

**ENGINEERING (CORE COURSES)**

***INTRODUCTION***

Engineering graduate programs require the study of some of the following general (core) graduate engineering courses.

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0600-503	Statistical Concepts in Engineering	(3)
0600-504	Numerical Analysis and Computation	(3)
0600-505	Finite Element Methods	(3)
0600-506	Continuum Mechanics	(3)
0600-507	Mathematical Optimization	(3)
0600-508	Random Variables and Stochastic Processes	(3)
0600-510	Advanced Fluid Mechanics	(3)
0600-511	Computational Fluid Dynamics	(3)
0600-512	Advanced Engineering Mathematics I	(3)
0600-513	Advanced Engineering Mathematics II	(3)

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***COURSE DESCRIPTION***

**0600-503: STATISTICAL CONCEPTS IN ENGINEERING  
CR: 3**

Elements of probability theory, random variables, analytical models of random phenomena, reliability, factor of safety, safety margin, extreme value statistics, Monte-Carlo simulation, empirical determination of distribution models, confidence intervals, regression and correlation analysis, general applications to engineering design problems, stochastic processes.

Computation of the eigenvalues of a matrix. the interpolation and polynomial approximation. Approximate methods for initial value problems and for boundary value problems.

**0600-504: NUMERICAL ANALYSIS AND COMPUTATION  
CR: 3**

Norms, limits and condition numbers. Inverses of perturbed matrices. Integrative techniques for solving systems of equations. The LU, QR and singular value decompositions. Algorithms for the linear least squares and linear minimax problems.

**0600-505: FINITE ELEMENT METHODS  
CR: 3**

Origin and basis of finite-element methods in continuum mechanics, stiffness method, assumed displacement field, potential energy and Rayleigh-Ritz method, types of elements, modeling, accuracy and convergence, solution techniques and computer application to structural and fluid mechanics.

**0600-506: CONTINUUM MECHANICS  
CR: 3**

Cartesian tensors. Basic principles of continuum mechanics: deformation, displacement, strain, stress, conservation of mass, continuum thermodynamics and constitutive equations.

Illustrative applications in elasticity, fluid dynamics, viscoelasticity and plasticity.

**0600-507: MATHEMATICAL OPTIMIZATION  
CR: 3**

Basic Concepts: The gradient vector and the Hessian Matrix, multidimensional Taylor's theorem, linear and quadratic approximation of a function. Unconstrained optimization, necessary and sufficient conditions for optimality. Algorithms for single variable minimization, the Fibonacci search and the Golden section search, algorithms that use repeated polynomial interpolation. Algorithms for multi-dimensional minimization; The steepest descent, the Newton method and its variations, conjugate gradient algorithms such as the Fletcher-Reeves, Polak and Ribiere, Quasi-Newton Methods such as the DEP-BFGS, Huang's family of algorithms. Constrained optimization: Necessary and sufficient conditions for constrained minima. Algorithms for constrained optimization: interior and exterior penalty function methods, augmented Lagrangian methods, Resen's gradient projection.

**0600-508: RANDOM VARIABLES AND STOCHASTIC PROCESSES  
CR: 3**

Introduction to probability theory and engineering applications of probability. random variables and expected values. distribution of functions of random variables and applications of R.V. to system problems. Stochastic processes, correlation and power spectra, systems and random signals. Engineering decisions and estimation theories.

**0600-510: ADVANCE FLUID MECHANICS  
CR: 3**

Motion of ideal, Newtonian, and non-Newtonian single-phase fluids. Continuity and Navier-Stokes

equations for one and two dimensional flows. Turbulence and boundary layer theories. Flow through conduits, and porous medium. Homogenous and non-homogenous multiphase flow systems.

**600-511: COMPUTATIONAL FLUID DYNAMICS  
CR: 3**

This course introduces students to the numerical and computational fluid dynamics. It will provide graduate students (Science and Engineering students) with techniques and approaches to solve numerical fluid mechanics problems encountered in real fluid flows. Methods for boundary layers, incompressible viscous flows, and inviscid compressible flows are studied. Finite differences and finite volume techniques are emphasized. The course utilizes using commercial CFD packages and MATLAB to solve fluid flow problems.

**0600-512: ADVANCED ENGINEERING MATHEMATICS I  
CR:3**

Analytic function, residues, contour integration. Power series solutions of ordinary differential equations: Bessel's, Legendre's, Chebyshev's and Laguerre's functions. Matrix algebra eigenvalues, eigen-functions, and solutions of systems of differential equations. Software applications.

**0600-513: ADVANCED ENGINEERING MATHEMATICS II  
CR:3 PR:0600-512**

Sturm-Liouville problem. Partial differential equations: Characteristic curves, separation of variables and integral transforms (Laplace and Fourier), method of characteristics. Wave, heat and diffusion-equations. Software applications.

## MASTER OF SCIENCE ELECTRICAL ENGINEERING

### ***INTRODUCTION***

The Department of Electrical Engineering (College of Engineering and Petroleum) offers a Master of Science Program in **Electrical Engineering**. Part-time and full-time Students are admitted to this program. 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.

*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***

The program requirements are (non-thesis option in Parenthesis):

#### **33(33) TOTAL COURSE CREDITS**

##### **6 CORE ELECTIVE COURSES (3 credits each)**

- 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) ELECTIVE COURSES (3 credits each)**

The student chooses from the following courses with the approval of his/her supervisor.

- 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

#### 6(9) FREE ELECTIVE COURSES

A maximum of 3 credit hours (thesis students) and 6 credits hours (project students) can be taken from **core engineering**, any other engineering, science, computer science, and engineering or joint graduate programs with the approval of the Graduate Program Director and Area Committee Chairman before registering the course. **Also, courses can be taken from the same graduate program courses.**

#### 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.

<b>Course Title (Computer Engineering)</b>	<b>Course Title (Electrical Engineering)</b>
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

### COMPULSORY

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, reciprocity, 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 Fundamentals, 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 propagation 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 PR: 610-530**

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 PR: 610-333**

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 PR: 610-551**

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 inverters. 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 PR: 610-551**

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 PR: 610-551**

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 PR: 610-551**

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 PR: 610-551**

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 operator 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 PR: 610-581**

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 PR: 600-508**

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 PR: 600-508**

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:3PR: 0600-508**

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 PR: 600-508**

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 PR: PR: 600-508**

Light guidance on fibers. Cabling design. Light attenuation and dispersion on fibers. Lasers, LED's and photodetectors. Design of digital and analog 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: -**

Following the directions of the graduate program committee related to thesis or project.

**0610-593: PROJECT  
CR: 3**

**0610-597: THESIS  
CR: 0**

**0610-598: THESIS  
CR: 0**

**2000-599: THESIS  
CR: 9**