estimation and observers. The self tuning regulator.

0610-574: REAL-TIME COMPUTER CONTROL
CR: 3

Real-time and on-line computers for control; constraints imposed by real-time operation, real-time control system elements: hardware components and interface problems associated with real-time control, applicable techniques and algorithms, software problems, real-time scheduling and coordination of user programs, real-time control languages, reliability and speed of recovery of real-time control systems.

0610-575: LARGE SCALE SYSTEMS
CR: 3

Modeling and model simplification methods: An overview. Aggregation technique and properties of the aggregation matrix. Introduction to time-scale modeling and singular perturbations. Decentralized control: Introduction to decentralized control from the optimal control point of view. Hierarchical optimization and control: Linear-quadratic problems and non-linear systems. Applications of these techniques to different fields of Electrical Engineering will be presented.

0610-576: SYSTEM OPTIMAL CONTROL THEORY
CR: 3

The dynamic optimization problem, calculus of variations, dynamic programming and maximum principle, optimal linear regulators and properties, extension to servo mechanism, optimal stochastic observers. Case studies.

0610-577: NONLINEAR SYSTEMS
CR: 3

Nonlinear characteristics of models of physical systems phase plane analysis. Describing function approach. Stability and second method of Lyapunov. Frequency domain stability criteria. Linearization and its properties. Introduction to operater theory and its application to the study of nonlinearities.

0610-578: COMPUTER CONTROLLED PROCESSES
CR: 3

Hardware and software aspect of computer-based control systems. Discretization techniques in frequency and time domains. Digital controller design techniques. Optimal control. Adaptive and self-tuning controllers.

0610-579: SPECIAL TOPICS IN SYSTEMS ENGINEERING
CR: 3

An upper division of graduate technical elective treating topics in systems and control Engineering not included in other systems and control courses.

0610-581: COMMUNICATION THEORY
CR:3

Review of probability and random processes. Methods of analog-to-digital conversion (PCM, DM). Multiplexing. Optimum digital receivers. Orthogonal and biorthogonal signal sets. Binary and M-ary digital modulation, ASK, FSK, PSK, DPSK, MSK, and QAM. Coherent and noncoherent detection. Channel capacity and intersymbol interference.

0610-582: SPREAD SPECTRUM AND CODE DIVISION MULTIPLE ACCESS
CR:3

Introduction to spread spectrum systems, spread sequences, code division multiple access (CDMA), synchronization and PN code tracking, PN code acquisition, communication over fading channels, advanced detection techniques for CDMA, and mobile cellular CDMA networks.

0610-583: INFORMATION THEORY
CR: 3

Information measures, asymptotic equipartition property, source coding theorem, noiseless coding, cryptography, channel coding theorem, Gaussian channels, multiple user source and channel theory, rate distortion theory.

0610-584: COMMUNICATION SYSTEMS
CR: 3

Introduction to analog and digital communication theory. Performance evaluation of communication systems. Line of sight microwave communication systems. Mobile communication systems. Satellite systems for communication, navigation and maritime applications. Fiber optic systems. Comparison between different communication systems.

0610-585: TWO-DIMENSIONAL SIGNAL PROCESSING
CR: 3

Fundamental properties of 2-D digital systems. Frequency representation of 2-D systems and the 2-D sampling theorem. The 2-D z- transform and stability of 2-D systems. Design techniques of 2-D FIR digital filters: The window method, the 2-D frequency sampling technique, optimal minimal design, frequency transformations from 1-D to 2-D filters. Design techniques of 2-D digital filters. Quantization effects and noise in digital filters. Application of digital signal processing to areas such as image processing, processing of sonar maps and biomedical images of maps.

0610-586: DETECTION OF SIGNAL IN NOISE
CR:3

Hypothesis testing and receiver operating characteristics. Detection of known signals in White Gaussian Noise. Detection of signals with random parameters. Multiple pulse detection. Detection of signals in colored noise. Estimation of signal parameters. Sequential detection and performance evaluation.

0610-587: TERRESTRIAL AND SPACE COMMUNICATION SYSTEMS
CR: 3

Line of sight communication systems: Atmospheric refraction. Effect of ducts on propagation. Multipath effects and signal fading. Power budget and system design. Satellite communication links: Satellite orbits. Spacecraft equipment. Design of down and up links. Satellite earth stations. Design examples.

0610-588: OPTICAL FIBER COMMUNICATION SYSTEMS
CR: 3

Light guidance on fibers. Cabling design. Light attenuation and dispersion on fibers. Lasers, LED's and photodetectors. Design of digital and analoge optical fiber systems. Design of coherent light systems.

0610-589: SPECIAL TOPICS IN COMMUNICATIONS
CR: 3

An upper division of graduate technical elective treating topics in Communications and/or Electromagnetics not included in other Communications/Electromagnetics courses.

0610-590: SPECIAL TOPICS IN ELECTRONICS
CR: 3

An upper division of graduate technical elective treating topics in Electronics not included in other Electronic courses.

0610-592: SEMINAR
CR: 0 CO-Requisites: 0610-593 Or 0610-597

With the guidance of the graduate program committee, the seminar topics include:
- Research writing methods.
- Presentation skills
- Surveying literature.
- Bibliography style.
- New tools (LaTeX, Data analysis etc...)

0610-593: PROJECT
CR: 3 CO-Requisites: 0610-592

The student undertakes an independent project on a research topic of theoretical and/or experimental focus under the supervision of a faculty member listed in the supervisory list of the College of Graduate Studies. The objective is to provide the student with an opportunity to integrate and apply the knowledge gained throughout the course of study in a practical problem. The student must document the project in a scientific report following standard research writing guidelines and give a public presentation to the project examination committee.

0610-597: THESIS
CR: 0 CO-Requisites: 0610-592

0610-598: THESIS
CR: 0

2000-599: THESIS
CR: 9