UNIVERSITY OF MANAGEMENT AND TECHNOLOGY

SCHOOL OF ENGINEERING (SEN)

Department of Electrical Engineering

Approved Curriculum

of

MS Electrical Engineering Program

Document updated Oct 2015

Program Overview

Electrical engineering has its foundation in physical science, mathematics and a broad knowledge of engineering techniques. The MS in Electrical Engineering program aims to produce highly-skilled professionals focused on productive research and development in the vast domain of Electrical and Electronics Engineering. MS Electrical Engineering program at UMT offers an understanding of the breadth of education and depth of training necessary for leadership in this profession. It provides the graduates with the broad technical education necessary for productive employment in the public or private sector with the development of understanding of fundamentals and current issues important for future years of the region. The program has been devised keeping in view the latest market demands and encompasses a broad area covering advanced digital and analogue electronics, communication, signal processing, multimedia & computer vision, advanced controls for robotics and microelectronics/nano-electronics.

Program Objectives

The goals and objectives of the graduate program in Electrical Engineering are to prepare graduate students/engineers for careers in professional practice, research, and for further study towards doctoral degrees in Electrical engineering. This MSEE Program will allow motivated researchers to expand their knowledge and acquire new skills in analysis and problem solving, creating challenging opportunities for a full, rewarding research career. The program will also cater the demands and needs of local industry and strategic research and development (R&D) organizations of the country. This graduate program will impart

1. Knowledge of the engineering principles.
2. Knowledge of current events and contemporary societal issues.
3. Knowledge of the state-of-the-art information technologies.
4. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context.
5. Facilitate systems engineering and project management.
6. Ability to communicate effectively (written, verbal and presentation) across all levels in the enterprise.
7. Ability to grow through life long acquisition of knowledge.
8. Ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
9. Ability to identify, formulate and solve Electrical Engineering problems.
10. Ability to function in multidisciplinary teams.
11. Capability to use state-of-art engineering/computer tools necessary for engineering practice or research.
12. Skills to find and use available technical information.
13. Ability to communicate effectively in written reports.
14. Ability to design and conduct experiments, tests or simulations as well as to analyze and interpret data to validate assumptions and hypotheses.
15. Ability to evaluate current electrical engineering techniques.

Career Prospects

Electrical engineering being one of the core fields of engineering is always evergreen in terms of scope and job prospects. Electricity has become the basic need for survival, globally. As such electrical engineers find their utility in maintenance and running of industrial plants, communication and satellite navigation systems and domestic electronic equipment. Electrical

Engineering equips the learner with the knowledge of electrical circuit design, digital electronics, instrumentation and control system, modern telecommunication and signal processing.

Admission Criteria

All applications are evaluated on the basis of merit as determined by their previous academic record and performance in admission test/interview.

- 16-years of education with Bachelors in either of the following disciplines.
    - BE in Electronics
    - BS in Electrical Engineering
    - BS in Computer Engineering
- GAT General 50% or above
- Minimum CGPA in Bachelor's degree should be equal to or above 2.25.

Degree Requirements:

The MSEE program is offered under the following two options:
"Plan-A: Thirty credit hours including a six credit hours thesis" and
"Plan-B: Thirty credit hours of course work".
The detail of which is given below in the table:

Plan A

Component	Credit Hours
Core Courses	12
Electives	12
Thesis	6
Total	30

Plan B

Component	Credit Hours
Core Courses	12
Electives	18
Total	30

The MSEE Program

The MS Electrical Engineering program commenced from Fall 2013 semester.

The MSEE program structure duly approved by UMT Academic Council is attached as **Annex-A**.

The course outlines for all MSEE courses can be seen in **Annex-B.**

Annex-A

MSEE Program Courses

The MSEE program comprised FOUR core courses and SIXTEEN elective courses.

While most courses are of 5xx level, three core and six elective courses are of 6xx level and can be taken by both MSEE and PhD_EE students.

These nine 6xx level courses are highlighted in **bold and underlined**.

MSEE Program Core Courses

Course Code	Title	Credit Hours
IE-631	**Research Methods and Techniques**	3
EE-504	Linear Systems	3
EE-628	**Advanced Circuit Design**	3
EE-622	**Digital Communication**	3

MSEE List of Electives

Course Code	Course Title	Credit Hours
EE-631	**Stochastic Processes**	3
EE-610	**Real-time Signal Processing**	3

EE-616	**Adaptive Filtering Theory and Design**	3
EE-518	Nonlinear Signal Processing	3
EE-511	Embedded Systems	3
EE-624	**Networks and Protocols**	3
EE-623	**Wireless Communication**	3
EE-625	**Software-Defined Radio**	3
EE-526	Photovoltaic Energy Systems	3
EE-527	Wireless Sensor Networks	3
EE-504	Advanced Power Systems	3
EE-506	Transients in Power Systems	3
EE-507	Advanced Concepts in Power System Protection	3
EE-508	Power System Planning	3
EE-512	Design of Optical Transmission Systems	3
EE-513	Photonics Technologies (Opto-electronics)	3

Annex-B

MSEE Course Descriptions/Outlines

IE-631 Research Methodology

Pre requisites	
Course Objectives	
Course Description	As Adopted from MSIE program
Required Textbooks	

EE-504 Linear Systems

Pre requisites	Linear Algebra or equivalent course
Course Objectives	This course is intended as a first semester graduate course on linear systems theory, design and implementation with application to signal processing, communications, estimation and control. The objective is to present a comprehensive coverage of the basic tools needed by an electrical engineering graduate student specializing in the above areas.
Course Description	1. Linear spaces and linear operators 2. Mathematical descriptions of systems 3. State-space models, solutions and realizations 4. Controllability and observability of linear systems 5. Minimal realizations and coprime fractions 6. State feedback, state estimators and observers 7. Stability of linear and non-linear systems 8. Applications
Required Textbooks	Linear System Theory and Design by Chi-Tsong Chen (2012) Linear Systems Theory by João P. Hespanha (2009) G. Strang, Linear Algebra and its Applications, Third Edition, 1988

EE-628 Advanced Circuit Design (ACD)

Pre-requisites	• Circuit Design: devices and Systems • Differential Equations • Signals and Systems Students must have a very good understanding of circuit analysis, electronics, electronic devices and models, and analog circuit design. Students need to be familiar with circuit simulation (Hspice/ADS) and CAD tools (Cadence design environment).
Expected Outcomes	• Develop mastery of circuit modeling, analysis and design techniques. • Explore advanced circuits not commonly covered in basic electronics courses. • Learn how to think and how to approach difficult, unconventional electronics problems. • Introduce practical insights to help bridge the gap between academic study and professional practice.
Course Description	Analysis and design emphasizing CMOS implementations. Gain stages, biasing circuits, comparators, sample-and-hold circuits, switched-capacitor circuits, Nyquist-rate and oversampling A/Ds and D/As, oscillators, PLLs. The focus of this course is on the analysis and design of analog integrated circuits with an emphasis on CMOS circuits. Simple modeling 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 intuition and simple hand calculations, and is verified by computer simulations. After a brief review of device modeling, process and layout issues, amplifiers, and biasing circuits, more advanced analog circuits and blocks including switched-capacitor circuits, comparators, sample and hold circuits, analog-to-digital (A/D) and digital-to-analog (D/A) converters fundamentals (Nyquist-rate and oversampling), and time permitting oscillators, phase-locked loops (PLLs), and delay-locked loops (DLLs) will be discussed.
Textbooks	• Analog Integrated Circuit Design (Wiley) by Tony Chan Carusone, David A. Johns and Kenneth W. Martin (2011)

	• Lee, T. H. *The Design of CMOS Radio-Frequency Integrated Circuits*. Cambridge University Press, 1998. • Analysis and Design of Analog Integrated Circuits by Paul R. Gray, Paul J. Hurst, Stephen H. Lewis and Robert G. Meyer (2009)

EE-622 Digital Communication

Pre-requisites	Graduate course in probability and stochastic processes or equivalent; Undergraduate courses in Digital Signal Processing and Linear Algebra, Analog Communication, Signals and Systems
Objectives	The student will learn to identify the functions of different components of a digital communication system. The student will convert a digital bandpass signal to an equivalent complex lowpass signal, represent a digital signal using several modulation methods, draw signal space diagrams, and compute spectra of modulated signals. The student will design correlation and matched filter receivers, compute the probability of error for several demodulators, and compare modulation methods based on the error rate and spectral efficiency. The student will learn about theoretical bounds on the rates of digital communication systems.
Course Description	Introduction, fundamental notions, block diagram of a basic digital communication system, basics of signal analysis, random variables and processes, noise in communication systems and its equivalents representation; analog signals digitization, sampling, quantization, pulse code modulation, differential PCM, DM, baseband transmission, inter-symbol interference, eye diagrams, Nyquist criterions and pulse shaping, common line codes and their performance analysis, binary and M-ary signaling methods, Linear and nonlinear digital modulations schemes, PSK, QAM MSK, CPM FSK, GMSK, etc., signal space representation of digital signals, detection theory and optimal receivers, Coherent and non-coherent detection with additive white Gaussian noise, union bounds, baseband and carrier transmission, performance analysis of digital

	modulations schemes, equalizations, synchronization, introduction to multiple access techniques TDMA, CDMA,OFDMA and MC-CDMA, Communication link analysis and transmission over fading multipath channels. Source coding and channel coding techniques Principles of communications theory applied to the representation and transmission of information analysis of deterministic and random signals, amplitude modulation, angle modulations, analog message digitization, introduction to the basic principles of the design and analysis of modern digital communication systems. Topics include source coding; channel coding; base-band and pass-band modulation techniques; receiver design; channel equalization; information theoretic techniques; block, convolutional, and trellis coding techniques; multi-user communications and spread spectrum; multi-carrier techniques and FDM; carrier and symbol synchronization
Textbooks	• Digital Communications, 5th Edition by John Proakis and Masoud Salehi (2007) • Digital Communication Systems Engineering with Software-Defined Radio (Mobile Communications) by Alexander M. Wyglinski and Di Pu (2013) • Digital Communications: Fundamentals and Applications (2nd Edition) by Bernard Sklar (2001) • Digital Communication Systems by Simon Haykin (2013) • Digital & Analog Communication Systems (8th Ed) by Leon W. Couch (2012) • Principles of Digital Communication by Robert G. Gallager (2008) • Digital Communication Receivers: Synchronization in Digital Communication Volume I, Phase-, Frequency-Locked Loops... by Heinrich Meyr and GerdAscheid (1990)

EE-511 Embedded Systems (ES)

Pre-requisites	Microprocessor architectures, Operating systems, Digital system design (Verilog/VHDL), C language
Course Objectives	The course uses a bottom-up approach to problem-solving building gradually from simple interfacing of switches and LEDs to complex concepts like display drivers, digital to analog conversion, generation of

	sound, analog to digital conversion, graphics, interrupts, and communication.
Course Description	In this course concepts of embedded system hardware and firmware design will be explored. Issues such as embedded processor selection, hardware/firmware partitioning, glue logic, circuit design, circuit layout, circuit debugging, development tools, firmware architecture, firmware design, and firmware debugging will be discussed. Embedded systems is a major class of computing systems that covers a wide spectrum of applications & devices: communications such as PDA, mobile phones, avionics & space exploration, automobiles, house-hold appliances (micro-wave oven, refrigerators, etc.)
Textbooks	• Real-time Systems Theory and Practice Rajib Mall, Pearson Education, 2007 • Embedded Systems: A Contemporary Design Tool by James K. Peckol (2007) • Computers as Components: Principles of Embedded Computer System Design Wayne Wolf, Morgan Kaufmann/Elsevier, 2005 • Embedded Systems Architecture, Second Edition: A Comprehensive Guide for Engineers and Programmers by Tammy Noergaard (2012)

EE-518 Non-Linear Signal Processing

Pre-requisite:	Digital Signal Processing, Adaptive Filtering Theory
Course Objectives	A statistical approach focuses on unifying the study of a broad and important class of nonlinear signal processing algorithms which emerge from statistical estimation principles, and where the underlying signals are non-Gaussian, rather than Gaussian, processes.
Course Description	The theoretical part lays foundations in the area of memory less nonlinearities (limiters/quantizer/classifiers), nonlinear dynamical systems (nonlinear filters/oscillators/chaos theory), nonlinear statistics (higher-order statistics and information theory), parallel distributed processing (neural networks). The application part is devoted to the modeling of natural signals with nonlinear systems, algorithms for time series analysis

	and signal synthesis, and nonlinear devices in digital communications systems.
Textbooks	Nonlinear Signal Processing: A Statistical Approachby Gonzalo R. Arce(2004)

EE-526 Photovoltaic Energy Systems

Pre-requisites	Electronics and devices
Objectives	The objectives of this course will be to introduce students to why is there a need of renewables worldwide and especially in Pakistan. Basic understanding of wind power system Detailed understanding of PV cells and technologies In depth analysis on PV systems and applications Costing of renewable systems Understanding of technologies available in renewables. Comprehensive understanding of fundamentals of PV cells and systems. Understanding of the economics of renewable and hybrid systems.
Course Description	This course shall review the renewable sources and their need in world energy scenario. Energy harvesting through wind and PV shall be covered in this course. This course will encapsulate PV systems in detail from design of a solar cell to standalone and grid tied PV systems. Costing of renewable and hybrid systems will also be focused in this course. The course also includes a research project in which students would be required to do a detailed literature survey and/or analysis of a known finding. Profiling of PV cells, modeling of systems and presentation of a potential PV application or detailed review of some applications in Pakistan scenario is also acceptable. Original research is encouraged while a simulation based known result would also be acceptable.

Textbooks	1. Solar Photovoltaics: Fundamental, technologies and applications SOLANKI, CHETAN SINGH: 2nd ed. 2009 (Prentice Hall) 2. Wind and Solar Power Systems, R.P Makund, 1999 (CRC press) 3. 'Renewable and Efficient Electric Power Systems' by Gilbert M. Masters (Wiley)

EE-527 Wireless Sensor Networks

Pre-requisites	Graduate standing, and strong understanding of TCP/IP and wireless networking
Objectives	By the completion of the course, you should be able to: · architect sensor networks for various application setups. · explore the design space and conduct trade-off analysis between performance and resources. · assess coverage and conduct node deployment planning. · devise appropriate data dissemination protocols and model links cost. · determine suitable medium access protocols and radio hardware. · prototype sensor networks using commercial components. · provision quality of service, fault-tolerance, security and other dependability requirements while coping with resource constraints. · evaluate the performance of sensor networks and identify bottlenecks.

Course Description	Wide range of applications such as disaster management, military and security have fueled the interest in sensor networks during the past few years. Sensors are typically capable of wireless communication and are significantly constrained in the amount of available resources such as energy, storage and computation. Such constraints make the design and operation of sensor networks considerably different from contemporary wireless networks, and necessitate the development of resource conscious protocols and management techniques. This course provides a broad coverage of challenges and latest research results related to the design and management of wireless sensor networks. Covered topics include network architectures, node discovery and localization, deployment strategies, node coverage, routing protocols, medium access arbitration, fault-tolerance, and network security.
Textbooks	Protocols and Architectures for Wireless Sensor Networks: Holger Karl, Andreas Willig, Wiley, 2005. Wireless Sensor Networks: Cauligi S. Raghavendra, Krishna Sivalingam, Taieb M. Znati, Springer, 2005

EE-625 Software Defined Radio

Pre requisites:	• Understanding of various digital communication techniques (EE410 or equivalent), • Basic understanding of probability • Familiarity with Matlab/Simulink, and • Familiarity with general C programming. • Digital Signal Processing
Course Objectives	This course provides students with hands-on exposure to the design and implementation of modern digital communication systems using software-defined radio technology. The prototyping and real-time experimentation of these systems via software-defined radio will enable greater flexibility in the assessment of design trade-offs as well as the illustration of 'real world' operational behavior. Performance comparisons with quantitative analytical techniques will be conducted in

	order to reinforce digital communication system design concepts. In addition to laboratory modules, a final course project will synthesize topics covered in class. After the first part, students shall have a deeper understanding of modulation and demodulation of digital signals. They shall know the structure of digital transmitters and receivers, and shall be able to develop adequate solutions using the modules which they are taught throughout the course. At the end of the second part, students will be familiar with the most important algorithms for parameter estimation and synchronization in digital receivers (classification, derivation from the Maximum Likelihood (ML) principle, theoretical limits, synchronization of carrier phase and frequency as well as symbol timing).
Course Description	The course focuses on transmitter and receiver structures for digital signals as they are used in satellite communications, in particular. Modulation and demodulation (sampling process, mixer and filter stage) as well as their implementation with hardware and software modules represent the first part. The second part concentrates on acquisition and tracking problems with respect to the most important transmission parameters (carrier phase, carrier frequency, symbol timing). <u>Part 1: Structures for Digital Transmitters and Receivers</u> Introduction SDR and Radio Front ends Multirate DSP Direct Digital Synthesis (DDS) mixing of signals, digital mixers and numerical oscillators Baseband algorithms, pulse shaping and receiver filtering, decimation and filter stage, digital modulation and matched filters Baseband digital hardware Software methods The sampling process & A/D conversion and D/A conversion Acquisition and tracking, Implementation of algorithms

	<u>Part 2: Parameter Estimation and Synchronization in Digital Receivers</u> • Motivation and background • Classification of estimator algorithms • Maximum-likelihood principle and Cramer-Rao bound • Synchronization of the carrier phase • Synchronization of the symbol timing • Synchronization of the carrier frequency <u>Part-3 Spectrum Sensing</u> Software-defined radio architectures and implementations, digital signaling and data transmission analysis in noise, digital receiver structures (matched filtering, correlation), multicarrier communication techniques, radio frequency spectrum sensing and identification (energy detection, matched filtering), and fundamentals of radio resource management. <u>Part-4 Cognitive radio fundamental and cognitive radio and networking communications</u>**.** Cognitive wireless radio networks, current industry standards
Required Textbooks	• Software Radio: A Modern Approach to Radio Engineering by Jeffrey H. Reed Prentice Hall PTR; 1st edition 2002 • RF and Baseband Techniques for Software Defined Radio by Peter B. Kenington (2005) • Direct digital synthesizer theory ,design and applications by JoukoVankka • Telecommunication Breakdown Concepts of Communication Transmitted via Software Defined Radio by C. Richar Johnson Jr. • Software Defined Radio: Enabling Technologies (Wiley Series in Software Radio) by Walter H.W. Tuttlebee (2002) • Implementing Software Defined Radio by Eugene Grayver (2012) • U. Mengali, A. N. D’Andrea: Synchronization Techniques for Digital Receivers. Plenum Press, 1997 • Research papers

EE-610 Real-time signal processing

Pre-requisites	(Microprocessors) -- Basic knowledge about microprocessors such as buses, data format, address, memory, CPU, Input/output devices and their inter-operation. (DSP) -- Continuous and Discrete time signals, ADC/DAC, linear time invariant (LTI) systems, impulse response, z-transforms, and Discrete Fourier Transforms. Working knowledge of Matlab and C programming.
Objectives	This course covers real-time digital signal processing (DSP) applications, algorithms and hardware. The aim is to bridge the mathematics introduced in an undergraduate DSP course with practical implementation issues. The interaction between hardware and software are studied in the context of the TMS320c6x using MATLAB/Simulink. Upon completion, students will: • be able to identify the basic architectural elements of DSP hardware; • understand common real-time DSP algorithms for filtering and multimedia processing applications; • be able to program DSP hardware to perform signal, image and video processing tasks using MATLAB/Simulink; • gain an appreciation for the trade-offs necessary in algorithm design for real-time DSP implementation; • be able to overcome technical obstacles through ingenuity and resourcefulness; and • acquire an appreciation of the importance of real-time DSP for a broad class of engineering applications.
Course Description	Students will study concepts, algorithms, and implementation of digital signal processing using programmable DSP chips. Students will use Texas Instruments floating point DSP platform (TMS320C6713) to implement real-time data acquisition, FIR/IIR filtering, and FFT algorithms, audio and speech signal processing, interrupt-driven programming, frame processing, quantization effects, code optimization, and DSP applications. This course will bridge the gap between computer engineering (which emphasizes embedded systems) and electrical engineering (which emphasizes signal processing algorithms).
Textbooks	• *Real-Time Digital Signal Processing: from Matlab to C with the TMS320C6x DSK* by T.B. Welch, C.H.G. Wright, and M.G. Morrow. CRC Press,2006. This book provides some coverage on DSP theory with reduced

	complexity and is highly recommended for students with EE background. • *Real-Time Digital Signal Processing based on the TMS320C6000.* by Nasser Kehtarnavaz, Elsevier, 2005. This book places more emphasis on DSP programming and is recommended for students with EE background. • *Digital Signal Processing and Applications with the C6713 and C6416 DSK* by Rulph Chassaing, Wiley, 2005. This book provides basic coverage on filter theory and DSK programming. There are many great examples and projects with applications to audio processing, video processing, and communications.

EE-616 Adaptive Filtering Theory and Design

Course Objectives	The course covers practical aspects of signal processing, and in particular adaptive systems. Current applications for adaptive systems are in the fields of communications, radar, sonar, seismology, navigation systems and biomedical engineering. This course will present the principles of adaptation, various adaptive signal processing algorithms (e.g., the LMS algorithm) and applications, such as adaptive noise cancellation, interference canceling, system identification, etc.
Course Description	This course is divided into four major topics: Spectral Estimation (non-parametric and parametric), signal modeling, adaptive filtering and array processing. This course will present the principles of spectrum estimation and adaptation.. A familiarity with using Matlab is recommended as some of the assignments will involve implementation of algorithms in Matlab. Specific topics are Eigen analysis, review of discrete-time random processes, FIR Wiener filters, derivation of the Wiener-Hopf equations, principle of orthogonality, the Discrete Kalman filter, gradient-based adaptive filters, steepest descent , the LMS algorithm, variations on the LMS algorithm, Gradient Adaptive Lattice filter, recursive least squares, transversal filters, lattice filters - optional, performance of the RLS algorithm, tracking of time-varying systems, adaptive IIR filters, IIR LMS, Fientuch and

	Horvath algorithms, HARF and SHARF, nonlinear adaptive filters, order statistic adaptive filters and Volterra systems, blind deconvolution - decision directed feedback, back propagation learning, radial basis function networks, adaptive line enhancement, adaptive spectrum estimation, frequency tracking, adaptive signal modeling
Textbooks	• Statistical and Adaptive signal processing, Dimitris G. Manolakis, Vinay K. Ingle, Stephen M. Kogon, Artech 2005 • B. Widrow and S. Stearns (1985). *Adaptive Signal Processing*, Prentice Hall. • Adaptive Filter Theory, S. Haykin, Prentice-Hall, 4-th edition, 2001 • Adaptive Filter by Ali H Syed UCLA • Fundamentals of Adaptive Filtering, Ali H. Sayed, John Wiley, 2003. • Statistical Digital Signal Processing and Modeling by M. H. Hayes (1996) • J.R. Treichler, C.R. Johnson, Jr., and M.G. Larimore: Theory and Design of Adaptive Filters, Prentice-Hall, 2001

EE-623 Wireless Communication

Pre-requisite:	Communication Systems, graduate-level probability theory/stochastic processes, some exposure to MATLAB
Course Objectives	Upon the completion of the course, the student should be able to • distinguish the major cellular communication standards (1G/2G/3G systems) • characterize the tradeoffs among frequency reuse, signal-to-interference ratio, capacity, and spectral efficiency • characterize large-scale path loss and shadowing • characterize small-scale fading in terms of Doppler spectrum, coherence time, power delay profile, and coherence bandwidth • analyze the error probabilities for common modulation schemes • design techniques and analytical tools of wireless communications • fundamental capacity limits.

	• various modulation, coding, and signal processing schemes, state-of-the-art adaptive modulation, multicarrier, spread spectrum, and multiple antenna techniques describe different types of diversity and how they improve performance for mobile radio channels • describe simple equalization schemes • characterize TDMA, FDMA and CDMA
Course Description	This course introduces fundamental technologies for wireless communications. The following topics will be covered: Analog and digital modulation Propagation, shadowing, fading Radio trunking Multiple access schemes: FDMA, TDMA, CDMA Cellular communications Diversity Equalization Channel coding Wireless systems and standards (1G/2G/3G systems) Speech coding OFDM, Multiuser detection, space time coding, smart antenna, software radio (if time permits) Introduction to wireless communication theories; short-range wireless technologies and standards (Bluetooth, IEEE 802.11); long-range wireless technologies and standards (cellular, UMTS, LTE/SAE); Mobility management (Mobile IP, location dependent services, power management); wireless network issues (ad hoc routing, packet scheduling) mobile data application issues (WAP, TCP over wireless, security, etc.); emerging mobile data architectures and services.
Textbooks	• 'Wireless Communications' by Andrea Goldsmith (2005) • T. S. Rappaport, 'Wireless Communications: Principles & Practice', 2nd Ed., Prentice-Hall, 2002

	• HarriHolma and AnttiToskala (ed.), 'WCDMA for UMTS : radio access for third generation mobile communications', Wiley, 2000. • J. D. Parsons, "The Mobile Radio Propagation Channel," 2nd Edition, Wiley, 2000. • G. L. Stueber, ``Principles of mobile communication,'' 2nd Ed., Kluwer, 2001.

EE-631 Stochastic Processes

Pre-requisites	Probability theory and random processes, Linear Algebra, Signals and Systems
Objectives	Many different communication and information systems will be examined, with the emphasis on determining the fundamental questions each one poses. For instance, an examination of computer networks and computer systems will be shown to lead to questions about conditions which guarantee stable operation, while an examination of optical communication systems will lead to questions about communications in the presence of impulsive noise.
Course Description	Engineering applications of probability theory, problems on events, independence, random variables, distribution and density functions, expectations and characteristic functions. Dependence, correlation and regression; multi-variate Gaussian distribution. Stochastic process, stationarity, ergodicity correlation functions, spectral densities, random inputs to linear systems, filtering of wide sense stationary processes, Wiener and Kalman filters, Markov processes and Markov chains, Gaussian, birth and death, Poisson and shot noise processes, elementary queuing analysis, detection of signals in Gaussian and shot noise, elementary parameter estimation. Other examples that will be used include estimation in dynamic environments, speech modeling, signal detection, and the modeling of neural processes. The stochastic processes that will be developed for the modeling and analysis of these systems include: Markov chains and processes; Point processes: Brownian motion; and Martingales.
Textbooks	• Stochastic Processes, Sheldon Ross, Wiley. • Probability and Stochastic Processes: A Friendly Introduction for Electrical and Computer Engineers by Roy D. Yates and David Goodman (2004)

	• Probability, Random Variables and Stochastic Processes, A. Papoulis, McGraw-Hill, 1991. • Applied Linear Algebra, Gilbert Strang, Academic Press, 1976;

EE-624 Networks and Protocols

Pre-requisites	Computer Networking and Data Communication, Communication Systems, Signals and Systems
Objectives	Upon completing this course student should be able to: - understand the architectures and elements of a network - understand the use and process of mobility management - understand the signaling schemes used in networks - understand the wired network protocols and standards - analyze the operation and performance of wireless protocols - capture most recent development in 3G wireless systems
Course Description	Overview of Internet Protocol; Application layer (HTTP, SMTP, FTP, DNS); Transport layer (UDP, TCP, congestion control) ; Network layer (routing, IP addressing, IPv6, NAT, DHCP); Link layer and LANs; Multimedia networking (streaming, RTSP, RTP, H.323); Quality-of-Service issues (IntServ, DiffServ, RSVP, MPLS); Network security (IPSec, SSL); Multicasting (addressing, routing); other advanced applications/topics (peer-to-peer protocols, grid computing, cloud computing, etc). This course addresses the fundamentals of wired and wireless networking, including architectures, protocols, and standards. It describes concepts, technology and applications of networking as used in current and next-generation wireless networks. It explains the engineering aspects of network functions and designs. Issues such as mobility management, wireless enterprise networks, GSM, network signaling are covered. WAP, mobile IP, and 3G systems are also covered. • 4G wireless network systems (WiMAX, LTE and LTE-A) • Peer-to-peer networks • Network Virtualization • Network testbeds (PlanetLab)

	• IPv6 • Quality of Service (QoS) and Quality of Experience (QoE) • High Speed Networks
Textbooks	1. Designing and Deploying 802.11n Wireless Networks by Jim Geier (2010) 2. Computer Networks 5e by A. Tannenbaum, 2011. 3. Telecommunication Networks: Protocols, Modeling and Analysis by Mischa Schwartz 4. K. Pahlavan and P. Krishnamurthy, Principles of Wireless Networks, Prentice Hall, 2002 5. W. Stallings, Wireless Communications & Networks, Prentice Hall, 2001. 6. Y. B. Lin and I. Chlamtac, Wireless and Mobile Network Architectures, Wiley , 2001. 7. G. Christensen, P. G. Florack, and R. Duncan, Wireless Intelligent Networking, Artech House, 2000.

EE-504 Advanced Power Systems

Pre-requisites	Graduate Standing
Objectives	The course is designed to provide the higher level knowledge of operation and control of the sophisticated power systems.
Course Description	The topics covered include: analysis and planning of power systems such as load flow studies, calculation of short circuit currents, stability calculations, determination of load growth, power generation and economics of locating stations, principles and limitations of AC transmission systems and development of HVDC systems.
Textbooks	• Electric Power Systems by Syed A. Nasar and F.C. Trutt, CRC Press, 1998 • Modern Power Systems Analysis by Xi F. Wang, Yonghua Song and Malcolm Irving, Springer, 2008.

EE-506 Transients in Power Systems

Pre-requisite	EE 504: Advanced Power Systems
Objectives	This course will cover the analysis of all types of transients produced in a power system.
Course Description	The course will start with the basic concepts of switching actions which are the major sources of abrupt voltage changes in power system. Afterwards, discussions will be made with respect to transients for 3 phase system and travelling waves. Study of HV circuit breakers, switching transients and discussion about transients recovery voltage will be covered in detail. Lightning induced transients will also be the part of the course. Numerical problems related to real power system analysis and faults are included in the course.
Textbooks	• Transients in Power Systems by Lou van der Sluis, Wiley, 2001 • Electrical Transients in Power Systems by Allan Greenwood, John Wiley & Sons, 1991

EE-507 Advanced Concepts in Power System Protection

Pre-requisite	EE 504: Advanced Power Systems
Objectives	The course aims to familiarize the student with the basic concepts of insulation coordination and then continues the study of insulation-coordination issues related to transmission lines, substations and distribution systems. Students will be introduced to the relevant international standards and are expected to be able to use them. The course is particularly suitable for practicing engineers. Latest developments in power system insulation coordination will be presented in the course.
Course Description	The topics covered include protection methods and the application of relays, non-pilot over-current protection of transmission lines, non-pilot distance protection of transmission lines, pilot protection of transmission lines, rotating machinery protection, transformer protection, bus protection, reactor and capacitor protection, power system phenomena

	and relaying considerations, relaying for system performance, switching schemes and procedures and monitoring performance of power systems. Additional topics include: classification of circuit breakers and isolator, terminology, circuit breaker arcs, SF6 switch gear and circuit breakers, air blast, oil, special purpose and DC circuit breaks. The second half of the course will cover design, operation and safety issues of different types of sub stations.
Textbooks	• Power System Relaying by Stanley H. Horowitz and Arun G. Phadke, Third Edition, John Wiley & Sons, England, 2008, • Protective Relaying: Principles and Applications by J. Lewis Blackburn and Thomas J. Domin, Third Edition, CRC Press, 2006, • Insulation Coordination for Power Systems by Andrew R Hileman, CRC Press, Taylor and Francis Group, USA, 1999, • Power Circuit Breaker Theory and Design by Charles H. Flurscheim (Editor), Institution of Electrical Engineers, 1985 • Electrical Power Substations Engineering by John D. McDonald, Second Edition, CRC Press, 2007

EE-508 Power System Planning

Pre-requisite	EE 504: Advanced Power Systems
Objectives	This course provides in-depth coverage of modern power transmission engineering
Course Description	The topic covered include transmission system planning, transmission line structures and equipment, overhead power transmission, underground power transmission and gas-insulated transmission lines, direct-current power transmission, transient overvoltage and insulation coordination, limiting factors for extra high and ultra-high voltage transmission: corona, radio noise and audible noise, symmetrical components and fault analysis, transmission system reliability, construction of overhead lines, sag and tension analysis. Also included are: general distribution/industrial system, selection of conductors and cables, capacities and calculation, substation design and location, voltage control, shunt capacitors, distribution economics,

	private power plants, distribution system protection and distribution system reliability.
Textbooks	• Electric Power Transmission System Engineering: Analysis and Design by Turan Gonen, CRC Press, 2009, • Electric Power Distribution System Engineering by Turan Gonen, CRC Press, 2007, • Power Distribution Planning Reference Book by H. Lee Willis, Marcel Dekker, 2004, • Electricity Distribution Network Design by E. Lakervi and E.J. Holmes, Institution of Electrical Engineers, 2003 • Electric Power Distribution Equipment and Systems by Tom A. Short, CRC Press, 2006.

EE-512 Design of Optical Transmission Systems

Pre-requisites	Basics of digital communications and optics
Objectives	The course reviews the most common transmission impairments that must be considered when designing today high capacity optical systems.
Course Description	- High capacity systems: applications perspectives and design issues - power budget - amplification and noise issues - Chromatic dispersion effect and its impact on system performance; - Chromatic dispersion compensation and dispersion mapping - System impairments due to Polarization mode Dispersion (PMD) -Optical receivers and noise - Nonlinear optical effects - stimulated scattering effects - Kerr nonlinear effects - impairments due to SPM - Cross Phase Modulation (XPM) and Four Wave Mixing (FWM)

Textbooks	• G. P. Agrawal, Nonlinear Fiber Optics, 4th Ed, Elsevier, 2007 • G. P. Agrawal, Fiber-Optic Communication Systems, Wiley, 2010

EE-513 Photonics Technologies (Opto-electronics)

Pre-requisites	Basic knowledge of semiconductor theory and electronic devices
Objectives	To gain in depth concepts of the technologies, device structures, and theoretical principles of opto-electronics devices.
Course Description	• Semiconductors for Photonics - Optical Proprieties of Semiconductors. - LEDs. - Optical guiding and cavities, losses and threshold condition. - DBR lasers, DFB lasers, VCSELs, quantum-cascaded lasers, microcavity lasers. - Key design parameters and degradation mechanisms in semiconductor lasers. - Semiconductor optical amplifiers - PIN and avalanche receivers. • Photonic Passive and Functional Integrated Devices - Integrated guided optics. - Passive integrated devices. - Functional integrated devices. - Nonlinear devices. • Deposition and Compound Semiconductors Growth Techniques • Processing/Manufacturing Devices • Material/Device Testing and Characterization • Photonic Crystals Devices. • Optical Fiber Technologies
Textbooks	• P. Kaminow, T. Li, and A. E. Willner: Optical Fiber Telecommunications: Components and Systems, Academic Press, 2008. • L. Kazovsky, S. Benedetto, and A. Willner: Optical Fiber Communication Systems, Artech House, 1996.