# Masters Syllabus

(Effective from Academic Session 2011-12)

E C E

Electronics and Communication Engineering Discipline
Science, Engineering and Technology School
Khulna University
Khulna 9208, Bangladesh

# Electronics and Communication Engineering Discipline

Khulna University, Khulna

Summary of Courses for the Degree of
Master of Science in Electronics and Communication Engineering, abbreviated as
M.Sc. Engg. (ECE)
(Effective from Academic Session 2011-2012)

| **Type of M.Sc. Engg. (ECE)** | **Taught Credits (Minimum)** | **Thesis/Project Credits** | **Total Credits (Minimum)** |
|---|---|---|---|
| Research Based | 18.00 | 18.00 | 36.00 |
| Coursework Based | 30.00 | 6.00 | 36.00 |

N.B.: Each student has to take at least 6 Taught Credits from the Electronics group and 6 Taught Credits from the Communications group.

## Courses: At A Glance

| Course No. | Course Title | Group | Credits |
|---|---|---|---|
| ECE 5101 | Electronics of Solids | Electronics | 3.00 |
| ECE 5102 | MOS Devices | | 3.00 |
| ECE 5103 | Compound Semiconductor Devices | | 3.00 |
| ECE 5104 | VLSI Technology and Device Modeling | | 3.00 |
| ECE 5105 | Thin Film Technology | | 3.00 |
| ECE 5106 | Advanced Electronic Engineering Materials | | 3.00 |
| ECE 5107 | Digital Circuit Design | | 3.00 |
| ECE 5108 | Power Semiconductor Circuits | | 3.00 |
| ECE 5109 | Nanoelectronics | | 3.00 |
| ECE 5110 | Advanced Quantum Electronics | | 3.00 |
| | | | |
| ECE 5201 | Signals and Systems | Communications | 3.00 |
| ECE 5202 | Statistical Theory of Communication | | 3.00 |
| ECE 5203 | Telecommunication Networks | | 3.00 |
| ECE 5204 | Teletraffic Engineering | | 3.00 |
| ECE 5205 | Advanced Digital Communication | | 3.00 |
| ECE 5206 | Cellular Mobile Systems | | 3.00 |
| ECE 5207 | Microwave Theory and Techniques | | 3.00 |
| ECE 5208 | Advanced Antennas | | 3.00 |
| ECE 5209 | Satellite Communication | | 3.00 |
| ECE 5210 | Error Control Coding | | 3.00 |
| ECE 5211 | Fiber-optic Communication | | 3.00 |
| ECE 5212 | Free Space Optical Communication | | 3.00 |
| ECE 5213 | Multicarrier Communication | | 3.00 |
| ECE 5214 | Advanced Wireless Communication | | 3.00 |
| ECE 5215 | Information Theory | | 3.00 |
| ECE 5216 | Network Management | | 3.00 |
| | | | |
| ECE 5301 | Engineering Analysis | Interdisciplinary | 3.00 |
| ECE 5302 | Advanced Digital Signal Processing | | 3.00 |
| ECE 5303 | Optical Networks | | 3.00 |
| ECE 5304 | Optical Components and Amplification | | 3.00 |
| ECE 5305 | Nanophotonics | | 3.00 |
| ECE 5306 | Photonic Technologies | | 3.00 |
| ECE 5307 | Laser Theory | | 3.00 |
| ECE 5308 | Laser Processing of Materials | | 3.00 |
| ECE 5309 | Wave Optics | | 3.00 |
| ECE 5310 | Advanced Computer Networks | | 3.00 |
| ECE 5311 | Wireless Sensor Networks | | 3.00 |
| ECE 5312 | Network Security | | 3.00 |
| ECE 5313 | Advanced Microprocessors | | 3.00 |
| ECE 5314 | Advanced Multimedia Communications | | 3.00 |
| ECE 5315 | Biomedical Signal Processing | | 3.00 |
| ECE 5316 | Bioinformatics | | 3.00 |
| ECE 5317 | Biomedical Image Processing | | 3.00 |
| ECE 5318 | ICT Applications | | 3.00 |
| ECE 5319 | Advanced Artifical Intelligence | | 3.00 |
| ECE 5320 | Renewable Power Generation Sources | | 3.00 |
| ECE 5321 | Transients in Power Systems | | 3.00 |
| | | | |
| ECE 5999† | Selected Topics in Electronics & Communication Engineering | Special Topic | 3.00 |
| | | | |
| ECE 6000* | Master's Thesis I: Research Proposal | Thesis/Project | 6.00 |
| ECE 6001* | Master's Thesis II: Research | | 12.00 |
| ECE 6002* | Master's Project | | 6.00 |

*†This course can be taken by a student only once in the entire program.*
**A student will either do M.Sc. Thesis (ECE 6000 and ECE 6001) or M.Sc. Project (ECE 6002).*

**Electronics**
**Code: 1**

**ECE 5101: Electronics of Solids**
Credit Hour: 3.00

Crystal Structure: Lattice types, basis, defects, reciprocal lattice, Miller indices. Free Electron Theory: Drude model, Sommerfield model, Application of Drude model. Electrons in a periodic potential, Bloch's theorem, The nearly free electron model, The tight binding method, Energy band structure of semiconductors and insulators, Band structure engineering, Measurment of band structure, Phonos, Elelctron-Electron Scattering, Thermal properties of metals and semiconductors, Magnetoresistance and Superconductivity. Carrier Transport: Boltzmann transpord theory, relaxation time approximation, high field transport and hot-carrier effects, Hall effect.

*Recommended books:*
[1] Walter A. Harrison, "Electronic Structure and the Properties of Solids", Dover Publications, 1989, ISBN: 978-0486660219.
[2] Sharon Ann Holgate, "Understanding Solid State Physics", Taylor & Francis, 2009, ISBN: 978-0750309721.

**ECE 5102: MOS Devices**
Credit Hour: 3.00

The two terminal MOS Structure: flat-band voltage, inversion, properties of the regions of inversion and small signal capacitance. The four terminal MOS structure: charge-sheet model, strong inversion, moderate inversion and weak inversion. Threshold voltage-effects of ion implantation, short channel and narrow width. The MOS transistor in dynamic operation, small signal model for low medium and high frequencies, Charge Coupled devices (CCD).

*Recommended books:*
[1] Dieter K. Schroder, "Advanced Mos Devices", Addison-Wesley Pub, 1987, ISBN: 978-0201165067.
[2] Dewitt G. Ong, "Modern Mos Technology: Processes, Devices, and Design", Mcgraw-Hill, 1984, ISBN: 978-0070477094.

**ECE 5103: Compound Semiconductor Devices**
Credit Hour: 3.00

Introduction to GaAs device technology. GaAs metal-semiconductor field effect transistor (GaAs MESFET): introduction, structure, equivalent circuits, current saturation, effect of source and drain resistances, gate resistance and application of GaAs MESFET. High electron mobility transistor (HEMT):practical HEMT structure, energy band line-up, equivalent circuit, HEMT noise, pseudomorphic HEMT and applications. Opto-electronic integration of compound semiconductor devices: heterojunction phototransistor (HPT) and light amplifying optical switch (LAOS). Low-temperature compound semiconductor electronics. Design consideration of MMICs and power MMICs using compound semiconductor devices.

*Recommended books:*
[1] S. Tiwari, "Compound Semiconductor Device Physics", Academic Press, 1991, ISBN: 978-0126917406.
[2] Osamu Oda, "Compound Semiconductor Bulk Materials and Characterization", World Scientific Publishing Company, 1st edition, 2007, ISBN: 978-9810217280.

**ECE 5104: VLSI Technology and Device Modeling**
Credit Hour: 3.00

VLSI process technology. Crystal growth and wafer preparation . Epitaxial growth on Si substrate. Oxidation of Si. Lithography, diffusion: methods and models. Ion implantation, metallization. Overview and process flow of a CMOS and a BICMOS process. VLSI si devices. Isolation techniques. Second order effects in BJT devices: base width modulation. Emitter current crowding, kirk effect. Second order effects in MOS devices: short channel effects, narrow width effects. Device scaling rules. Device models. Compact models for bipolar devices. Ebers-Moll type model. Gummel-poon type model and their implementation in SPICE. BJT model in SPICE2. Compact models for MOS transistor and their implementation in SPICE. Level 1, 2 and 3 MOS model parameters in SPICE. Parameter extraction for bipolar and MOS device models. Geometry, process and temperature dependency of bipolar and MOS model parameters. Parameter optimization, statistics of parameters and statistical modeling.

*Recommended books:*
[1] Wai-Kai Chen, "VLSI Technology (Principles and Applications in Engineering)", CRC press, 2003, 1st edition, ISBN: 978-0849317385.
[2] Kwyro Lee, Michael shur, Tor A. Fjeldly and Tron Ytterdal, "Semiconductor Device Modeling For VLSI" , Prentice Hall, 1997, 1st edition, ISBN: 978-0138056568.

**ECE 5105: Thin Film Technology**
Credit Hour: 3.00

Introduction to thin films: Nucleation, growth, kinetics and thermodynamics of materials; Physical vapor deposition, Chemical vapor deposition, Plasma / Ion beam deposition, Epitaxial thin films: LPE, MBE, MOCVD; Film formation, Thin film characterization, Interdiffusion and reaction in thin films, Film formation, structural and physical properties: thickness, composition, morphology, mechanical properties, uniformity, grain size, Electrical, Optical and Magnetic properties of thin films, Electrical conduction in thin films- size effects, interface properties, electromigration. Applications and emerging technologies: Thin films for microelectronics, MEMS, optical coatings, photodetectors, smart sensors, xerographic devices, TFTs, switching devices, antiabrasive coatings, solar cells, superconducting and GMR devices, integrated optics, thin film superlattices, quantum and nano devices, bioelectronics devices.

*Recommended books:*
[1] Zexian Cao, "Thin Film Growth: Physics, materials science and applications", Woodhead Publishing, 2011, ISBN: 978-1845697365.
[2] Donald Smith, "Thin-Film Deposition: Principles and Practice", McGraw-Hill Professional, 1st edition, 1995, ISBN: 978-0070585027.
[3] R. W. berry, P. M. Hall and M. T. Harris, "Thin Film Technology", Van Nostrand Reinhold Inc., U.S., 1968, ISBN: 978-0442007171.

**ECE 5106: Advanced Electronic Engineering Materials**
Credit Hour: 3.00

Electric Properties: Polarization, electrical conductivity and dielectric losses. Pyroelectric phenomena . Piezoelectric effect and electrostriction. Domain structure and peculiarities, electric properties of ferroelectrics and anti-ferroelectrics. Structure and properties of some ferroelectrics and anti-ferroelectrics. Phase transition in ferroelectrics, fundamentals of spontaneous polarization theory. Magnetic Properties: Disordered magnetics, ordered magnetics. Domain structure of ferromagnetic crystals and magnetization processes. Anisotropy of ferroelectric crystals. Structure of some magnetically ordered crystals and reorientation transition. Piezomagnetic and magnetoelectric effect.

*Recommended books:*

[1] Philippe Robert, "Electrical and Magnetic Properties of Materials", Artech House Publishers, 1988, ISBN: 978-0890062623.
[2] W. Bolton, "Electrical and Magnetic Properties of Materials", Longman, 1991, ISBN: 978-0582070257.

**ECE 5107: Digital Circuit Design**
Credit Hour: 3.00

Introduction: Digital Design, Analog versus Digital, Digital Devices, Electronic Aspects of Digital Design, Software Aspects of Digital Design, Printed-Circuit Boards, Digital-Design Levels. Digital Circuits: Logic Signals and Gates, Logic Families, CMOS Logic, Electrical Behavior of CMOS Circuits, CMOS Steady-State Electrical Behavior, CMOS Dynamic Electrical Behavior, CMOS Logic Families, Bipolar Logic, Transistor-Transistor Logic, TTL Families, CMOS/TTL Interfacing, Low-Voltage CMOS Logic and Interfacing, Emitter-Coupled Logic. Combinational Logic Design Principles: Switching Algebra, Combinational-Circuit Analysis, Combinational- Circuit Synthesis, Programmed Minimization Methods, Timing Hazards,The VHDL Hardware Description Language. Combinational Logic Design Practices:Documentation Standards, Circuit Timing, Combinational PLDs, Decoders, Encoders, Three-State Devices, Multiplexers, Exclusive-OR Gates and Parity Circuits, Comparators, Adders, Subtractors, ALUs, Combinational Multipliers. Sequential Logic Design Principles: Bistable Elements, Latches and Flip-Flops, Clocked Synchronous State-Machine Analysis, Clocked Synchronous State-Machine Design, Designing State Machines Using State Diagrams, State-Machine Synthesis Using Transition Lists, Decomposing State Machines, Feedback Sequential Circuits, Feedback Sequential-Circuit Design, VHDL Sequential-Circuit Design Features. Sequential Logic Design Practices: Sequential-Circuit Documentation Standards, Latches and Flip-Flops, Sequential PLDs, Counters, Shift Registers, Iterative versus Sequential Circuits, Synchronous Design Methodology. Combinational-Circuit and Sequential-Circuit Design Examples using VHDL.

*Recommended books:*

[1] John F. Wakerly, "Digital Design: Principles and Practices", Prentice Hall, 4th edition , 2005, ISBN: 978-0131733497.
[2] Volnei A. Pedroni, "Circuit Design and Simulation with VHDL", The MIT Press, 2nd edition, 2010, ISBN: 978-0262014335.

**ECE 5108: Power Semiconductor Circuits**
Credit Hour: 3.00

Introduction to power electronics, Static switching devices, characteristics of SCR, BJT, MOSFET, IGBT, SIT, GTO, MCT. Classifications of static power converters and their applications, Control circuits for static power converters, PWM control of static power converters. Switch mode DC to DC converters, Resonant converters, Fourier analysis of static converter waveforms, HD, THD, pf, ZVS and ZCS of static converters. Hysteresis current of AC drives, Design of SCR communication circuits, Design of protection circuits for static power converters.

*Recommended books:*

[1] Shashi B. Dewan and Alan Straughen, "Power Semiconductor Circuits", John Wiley & Sons, 1975, ISBN: 978-0471211808.
[2] B. J. Baliga, "Fundamentals of Power Semiconductor Devices", Springer, 1st edition, 2008, ISBN: 978-0387473130.

**ECE 5109: Nanoelectronics**
Credit Hour: 3.00

Introduction to Nanoelectronics. Fabrication of nanoscale building blocks: E-beam, AFM, STM, dip-pen, nanoimprint, self-assembly. Single electron devices: Coulomb blockade, Fabrication

issues for logic and memory applications, Device examples. Graphene and carbon nanotubes: Material structures and properties, Electric and mechanical properties, FET, Chemical sensors, Nanoelectromechanical systems (NEMS). Semiconductor nanowires: Growth, Heterostructures, Biosensors, Environmental sensors, Solar cells, Lasers. Molecular electronics: Single molecule devices, Memory devices, Spintronics: Spin-FET, spin valves and MRAM.

*Recommended books:*

[1] Vladimir V. Mitin, Viatchaslav A. Kochelap and Michael A. Stroscio, "Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications", Cambridge University Press, 2012, ISBN: 978-1107403765.
[2] George W. Hanson, "Fundamentals of Nanoelectronics", Prentice Hall, 1st edition, 2007, ISBN: 978-0131957084.
[3] Mircea Dragoman and Daniela Dragoman, "Nanoelectronics: Principles and Devices", Artech House Publishers, 2nd edition, 2008, ISBN: 978-1596933682.

**ECE 5110: Advanced Quantum Electronics**
Credit Hour: 3.00

Basic notions of quantum electronics: Stimulated emission, Population inversion, Feedback and the lasing condition, Saturation and relaxation. History of quantum electronics, Stimulated quantum transitions, Density matrix, Populations of levels, Evolution of the density matrix. Susceptibility of matter: general properties of susceptibility, dispersion theory, two-level model and saturation, Bloch equations. Non-stationary optics: stimulated non-stationary effects, emission of an atom, collective emission. Nonlinear optics, The Kirchhoff law of quantum amplifiers, basic concepts of the statistical optics, Hamiltonian form of Maxwell's equations, Quantization of the field, States of the fields and their properties, Statistics of photons and photoelectrons, Interaction of an atom with quantised field, Recent progress in quantum electronics.

*Recommended books:*

[1] Maria Chekhova and Sergey Kulik, "Physical Foundations of Quantum Electronics", World Scientific Publishing Company, 1st edition, 2011, ISBN: 978-9814324502.
[2] D. Marcuse, "Principles of Quantum Electronics", Academic press, 1980, ISBN: 978-0124710504.

**Communications**
**Code: 2**

**ECE 5201: Signals and Systems**
Credit Hour: 3.00

Generic description of transmission systems: Signals, Systems, Model of a communication system. Classifications of signals: Periodic and Aperiodic signals, Deterministic and Random signals, Energy signals and Power signals, Discrete-Time signals and Continuous-Time signals, Signal representation. Fourier analysis: Fourier series and discrete spectrum, Fourier transform and continuous spectrum, Properties of Fourier Transform. The Impulse function. Fourier transform of periodic signals. Sampling of continuous-time signals. Reconstruction of a band-limited signal from its samples. Spectral densities. Correlation functions. Discrete Time Fourier Transform (DTFT). Laplace Transform. Z-transform. Signal transmission through LTI Systems: Impulse Response and Frequency Response of LTI Systems, Causality and Stability of LTI Systems, Relation of Spectral Densities of Input and Output of LTI Systems, Systems Analysis, Calculation of Transfer Functions. Design of Infinite Impulse Response (IIR) and Finite Impulse Response (FIR) filters.

*Recommended books:*

[1] Alan V. Oppenheim, Alan S. Willsky and With H. Hamid , "Signals and Systems", Prentice Hall, 2nd edition, 1996, ISBN: 978-0138147570.

[2] Chi-Tsong Chen, "Signals and Systems", Oxford University Press, USA, 3rd edition, 2004, ISBN: 978-0195156614

**ECE 5202: Statistical Theory of Communication**
Credit Hour: 3.00

An introduction to statistical communication theory. Statistical preliminaries: Probability distributions and distribution densities, Random Processes, time and ensemble averages, Ergodicity. Spectra, covariance and correlation functions. Sampling, interpolation and random pulse trains. Basics of information theory. Random noise processes. Signal detection and extraction. Binary detection systems minimising average risk: The average risk, Optimum detection, The Neyman-Pearson detection system, The ideal observer detection system, Minimax detection rule, Threshold detection. Extraction systems minimizing average risk: Estimates, Estimators, Cramer-Rao Inequality, Maximum likelihood estimation, Bayes Extraction with cost functions, coherent and incoherent estimation of signal amplitudes, Waveform estimation. Information measures in reception: Information and sufficiency, Information-loss criterion for detection/extraction.

*Recommended books:*
[1] David Middleton, "Introduction to Statistical Communication Theory", Peninsula Pub, 1987, ISBN: 978-0932146151.
[2] Y. W. Lee, "Statistical Theory of Communication", Dover Publications, 2004, ISBN: 978-0486438900.

**ECE 5203: Telecommunication Networks**
Credit Hour: 3.00

Telecommunications Fundamentals: History of Telecommunications, Telecommunications in Asia-Pacific Region, Telecom Organizations and Standardization. Public Switched Telephone Network (PSTN): International, National and Local Networks topology, Architecture of the Analog PSTN, Switching Hierarchy, Trunk Networks, Junction Networks, Local Distribution Networks, Local Loop and 2W/4W Circuits, Architecture of the Digital PSTN, Utilization of Existing Copper Pairs, DSL Technologies, Signaling, Dialing, Tone Dialing, DTMF, Telephone Terminals Common Channel Signaling, Telephone Numbering in PSTN. Signals Carried Over the Network: Types of Information and Their Requirements, Simplex, Half-Duplex, and Full-Duplex Communications, Frequency and Bandwidth, Analog and Digital Signals and Systems, Frequency Division Multiplexing (FDM), Time Division Multiplexing (TDM), Pulse Code Modulation, Speech Coding, Power Levels of Signals, Decibel, Gain and Loss. Transmission Media and systems: Twisted-Pair Copper Cable, Coaxial Cable, Microwave, Satellite, Fiber Optics, Microwave Radio Relay Lines, Satellite Communications Networks, Optical Fiber Communication Networks, Mobile Communication Systems, Wireless Local Loop Systems. Integrated Services Digital Network (ISDN): Principle of ISDN, ISDN Standardization, Telecommunication Services Supported by ISDN, ITU-T Signaling Systems No.7 (SS7), B-ISDN Principles & Recommendations, Services Supported by B-ISDN, Architecture of B-ISDN.

*Recommended books:*
[1] Tarek N. Saadawi and Mostafa H. Ammar , " Fundamentals of Telecommunication Netowrks", Wiley-Interscience, 1st edition, 1994, ISBN: 978-0471515821.
[2] Roger L. Freeman, "Telecommunication System Engineering", Wiley-Interscience, 4th edition, 2004, ISBN: 978-0471451334.

**ECE 5204: Teletraffic Engineering**
Credit Hour: 3.00

Introduction to Teletraffic Engineering. Traffic Flows in Networks: Traffic Units and Parameters, Holding Time and Call Intensity, Offered Traffic and Carried Traffic, Congestion and Delay,

Traffic Variations, Subscriber Behaviour. Classical Loss Systems: Poisson Traffic Model, Erlang's Model, Binomial, and Engset's Models, Limited Availability, and Gradings-PJ Formula, Link Systems in Switching Networks, Dimensioning Tables and Charts, Computerized Aids. Delay Systems: Classical Waiting Time Systems, Classification of Queuing Models, Infinite Source Delay-Loss Systems, Limited Source Delay-Loss Systems. Traffic Measurements: Measurements Recommended by ITU-T, Measurement of Holding Times and Traffic Intensity, Measurement Accuracy. Multi-Dimensional Traffic: Multidimensional Traffic Models, Overflow Traffic Modeling, ATM Traffic Characteristics and Modeling.

*Recommended books:*

[1] Haruo Akimaru and Konosuke Kawashima , " Teletraffic: Theory and Applications", Springer; 2nd ed. edition (June 22, 1999), ISBN: 978-1852331627.
[2] Hiroshi Saito, "Teletraffic Technologies in ATM Networks", Artech House Publishers, 1994, ISBN: 978-0890066225.

**ECE 5205: Advanced Digital Communication**
Credit Hour: 3.00

Review of Probability and Stochastic Processes. Power Spectrum and Communication over Memoryless Channel: PSD of a synchronous data pulse stream, M-ary Markov source, Convolutionaly-coded modulation, Continuous phase modulation, Scalar and vector communication over memoryless channel, Detection Criteria. Coherent and Non-Coherent Communication: Coherent receivers, Optimum receivers in WGN, IQ modulation & demodulation, Noncoherent receivers in random phase channels, M-FSK receivers, Rayleigh and Rician channels, Partially coherent receives – DPSK, M-PSK, M-DPSK, BER Performance Analysis. Band-limited Channels and Digital Modulations: Eye pattern, demodulation in the presence of ISI and AWGN, Equalization techniques, IQ modulations, QPSK, π/4-QPSK, QAM, QBOM, BER Performance Analysis, Continuous phase modulation, CPFM, CPFSK, MSK, OFDM. Block Coded Digital Communication: Architecture and performance, Binary block codes, Orthogonal, Biorthogonal, Transorthogonal- Shannon's channel coding theorem, Channel capacity, Matched filter, Concept of Spread Spectrum Communications, Coded BPSK and DPSK demodulators, Linear block codes, Hammning , Golay, Cyclic, BCH, Reed–Solomon codes. Convolutional-Coded Digital Communication: Representation of codes using Polynomial, State diagram, Tree diagram, and Trellis diagram, Decoding techniques using Maximum likelihood, Viterbi algorithm, Sequential and Threshold methods – Error probability performance for BPSK and Viterbi algorithm.

*Recommended books:*

[1]John G. Proakis, "Digital Communications", McGraw-Hill Science/ Engineering/Math, 5th edition, 2007, ISBN: 978-0072957167.
[2] Kamilo Feher, "Advanced Digital Communications: Systems and Signal Processing Techniques", Scitech Pub Inc, 1997, ISBN: 978-1884932021.

**ECE 5206: Cellular Mobile Systems**
Credit Hour: 3.00

Introduction to wireless communication: Evolution of mobile communications, mobile radio systems- Examples, trends in cellular radio and personal communications. Cellular Concept: Frequency reuse, channel assignment, hand off, Interference and system capacity, tracking and grade of service, Improving Coverage and capacity in Cellular systems. Mobile Radio Propagation: Free space propagation model, reflection, diffraction, scattering, link budget design, Outdoor Propagation models, Indoor propagation models, Small scale Multipath propagation, Impulse model, Small scale Multipath measurements, parameters of Mobile multipath channels, types of small scale fading, statistical models for multipath fading channels. Modulation Techniques: Minimum Shift Keying, Gaussian MSK, M-ary QAM, M-ary FSK, Orthogonal Frequency Division Multiplexing, Performance of Digital Modulation in Slow-Flat Fading

Channels and Frequency Selective Mobile Channels. Equalization: Survey of Equalization Techniques, Linear Equalization, Non-linear Equalization, Algorithms for Adaptive Equalization. Diversity Techniques, RAKE receiver. Coding: Vocoders, Linear Predictive Coders, Selection of Speech Coders for Mobile Communication, GSM Codec, RS codes for CDPD. Multiple Access Techniques: FDMA, TDMA, CDMA, SDMA, Capacity of Cellular CDMA and SDMA. Wireless Systems and Standards: Second Generation, Third Generation and fourth Generation Wireless Networks and Standards, WLL, Bluetooth, AMPS, GSM, IS-95, DECT.

*Recommended books:*

[1] Ian poole, "Cellular Communications Explained: From Basics to 3G", Newnes, 1st edition , 2006, ISBN: 978-0750664356.
[2] Mischa Schwartz, "Mobile Wireless Communications", Cambridge University Press 2005, ISBN: 978-0521843478.

**ECE 5207: Microwave Theory and Techniques**
Credit Hour: 3.00

Introduction to Microwaves: History of Microwaves, Microwave Frequency bands, Applications of Microwaves. Mathematical model of Microwave Transmission: Concept of Mode, Characteristics of TEM, TE and TM Modes, Losses associated with microwave transmission, Concept of Impedance in Microwave transmission. Analysis of RF and Microwave Transmission Lines: Coaxial Line, Rectangular Waveguide, Circular waveguide, Stripline, Microstrip Line. Microwave Network Analysis: Equivalent Voltages and currents for non-TEM lines, Network parameters for microwave Circuits, Scattering Parameters. Microwave Design Principles: Impedance transformation, Impedance Matching, Microwave Filter Design, RF and Microwave Amplifier Design, Microwave Power amplifier Design, Low Noise Amplifier Design, Microwave Mixer Design, Microwave Oscillator Design. Modern Trends in Microwaves Engineering: Effect of Microwaves on human body, Medical and Civil applications of microwaves, Electromagnetic interference / Electromagnetic Compatibility (EMI / EMC), Monolithic Microwave IC fabrication, RFMEMS for microwave components, Microwave Imaging.

*Recommended books:*

[1] Stephen F. Adam, "Microwave Theory and Applications", Adam Microwave Consulting, 1992, ISBN: 978-0963428400.
[2] Robert E. Collin, "Foundations for Microwave Engineering", Wiley-IEEE Press, 2nd edition, 2000, ISBN: 978-0780360310.

**ECE 5208: Advanced Antennas**
Credit Hour: 3.00

Some important concepts: Radiation Impedance, Radiation Pattern, Antenna Impedance, Bandwidth, Directivity, Gain, Antenna efficiency, Radiation Efficiency, Antenna Polarization, Antenna Apertures, Antenna temperature, near-field and far-field concepts, and radiation mechanism. Introduction to various methods of antenna synthesis such as Schelkunoff Polynomial, Fourier transform, Woodward Lawson. Introduction to antenna analysis methods: Integral equation method, Moment method, Finite Difference Time Domain methods; Applications of these methods to the practical antennas such as dipole, loop, helical, micro-strip patch, and PIFA. Antenna Design: Various impedance matching techniques such as Quarter wavelength transformer, T-match, Gamma Match, Omega match, Baluns and Transformers. Analytical comparative study of wire type and aperture type, narrow band and wide band, element and antenna array antennas. Designing an antenna with a set of given specifications using standard software. Material selection for antenna to be designed, understanding the specifications – errors responses – corrections methods. Concepts of antenna coupling, coupling methods, interferences and effects on performance of the antenna system. Techniques to miniaturize an antenna for wireless LAN and Blue tooth applications, Wide-band and multi-band antennas, Mobile antennas and antenna diversity, Reconfigurable antennas, Practical consideration in

designing antennas for wireless communications (such as the interaction between mobile antenna and human body). Measurement of various antenna parameters necessarily needed for practical antennas.

*Recommended books:*

[1] Constantine A. Balanis, "Antenna Theory: Analysis and Design", Wiley-Interscience, 3rd edition , 2005, ISBN: 978-0471667827.
[2] Joel R. Hallas, "Basic Antennas: Understanding Practical Antennas and Design", Amer Radio Relay League, 1st edition, 2009, ISBN: 978-0872599994.

**ECE 5209: Satellite Communication**
Credit Hour: 3.00

Orbital Mechanics: Kepler's laws of motion, Orbits, Orbit Equations, Orbit Description, Locating the Satellite in the Orbit and with Respect to Earth, Orbital Elements-Look Angle Determination and Visibility, Orbital Perturbations, Orbit Determination, Launch Vehicles, Orbital Effects in Communication System, Performance Attitude control, Satellite launch vehicles, spectrum allocations for satellite systems. Spacecraft Subsystems and Earth Station: Spacecraft Subsystems, Altitude and Orbit Control, Telemetry and Tracking, Power Systems, Communication Subsystems, Transponders, Antennas, Equipment Reliability, Earth Stations, Example of payloads of operating and planned systems. Space Links: The Space Link, Satellite Link Design, Satellite uplink -down link power Budget, Basic Transmission Theory, System Noise Temp, G/T Ratio, Noise Figure, Downlink Design, Design of Satellite Links for Specified C/N, Microwave Propagation on Satellite-Earth paths, Interference between satellite circuits, Energy Dispersal, Propagation Characteristic of mobile and fixed satellite links. Multiple Access Techniques and network Aspects: Single access vs. Multiple access (MA). Classical MA techniques: FDMA, TDMA. Single channel per carrier (SCPC) access, Code division multiple access (CDMA). Demand assignment techniques. Examples of MA techniques for existing and planned systems (e.g. the satellite component of UMTS). Mobile satellite network design, ATM via satellite. TCP/IP via satellite, Call control, handover and call set up procedures. Hybrid satellite-terrestrial networks. Services and Applications: Fixed and mobile services, Multimedia satellite services, Advanced applications based on satellite platforms, INTELSAT series, INSAT, VSAT, Remote Sensing. Mobile satellite service: GSM. GPS, INMARSAT, Navigation System, Direct to Home service (DTH), Special services, E-mail, Video conferencing and Internet connectivity.

*Recommended books:*

[1] Dennis Roddy , "Satellite Communications", McGraw-Hill Professional, 4th edition, 2006, ISBN: 978-0071462983.
[2] Anil K. Maini and Varsha Agrawal, "Satellite Technology: Principles and Applications", Wiley, 2nd edition, 2010, ISBN: 978-0470660249.

**ECE 5210: Error Control Coding**
Credit Hour: 3.00

The principles of Coding in Digital Communications. Introduction to Error Control Coding: ARQ, HARQ, FEC. Block codes, Groups and Vector spaces. Generator and Parity check Matrices. Dual codes. Hamming Codes, General properties of Linear codes, Cyclic codes, rings, Encoding and decoding of cyclic codes, Finite fields. BCH codes: Construction, properties, dimension, encoding, decoding. RS codes: Definition, overview of decoding. Convolution codes: Definition, Trellis representation, encoding, Viterbi decoding; LDPC codes: Definition, Tanner graph, Cycles, Irregular codes, Sum Product Algorithm (SPA), Density evolution, Optimization. Turbo-codes: Definition, BCJR algorithm, EXIT charts, Interleaver, design of Interleaver , RSC encoder.

*Recommended books:*

[1] Shu Lin and Daniel J. Costello , " Error Control Coding", Prentice Hall, 2nd edition , 2004, ISBN: 978-0130426727.

[2] Peter Sweeney, "Error Control Coding: From Theory to Practice", Wiley, 1st edition, 2002, ISBN: 978-0470843567.

**ECE 5211: Fiber-optic Communication**
Credit Hour: 3.00

Optical fibre: modes of propagation, transmission characteristics, waveguide analysis. Optical sources: light emitting diode (LED) and semiconductor laser diode (SLD), operational principles, characteristic curves, Optical transmitter design using LED/SLD. Optical switches: coupled mode analysis of directional couplers, electro-optic switches. Optical amplifiers: laser and fibre amplifiers. Photo detectors: P-i-N and avalanche photo detectors (APDs), noise sources. Optical modulation and detection schemes. Direct and coherent detection receivers: configuration, operation, noise sources, sensitivity calculation, performance curves. Design of analog and digital receivers. Transmission link analysis: point-to point and point-to multi-point links, system configuration, link power budget, rise time budget, line coding schemes, transmission system limitations, design of fibre-optic systems. Optical data buses, optical networks, fibre distributed data interface (FDDI) and synchronous optical network (SONET), Synchronous Digital Hierarchy (SDH), Wavelength division multiplexing (WDM) transmission systems. Nonlinear effect in fiber optic links, Concept of self-phase modulation, group velocity dispersion and soliton based communication.

*Recommended books:*
[1] Gobind P. Agrawal , "Fiber-optic Communication Systems", Wiley-Interscience, 4th edition , 2010, ISBN: 978-0470505113.
[2] John Senior, "Optical Fiber Communications: Principles and Practice", Prentice Hall, 3rd edition, 2008, ISBN: 978-0130326812.

**ECE 5212: Free Space Optical Communication**
Credit Hour: 3.00

Introduction: Technology Overview, System Configurations, Evolution of Infrared Communication Systems, The Optical Wireless Channel, Design Fundamentals, Power Budget Considerations. Atmospheric Transmission, Effect of Rain, Fog and Mist, Scintillation, Data Transmission Limitations, Eye Safety, Light-Emitting Diodes versus Laser Diodes, Fundamentals of Optical Concentration, Optical Concentrators, Optical Wireless Transmitter Design, Optical Source Characteristics, External Optical Modulators, Direct Digital Modulator, Driver Circuit Design Concepts, Transmitter Linearization Techniques, Optical Wireless Receiver Design, Photodetection in Reverse-Biased Diodes, Choosing the Photodetector, Bit Error Rate and Sensitivity, Bandwidth, Signal Amplification Techniques, Transceiver Circuit Implementation Technologies-Hybrid and Monolithic Integration. Optical Modulation, Coding, and Multiple Access techniques. Infrared Data Association (IrDA) Protocols. Wireless Infrared Networking: Network Architecture, Optical Wireless Network Specifications, The Ad Hoc Network, Quality of Service, Future Infrared Networking.

*Recommended books:*
[1] Roberto Ramirez-Iniquez, Sevia M. Idrus and Ziran Sun , "Optical Wireless Communications: IR for Wireless Connectivity", Wiley-Interscience, 1st edition , 2008, ISBN: 978-0849372094.
[2] Steve Hranilovic, "Wireless Optical Communication systems", Springer, 1st edition, 2010, ISBN: 978-1441919823.

**ECE 5213: Multicarrier Communications**
Credit Hour: 3.00

Direct-Sequence Spread Spectrum, Multicarrier Spread-Spectrum Communications, Frequency-Hopped Spread-Spectrum Communications, Time-Hopping Spread-Spectrum Communications, Principles of Single carrier and Multicarrier Communications, Orthogonal Frequency-Division

Multiplexing (OFDM), Frequency-Domain Spread Multicarrier CDMA, Single-Carrier Frequency-Division Multiple Access, Orthogonal Multicarrier DS-CDMA, Multi-tone DS-CDMA, Generalized Multicarrier DS-CDMA, Time-Hopping Multicarrier CDMA, Time-Frequency-Domain Spread Multicarrier DS-CDMA, Performance of Multicarrier Systems over Gaussian Channels, Performance of Multicarrier Systems over Frequency-Selective Fading Channels, Coherent Multiuser Detection, Non-coherent Multiuser Detection, Multiuser Transmitter Pre-processing, Multiple-Input Multiple-Output (MIMO) Communications, Spatial Diversity, Spatial-Division Multiple Access, Performance of Multicarrier CDMA Using Space–Time Coding, Time-Frequency-Domain Space–Time Spread Multicarrier DS-CDMA, Space–Time MC DS-CDMA over Fast Time-Varying Fading channels.

*Recommended books:*

[1] Lie-Liang Yang , "Multicarrier Communications", Wiley, 1st edition , 2009, ISBN: 978-0470722008.
[2] Carl R. Nassar, Bala Natarajan, Zhiqiang Wu, David A. Wiegandt, S. Alireza Zekavat and Steve Shattil, "Multi-Carrier Technologies for Wireless Communication", Springer, 1st edition, 2010, ISBN: 978-1441949370.

**ECE 5214: Advanced Wireless Communication**
Credit Hour: 3.00

Wireless Medium: Air Interface Design, Radio propagation mechanism, Path-loss modeling and Signal Coverage, Effect of Multipath and Doppler, Channel Measurement and Modelling, Simulation of Radio Channel. Wireless Medium Access: Fixed Assignment Access for Voice Networks, Random Access for Data Networks, Integration of Voice and Data traffic. Wireless Network Operation: Wireless Network Topologies, Cellular Topology, Cell fundamentals, Signal to Interference Ratio, Capacity Expansion, Mobility Management, Resources and Power Management, Security in Wireless Networks. Wireless WAN: GSM and TDMA Technology, Mobile Environment, CDMA Technology, IS95, IMT2000, Mobile Data Networks, CDPD Networks, GPRS, Mobile Application Protocol. Wireless LANs and HiperLANs: Introduction to wireless LANs, IEEE 802.11,WPAN IEEE 802.15 –Mobile Ad Hoc Networks (MANET)- Principle and operation. IEEE 802.16: WiMAX, IEEE 802.21: MIH (Media Independent Handover (MIH), IEEE 802.15.7:Visible Light Communication, IEEE 802.15.3c: High rate WPAN, WiMedia. Wireless Home Networking, Concepts of Bluetooth Technology.

*Recommended books:*

[1] Andreas F. Molisch , " Wireless Communications", Wiley, 2nd edition , 2011, ISBN: 978-0470741863.
[2] Savo G. Glisic, "Advanced Wireless Communications: 4G Cognitive and Cooperative Broadband Technology", Wiley-Interscience, 2nd edition, 2007, ISBN: 978-0470059777.

**ECE 5215: Information Theory**
Credit Hour: 3.00

Introduction, entropy. Jensen's inequality, data processing theorem, Fanos's inequality. Different types of convergence, asymptotic equipartition property (AEP), typical set, joint typicality. Entropies of stochastic processes. Data compression, Kraft inequality, optimal codes. Huffman codes, Shannon-Fano-Elias codes, Slepian-Wolf coding. Channel capacity, binary symmetric and erasure channels, Maximizing capacity, Blahut-Arimoto Algorithms for computing channel capacity. The channel coding theorem, Strong coding theorem, types of errors. Fano's inequality and the converse to the coding theorem, Fano's inequality and the converse to the coding theorem. Differential entropy, maximizing entropy. Additive Gaussian noise channel, Gaussian channels with feedback, Multiple access channels, Broadcast channels, Finite state Markov channels, Channel side information, wide-band channels.

*Recommended books:*
[1] Thomas M. Cover and Joy A. Thomas, "Elements of Information Theory", Wiley-Interscience, 2nd edition, 2006, ISBN: 9780471241959.
[2] Robert G. Gallagher, "Information Theory and Reliable Communication", Wiley, 1st edition, 1968, ISBN: 9780471290483.

**ECE 5216: Network Management**
Credit Hour: 3.00

Overview. Standards, Models, and Functions. A Framework for Network Management: TMN. SNMP v1 Network Management: Organization Models. SNMP v1 Network Management: Information Models. SNMP v1 Network Management: Communication and Functional Models. SNMPv2. SNMPv3. RMON. NM Applications – Configuration Management. NM Applications – Fault and Performance Management. NM Applications – Security and Accounting Management. Web Based Management. NM Tools.

*Recommended books:*
[1] Mani Subramanian 'Network Management: Principals and Practice' Addison Wesley, 1st edition, 1999, ISBN: 978-0201357424.
[2] William Stallings, "SNMP, SNMPv2, SNMPv3, and RMON 1 and 2", Addison-Wesley Professional, 3rd edition, 1999, ISBN: 978-0201485349.

**Interdisciplinary**
**Code: 3**

**ECE 5301: Engineering Analysis**
Credit Hour: 3.00

Wavelet transform. Chaos and bifurcation theorems. Walsh function. Green's function. Finite element techniques. Fuzzy logic. Genetic algorithms.

*Recommended books:*
[1] Raghuveer M. Rao and Ajit S. Bopardikar, "Wavelet Transforms: Introduction to Theory and Applications", Prentice Hall PTR; Har/Dskt edition, 1998, ISBN: 978-0201634631.
[2] J Reddy, "An Introduction to the Finite Element Method", McGraw-Hill Science/Engineering/Math; 3rd edition, 2005, ISBN: 978-0072466850.
[3] Timothy J. Ross, "Fuzzy Logic with Engineering Applications", Wiley, 3rd edition, 2010, ISBN: 978-0470743768.
[4] S.N. Sivanandam and S. N. Deepa, "Introduction to Genetic Algorithms", Springer, 1st edition , 2010, ISBN: 978-3642092244.

**ECE 5302: Advanced Digital Signal Processing**
Credit Hour: 3.00

Parametric Methods for Power Spectrum Estimation: Relationship between the auto correlation and the model parameters, The Yule-Walker method for the AR Model Parameters, The Burg Method for the AR Model parameters,unconstrained least-squares method for the AR Model parameters, sequential estimation methods for the AR Model parameters, selection of AR Model order. Adptive Signal Processing: FIR adaptive filters, steepest descent adaptive filter, LMS algorithm convergence of LMS algorithms, Application- noise cancellation, channel equalization , adaptive recursive filters, recursive least squares. Multirate Signal Processing: Decimation by a factor D, Interpolation by a factor I, Filter Design and implementation for sampling rate conversion-Direct form FIR filter structures, Polyphase filter structure. Speech Signal Processing: Digital models for speech signal-Mechanism of speech production, model for vocal tract, radiation and excitation, complete model, time domain processing of speech signal- Pitch period estimation,

Linear predictive Coding-Basic Principles, autocorrelation method, Durbin recursive solution. Introduction to Wavelet Transforms.

*Recommended books:*

[1] John G. Proakis and Dimitris K. Manolakis, "Digital Signal Processing", Prentice Hall, 4th edition, 2006, ISBN: 978-0131873742.
[2] Saeed V. Vaseghi, "Advance Digital Signal Processing and Noise Reduction", Wiley, 4th edition, 2009, ISBN: 978-0470754061.

**ECE 5303: Optical Networks**
Credit Hour: 3.00

Optical networking: principles and challenges; evolution of optical networks, wavelength routed network, wavelength division multiplexing (WDM) network, sub-carrier multiplexing optical networks. Enabling technologies: optical transmitter, optical fiber, optical receivers, optical amplifiers, optical switching elements, optical cross-connects (OXC), multiplexers/demultiplexers, filters, wavelength routers, optical wavelength converters, WDM network test beds. Network architecture, IP over WDM. Broadcast optical networks: single and multiple hop networks, channel sharing and multi-casting, shared channel multicasting network-GEMNET, performance evaluation for unicast and multicast traffic, experimental WDM networks. Wavelength routed networks: virtual topology design, routing and wavelength assignment, circuit switched and packet switched approaches, performance evaluation. Reconfiguration in WDM network, network control and management, network optimization, design considerations. Multi wavelength star and ring networks. Network Survivability. Passive optical networks (PONs). Photonic switching, optical TDM (OTDM) and optical CDMA (O-CDMA) networks, next generation optical networks.

*Recommended books:*

[1] Leonid G. Kazovsky, Ning Cheng, Wei-Tao Shaw, David Gutierrez and Shing-Wa Wong, "Broadband Optical Access Networks", Wiley-Interscience, 1st edition, 2011, ISBN: 978-0470182352.
[2] Jane M. Simmons, **"**Optical Network Design and Planning", Springer, 2010, ISBN: 978-1441945556.
[3] Rajiv Ramaswami and Kumar N. Sivarajan, "Optical Networks," Academic Press, 2nd edition, 2002, ISBN: 1-55860-655-6.

**ECE 5304: Optical Components and Amplification**
Credit Hour: 3.00

Optical components in WDM transmission systems: Multi-mode/Single-mode optical fibers, Lasers (DFB, FP, FRL) and laser noise, Mach-Zender modulators, Photodiodes, Multiplexer and Demultiplexer, Isolators and circulators, Optical filters, Optical splitters and couplers. Erbium-doped Fiber Amplifier(EDFA): Physical mechanisms and modeling, Measurement of input fiber parameters, Large bandwidth EDFA, L-band EDFA and FWM crosstalk, EDFA dynamics, Applications of EDFA in WDM optical communication systems and networks. Integrated Amplifiers: High concentration in Erbium-Doped Waveguide Amplifier (EDWA), EDWA design by finite element method, Er/Yb co-doped waveguide amplifiers, Silicon-Nanocrystal sensitized EDWAs, Applications of EDWA in WDM optical communication systems and networks, Semiconductor optical amplifiers. Raman Amplifiers (RA): Physical mechanisms, Static and dynamic models, Measurement of input fiber parameters, Noise sources in RAs, Distributed and discrete RAs, Advanced techniques for distributed Raman amplification, Application of RAs in WDM optical communication systems, All-Raman based WDM optical communication systems, Raman based unrepeated WDM transmission systems. Photonic crystal fiber (PCF) based optical amplifiers: Physical mechanisms, Optical Parametric Amplifiers (OPA), PCF based Raman amplifiers, High power amplifiers.

*Recommended books:*

[1] Emmanuel Desurvire, "Erbium-Doped Fiber Amplifiers: Principles and Applications", Wiley-Interscience, 1st edition, 1994, ISBN: 978-0471589778.
[2] Malin Premaratne and Govind P. Agrawal, "Light Propagation in Gain Media: Optical Amplifiers", Cambridge University Press, 2011, ISBN: 978-0521493482.

**ECE 5305: Nanophotonics**
Credit Hour: 3.00

Introduction: Nanophotonics at a glance. Foundations for Nanophtonics: Maxwell Equations, Quantum Mechanics, Optics, Principles of Nanophotonics. Light generation by nanostructures: semiconductor quantum wells, wires, dots, nanocrystals, nanowires. Light propagation in nanostructures: nanowires, nano-waveguides. Nanolasers: laser basics, nanowire lasers. Photonic crystal: Theoretical modeling of photonic crystals, Features of photonic crystals, phase, group and energy velocity; defect mode. Near-field interaction and microscopy: Near-field optics and theoretical modeling of near-field nanoscopic interactions, Near-field interaction & microscopy. Plasmonics: Plasmonic fundamentals and sensors, Local field enhancement , Plasmonic waveguiding, Super-resolution imaging, Metamaterials, Nanolithography. Silicon Photonics: basic properties of Si materials and design guidelines in Si-photonics, silicon photonic waveguides, optical modulators in silicon photonics circuits, silicon lasers.

*Recommended books:*

[1] Sergey V. Gaponenko, "Introduction to Nanophotonics", Cambridge University Press, 1st edition, 2010, ISBN: 978-0521763752.
[2] Paras N. Prasad, "Nanophotonics", Wiley-Interscience, 1st edition, 2004, ISBN: 978-0471649885.
[3] Motoichi Ohtsu, Kiyoshi Kobayashi, Tadashi Kawazoe, Takashi Yatsui, and Makoto Naruse," Principles of Nanophotonics," CRC Press, 1st edition, 2008, ISBN : 978-1-58488-972-4.
[4] Dennis W. Prather, Shouyuan Shi, Ahmed Sharkawy, Janusz Murakowski, and Garrett J. Schneider, "Photonic Crystals," John Willey & Sons, 1st edition, 2009, ISBN: 978-0-470-27803-1.
[5] Stephan A. Maier, "Plasmonics: Fundamentals and Applications," Springer, 1st edition, 2007, ISBN: 978-0387-33150-8.
[6] Graham T. Reed, "Silicon Photonics," John Willey & Sons, 1st edition, 2008, ISBN: 978-0-470-02579-6.

**ECE 5306: Photonic Technologies**
Credit Hour: 3.00

An Introduction to optoelectronic Integrated Circuit, Optical Waveguide design: Propagation in optical waveguide- geometric theory and electromagnetic theory, Modal property of the optical waveguide, Modal Solution for a Slab Waveguide, Modal Solution of the Channel Waveguide. Waveguide technology: Short description of the technologies- Glass on Silicon, Lithium Niobate, Silicon Photonics, Polymer, InP, Packaging and Coupling of Optical Waveguide, Bending in Optical waveguide. Simple Design of passive optical devices: Coupled mode theory for Optical waveguides, Design of simple passive optical devices-Directional Coupler, WDM, Mach Zehnder Filter, AWG.

*Recommended books:*

[1] Gines Lifante, "Integrated Photonics: Fundamentals", Wiley, 1st edition, 2003, ISBN: 978-0470848685.
[2] Tamir Theodor, "Guided-Wave Optpelectronics", Springer-Verlag, 2nd edition, 1990, ISBN: 978-0387527802.
[3] L. A. Coldren (Author), S. W. Corzine, "Diode Lasers and Photonic Integrated Circuits", Wiley-Interscience, 1st edition, 1995, ISBN: 978-0471118756.

**ECE 5307: Laser Theory**
Credit Hour: 3.00

Overview of Laser Operation, Optical Coherence, Optical Resonators: Mode Frequencies, Mode Width, Fabry-Perot Interferometer. Gaussian Beam Optics: Gaussian Beams in Free Space, Gaussian Beams in a Laser Cavity, Gaussian Beams Passing Through a Lens. Emission, Absorption, and Rate Equations. Stimulated Emission and Optical Gain: Broadband Radiation, Narrowband Radiation, Gain Coefficient, Gain Cross Section, Fluorescence Lifetime, Quantum Yield, Lineshape Function. Laser pumping, Laser amplification, Laser Oscillation: Threshold Condition, Above Lasing Threshold-Rate Equation Approach, Steady-State Laser Output, Laser Output Efficiency, The Laser Bandwidth. Continuous Wave Laser Behavior: Mode Spectrum of Laser Light, Single-Mode Lasing, Multimode Lasing, Laser noise. Relaxation Oscillations, Q-Switching, Principles of Modelocking, Active Mode Locking, Passive Mode Locking, Principles of operation of gas, solid state and semiconductor lasers. Laser Applications: Distance & Velocity Measurements, Laser Gyroscope, Holography, Optical Communications, Lasers in Medicine, Laser Processing of Materials. Introduction to Nonlinear Optics: Second/Third Harmonic Generation, Phase Matching, Three/Four-Wave Mixing, Multiphoton Absorption and Emission, Raman Scattering, Self-Focusing.

*Recommended books:*
[1] William T. Silfvast, "Laser Fundamentals", Cambridge University Press, 2nd edition, 2008, ISBN: 978-0521541053.
[2] K. Thyagarajan and Ajoy Ghatak, "Lasers: Fundamentals and Applications", Springer, 2nd edition, 2010, ISBN: 978-1441964410.
[3] Peter W. Milonni and Joseph H. Eberly, "Lasers," John Willey & Sons, 1st edition, 1988, ISBN: 0-471-62731-3.

**ECE 5308: Laser Processing of Materials**
Credit Hour: 3.00

Common industrial lasers and their output characteristics: Gas Lasers, Solid-state Lasers, Dye Lasers, Free-electron Lasers. Fundamentals of Laser-Material Interactions: Heat in Solids, Single Photon and Multi-Photon Processes, Laser Reflection & Absorption, Vaporization, Recondensation, Plasma Formation. Laser Plasma Interaction: Processes in Nanosecond Laser-Plasma Interactions, Plasma Interactions with Femtosecond Laser Pulses. Overview of Laser Applications: Laser Application in Various Fields, Advantages & Disadvantages, Economics. Laser processing fundamentals: Beam characteristics, Optical Components and Design of Beam Delivery Systems, Absorption Characteristics of Materials, Heat Flow Theory and Metallurgical Considerations. Working principles of interferometers and elementary holography. Laser Cutting, Drilling, and Piercing: process characteristics, material removal modes, development of theoretical models and practical performances. Welding: process mechanisms like keyhole and plasma, development of theoretical models, operating characteristics and process variation. Laser Surface Treatment: Heat Treatment, Surface Melting, Surface Alloying & Cladding, Surface Texturing, development of theoretical models, LCVD and LPVD. Micro/Nano-Machining of Materials: Optical Waveguides, Photonic Devices & Circuits, Photonic Crystals, Metamaterials, Micro/Nano-Fluidic Channels. Laser Cleaning: Mechanisms of Laser Cleaning, Overview of Laser Cleaning Process. Biomedical Laser Processes and Equipment: Interaction of Laser Radiation with Biological Tissues, Medical Applications of Lasers, Medical Diagnostics, Laser Manufacture of Medical Devices. Laser Automation and In-process Sensing: Automation Principles, In-process Monitoring, In-process Control. Laser Safety.

*Recommended books:*
[1] Peter Schaaf, "Laser Processing of Materials: Fundamentals, Applications and Developments", Springer, 1st edition, 2010, ISBN: 978-3642132803.
[2] John C. Ion, "Laser Processing of Engineering Materials: Principles, Procedure and Industrial Application", Butterworth-Heinemann, 2005, ISBN: 978-0080971896.

[3] William M. Steen and Jyotirmoy Mazumder, "Laser Material Processing," Springer, 4th edition, 2010, ISBN: 978-1-84996-061-8.
[4] John Dowden, "The Theory of Laser Materials Processing," Springer, 1st edition, 2009, ISBN: 978-1-4020-9339-5.

**ECE 5309: Wave Optics**
Credit Hour: 3.00

Electomagnetism: Maxwell's equations and the wave equation in a dielectric, General solutions to the wave equation, Boundary Conditions, Particular solutions to the wave equation:- plane & spherical waves, Wavefronts, rays, Poynting vector, the time-averaged optical field, Optical spectra - temporal and spatial frequencies, Huygens' wavelets and Fermat's principle. Ray Optics: Classification of Optics, Ray Equations, Matrix Formulation for Mirrors and Mirror Systems. Polarization: Polarization states, unpolarized and partially polarized light, Polarization by reflection and scattering, Brewster's angle, Polaroid and Malus' law, Optical anisotropy, wave equation in anisotropic media, birefringence, o- and e-rays, double refraction, Polarizing beam-splitters and wave-plates, Faraday rotators. Coherence and Interference: Principle of Superposition, Conditions for Interference, Interferomrters, Temporal and Spatial Coherence, Young's Slits, Lloyd's Mirror, Multiple Slits, The Michelson interferometer, Fourier Transform spectroscopy, Thin films, Fabry-Perot etalon:- resolution, FSR and finesse. Diffraction: Fraunhofer diffraction:- single and double slit, rectangular and circular apertures, resolution of optical instruments, Fraunhofer diffraction as a Fourier transform, convolution, The diffraction grating and spectrometers, Fresnel diffraction:- circular obstacles and half-period zones, straight edges, Kirchhoff's Scalar Diffraction Theory, Boundary Diffraction Waves. Fourier Optics. Propagation of Laser Beams: TEM Waves, Physical Description of different Modes, Fundamental Gaussian Beam in a lens like medium, ABCD Law for Gaussian Beams, Higher-order Gaussian Beam modes in a homogeneous medium & Quadratic index medium. Vectorial Nature of Light. Electro-Optics: Electro-Optic Effect, Electro-Optic Modulation, Electro-Optic Devices. Acousto-Optics: Photo-elastic Effect, Acoustic-Optic Interactions, Coupled-mode Theory in Periodic Media, Surface Acoustic-Optics. Nonlinear Optics. Application of Optics.

*Recommended books:*
[1] J. Petykiewicz, "Wave optics", Springer, 2010, ISBN: 978-9048140657.
[2] Chin-Lin Chen, "Foundations for Guided-Wave optics", Wiley-Interscience, 1st edition, 2006, ISBN: 978-0471756873.
[3] Robert H. Webb, "Elementary Wave Optics", Dover Publications (April 12, 2005), ISBN: 978-0486439358.

**ECE 5310: Advanced Computer Networks**
Credit Hour: 3.00

Modifications of TCP, TCP over ATM, ATM internetworking, ATM service categories and quality of services, ATM switch architectures and their performance, Digital switching, Traffic analysis, Fiber optics networks optical packet switching, Metropolitan networks, Wide area networking, Gigabit Ethernet, ADSL, HTTP, pHTTP and recent advances in internet protocols, Web server performance, proxy servers, load balancing in web servers, IP switching, Tag switching, Multi-protocol label switching, IP security; Queuing models for networks and protocols, Real time protocols- RTP, RTCP, RTSP, Voice over IP, Distributed object technology for networking, Networks agents, Active networks and protocol boosters, Multimedia Networking, Integrated Service, Differential Service, MPLS.

*Recommended books:*
[1] Andrew S. Tanenbum and David J. Wetherall, "Computer Networks", Prentice Hall, 5th edition, 2010, ISBN: 978-0132126953.
[2] Larry L. Peterson and Bruce S. Davie, "Computer Networks: A Systems Approach", Morgan Kaufmann, 4th edition, 2007, ISBN: 978-0123705488.

**ECE 5311: Wireless Sensor Networks**
Credit Hour: 3.00

Introduction of Ad hoc/ Sensor networks: Key definitions of Ad hoc/ Sensor networks, Advantages of Ad hoc/ Sensor networks, Unique constraints and challenges, Driving applications. Wireless communications/Radio characteristics. Ad-hoc wireless networks. Media Access Control (MAC) Protocols: Issues in designing MAC protocols, Classification of MAC protocols, MAC protocols. Routing protocols: Issues in designing Routing protocols, Classification of Routing protocols, Routing protocols. Networking sensors: Unique features, Deployment of Ad hoc/ Sensor network, Sensor tasking and control, Transport layer and security protocol. Sensor network platform and tools: Berkley Motes, Sensor network programming challenges, Embedded operating systems, Simulators. Applications of Ad hoc/ Sensor network and future direction: Ultra wideband radio communication, Wireless fidelity systems.

*Recommended books:*
[1] Xiang-Yang Li, "Wireless Ad Hoc and Sensor Networks: Theory and Applications", Cambridge University Press, 2008, ISBN: 978-0521865234.
[2] Maggie Xiaoyan Cheng and Deying Li, "Advances in Wireless Ad Hoc and Sensor Networks", Springer, 2010, ISBN: 978-1441943286.

**ECE 5312: Network Security**
Credit Hour: 3.00

Network Security Overview, Introduction to Critical Infrastructure Protection, Risk Analysis Theory and Practice, Eavesdropping and Wiretapping, Informants and Surveillance, Cyber Crime and Cyber Criminals,Privacy and Cyberspace Law, Privacy and Information Operations, The Modus Operandi of Hacking, Cyberterrorism and Cybervigilantism, Cyberterrorism Threat Spectrum, Algorithm Security, Application Software Security Land-Based Networks, Application Software Security Wireless Networks, Systems Software Security, Intrusion Detection, Incident Response and Integrity Control, Malware, Spyware, Riskware and Spam, Identity Theft and Consumer Profiling, Disaster Data Recovery and Computer Forensics.

*Recommended books:*
[1] Robert Moore, "Cybercrime: Investigating High-Technology Computer Crime", Anderson, 2nd edition, 2010, ISBN: 978-1437755824.
[2] William Stallings, "Cryptography and Network Security: Principles and Practice", Prentice Hall, 5th edition, 2010, ISBN: 978-0136097044.
[3] Sean Convery, "Network Security Architectures", Cisco Press, 1st edition, 2011, ISBN: 978-1587142970.

**ECE 5313: Advanced Microprocessors**
Credit Hour: 3.00

Advanced Microprocessor Architecture: Internal Microprocessor Architecture, Real mode memory addressing, Protected Mode Memory addressing, Memory paging, Data addressing modes, Program memory addressing modes, Stack memory addressing modes, Data movement instructions, Program control instructions, Arithmetic and Logic Instructions. Pentium Processors: Introduction to Pentium Microprocessor, Special Pentium registers, Pentium memory management, New Pentium Instructions, Pentium Processor, Special Pentium pro features, Pentium 4 processor. 16-Bit Micro Controller: 8096/8097 Architecture, CPU registers, RALU, Internal Program and Data memory Timers, High speed Input and Output, Serial Interface, I/O ports, Interrupts, A/D converter, Watch dog timer, Power down feature, Instruction set, External memory Interfacing, External I/O interfacing. RISC Processors and ARM: The RISC revolution, Characteristics of RISC Architecture, The Berkeley RISC, Register Windows, Windows and parameter passing, Window overflow, RISC architecture and pipelining, Pipeline bubbles, Accessing external memory in RISC systems, Reducing the branch penalties, Branch prediction,

The ARM processors, ARM registers, ARM instructions, The ARM built-in shift mechanism, ARM branch instructions, sequence control, Data movement and memory reference instructions.

*Recommended books:*

[1] Barry B. Brey, "Intel Microprocessors", Prentice Hall, 8th edition, 2008, ISBN: 978-0135026458.
[2] N. Senthil Kumar, M. Saravanan and S. Jeevananthan, "Microprocessors and Microcontrollers", Oxford University Press, USA, 2011, ISBN: 978-0198066477.
[3] Alan Clements, "The principles of computer Hardware", Oxford University Press, 4th Edition, 2006, ISBN: 978-0199273133.
[4] John B. Peatman, "Design with Microcontrollers", Mcgraw-Hill College, 1988, ISBN: 978-0070492387.

**ECE 5314: Advanced Multimedia Communications**
Credit Hour: 3.00

Multimedia information representation, Multimedia networks, Multimedia services and applications, Network QoS and application QoS, Transform coding, Motion compensated predictive coding; Information representation: text, image, audio and video; Text and image compression: compression principles, text compression, image compression; Audio and Video compression: Audio compression, Video compression, Video compression principles, Multimedia compression standards: JPEG, H.26x, MPEG 1/2/4/7, AVC, Scalable Video Coding, Other coding formats for text, speech, image and video, Multimedia communication across networks: Layered video coding, Error relevant video coding techniques, Multimedia transport across IP networks and relevant products such as RSVP, RTP, RTCP, DVMRP, Multimedia in mobile networks, Multimedia broadcast networks, Content based retrieval in digital libraries, End-to-End QoS for video delivery, Wireless video, Error control in video streaming, Cross-layer video adaptation.

*Recommended books:*

[1] Mario Marques da Silva, "Multimedia Communications and Networking", CRC Press, 1st edition, 2012, ISBN: 978-1439874844.
[2] Fred Halsall, "Multimedia Communications: Applications, Networks, Protocols and Standards", Addison Wesley, 1st edition, 2000, ISBN: 978-0201398182.

**ECE 5315: Biomedical Signal Processing**
Credit Hour: 3.00

Introduction to Human physiological system, Types of Biomedical signals: ECG, EEG, EMG, EOG, ERG etc. Introduction to short term Fourier transform (STFT), Design of filters using Hanning window, Hamming window, Kaiser window, Haar window. Introduction to Electrocardiograph and ECG signals, Types of interferences in ECG signals, ECG signal analysis and noise removal, Detection of ECG abnormalities, ANN-based ECG analysis system, Introduction to Electroencephalograph and EEG signals, EEG signal analysis, Kurtosis coefficients, Independent component analysis (ICA), Principle component analysis (PCA). Autoregressive (AR) Model, Fast Fourier Transform (FFT) and Inverse Fast Fourier Transform (IFFT), Data Compression methods: Arithmetic coding, Huffman coding, LZW coding, Bit-plane coding.

*Recommended books:*

[1] Kayvan Najarian and Robert Splinter, "Biomedical Signal and Image Processing", CRC Press, 1st edition, 2005, ISBN: 978-0849320996.
[2] Geoff Dougherty, "Digital Image Processing for Medical Applications", Cambridge University Press, 1st edition, 2009, ISBN: 978-0521860857.

**ECE 5316: Bioinformatics**
Credit Hour: 3.00

Introduction. Molecular biology basics: DNA, RNA, genes, and proteins. Restriction mapping algorithm. Motif in DNA sequences, motif finding algorithms. Genome rearrangements, sorting by reversals and breakpoints. DNA sequence alignments. Gene prediction. Space-efficient sequence alignments, sub-quadratic alignment, DNA sequencing, genome sequencing, protein sequencing, spectrum graphs. Combinatorial pattern matching: Exact pattern matching, heuristic similarity search algorithms, approximate string matching, BLAST, FASTA. Clustering: Microarrays, hierarchical clustering, K-means clustering, corrupted Cliques problem, CAST clustering algorithm, Evolutionary trees. Feature extraction of different Biosignals.

*Recommended books:*
[1] Arthur Lesk, "Introduction to Bioinformatics", Oxford University Press, USA, 3rd edition, 2008, ISBN: 978-0199208043.
[2] Neil C. Jones and Pavel A. Pevzner, "An Introduction to Bioinformatics Algorithms", The MIT Press, 1st edition, 2004, ISBN: 978-0262101066.
[3] Marketa Zvelebil and Jeremy Baum, "Understanding Bioinformatics", Garland Science, 1st edition, 2007, ISBN: 978-0815340249.

**ECE 5317: Biomedical Image Processing**
Credit Hour: 3.00

Imaging systems: The human visual pathway, Photographic film, Digitizing an image, The quality of a digital image, Colour images. Medical images: Medical imaging modalities, Images from x-rays and γ-rays, Ultrasound imaging, Magnetic resonance imaging. Image Sampling and Reconstruction, Image quantization, discrete image mathematical characterisation, Image enhancement in the spatial and frequency domain, Image restoration: Image degradation, Noise, Noise-reduction filters, Blurring, Modelling image degradation, Geometric degradations. Morphological image processing, Image segmentation, Feature extraction, Image data visualization, Image detection and registration, Biomedical image processing Toolkits and software.

*Recommended books:*
[1] Thomas Martin Deserno, "Biomedical Image Processing", Springer, 1st edition, 2011, ISBN: 978-3642158155.
[2] Geoff Dougherty, "Digital Image Processing for Medical Applications", Cambridge University Press, 1 edition (May 11, 2009), ISBN: 978-0521860857.
[3] 1. J. L. Semmlow, "Biosignal and Biomedical Image Processing", CRC Press, 2nd edition, 2008, ISBN: 978-1420062304.

**ECE 5318: ICT Applications**
Credit Hour: 3.00

User-Centred Development of ICT Applications: Characteristics of ICT, software, data storage, telecommunications and networks , User-centred development methodology, User capabilities and design implications, Analysis, Specifications, Design, Evaluation, Product and service development in emerging markets. Professional Issues in ICT Application Development: Ownership and Intellectual Property Rights, Open source development, Contracts and liability, Privacy and misuse, Professional codes of conduct:- IEEE, IEE, ACM, BCS. E-Learning : Online classrooms, training and education, Theories for e-learning, Course delivery systems and learning management systems, Interaction in e-learning, Evaluation and quality assurance of e-learning, Research issues in e-learning. E-Health: From telemedicine and telehealth to e-health, Telecommunication technologies in health care, Clinical applications, Privacy, confidentiality, security and data integrity, Legal and ethical issues, Research: issues, methods, outcomes. E-Government: Transformation of government, politics and society, Introduction to E-governance,

Restructuring public administration, Citizen access, Urban and regional online communities. ICT in Rural Development: ICT strategies for development, Conditions for ICT adoption, Connectivity and accessibility, Impact assessment.

*Recommended books:*

[1] T. Korhonen and A. Ainamo, "Handbook of Product and Service Development in Communication and Information Technology", Springer, 1st edition, 2003, ISBN: 978-1402075957.
[2] K. Vredeburg, S. Isensee, C. Righi, "User-Centered Design: An Integrated Approach", Prentice Hall, 2001, ISBN: 978-0130912954.

**ECE 5319: Advanced Artificial Intelligence**
Credit Hour: 3.00

Introduction to AI and intelligent agents, State space representation of problems, Advanced search techniques in AI, Problem solving as constraint satisfaction, Logical agents and automated inference, Problem solving as planning, Creating plans in complex and unknown environments, Representing uncertain knowledge, Probabilistic reasoning, Bayesian networks, Temporal reasoning, Utility theory for decision making with uncertain knowledge, Automated learning from examples, Knowledge-based learning, Probabilistic and reinforcement learning, Learning in neural belief networks, Practical natural language processing, Computer vision, Introduction to Robotics.

*Recommended books:*

[1] M. Team Jones, "Artificial Intelligence: A Systems Approach", Jones and Bartlett Publishers, Inc, 1st edition, 2008, ISBN: 978-0763773373.
[2] Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", Prentice Hall, 3rd edition, 2009, ISBN: 978-0136042594.
[3] Patrick Henry Winston, "Artificial Intelligence", Addison Wesley, 3rd edition, 1992, ISBN: 978-0201533774.

**ECE 5320: Renewable Power Generation Sources**
Credit Hour: 3.00

Basic characteristics of sunlight, solar energy resource, photovoltaic cell-characteristics, equivalent circuit, photo voltaic for battery charging. Wind source, wind statistics, energy in the wind, aerodynamics, rotor types, forces developed by blades, Aerodynamic models, braking systems, Power control and monitoring system, power performance. Wind driven induction generators, power circle diagram, steady state performance, impact on central generation, transmission and distribution systems, wind farm electrical design. Wind-diesel systems, fuel savings, permanent magnet alternators, modeling, steady state equivalent circuit, self-excited induction generators, integrated wind-solar systems. Micro-hydroelectric systems, power potential, scheme layout, generation efficiency and turbine part flow-isolated and parallel operation of generators, geothermal-tidal and Ocean Thermal Energy Conversion (OTEC) systems.

*Recommended books:*

[1] John F. Walker and Nick Jenkins, "Wind energy Technology", John Wiley and sons, 1st edition, 1997, ISBN: 978-0471960447.
[2] Van Overstraeton and R. P. Mertens, "Physics, Technology and use of Photovoltaics", Taylor & Francis, 1st edition, 1986, ISBN: 978-0852744871.

**ECE 5321: Transients in Power Systems**
Credit Hour: 3.00

Transients in simple electric and magnetically linked circuits, fundamentals: impacts of switching on rotating machinery. Parallel operation of interconnected networks; distribution of power impacts. Interaction of Governor's in power systems. Overvoltage during power system faults.

Systems voltage recovery characteristics. Effect of arc restriking on recovery voltage. Switching surges and overvoltage caused by sudden loss of load and by open conductor. Numerical simulation of electrical transients.

*Recommended books:*

[1] Allan Greenwood, "Electrical Transients in Power Systems", Wiley-Interscience, 2nd edition, 1991, ISBN: 978-0471620587.
[2] Lou van der Sluis, "Transients in Power Systems", Wiley, 1st edition, 2001, ISBN: 978-0471486398.
[3] Juan A. Martinez-Velasco, "Power System Transients: Parameter Determination", CRC Press, 1st edition, 2009, ISBN: 978-1420065299.
[4] M. Pavella and P. G. Murthy, "Transient Stability of Power Systems: Theory and Practice", Wiley, 1st edition, 1994, ISBN: 978-0471942139.

**Special Topic _____**
**Code: 9**

**ECE 5999: Selected Topics in Electronics and Communication Engineering**
Credit Hour: 3.00

Course contents to be decided by the course teacher(s) with the approval of the ECE Discipline. This course can be taken by a student only once in the entire program.

**Thesis/Project_____**

**ECE 6000: Master's Thesis I (Research Proposal)**
Credit Hour: 6.00

Successful completion of this course leads a student to undertake the course ECE 6001: Master Thesis II (Research) in the next term (with continue). Upon successful completion of ECE 6001: Master Thesis II (Research), grade will be awarded for this course.

**ECE 6001: Master's Thesis II (Research)**
Credit Hour: 12.00
Prerequisite: ECE 6000: Master Thesis I (Research Proposal)

**ECE 6002: Master's Project**
Credit Hour: 6.00

A student will do either Master's Thesis (ECE 6000 and ECE 6001) or Master's Project (ECE 6002). The thesis/project should be a challenging piece of work that integrates the skills and concepts students have learned during their tenure in the Master's program.