MSc Core Courses

EN-5001 Mathematical Methods for Engineers and Scientists

Objective:

Review of the ordinary differential and difference equations and integration methods. Introduce nonlinear differential equations. Learn the approximate techniques for solving differential equations. To learn the advance techniques in integration

Course Description:

Solution of linear and nonlinear differential equations and initial and boundary value problems, Approximate solutions of differential equations, Exact and approximate solutions of difference equations, Review of the integration by parts, Asymptotic expansion of integrals, Laplace's Method and Watson's Lemma for solving integrals, Methods of stationary phase, Method of steepest decent, Asymptotic evaluation of integrals

Recommended Books:

- "Mathematical Methods for Engineers and Scientists", Carl M. Bender and Steven A. Orszag, McGraw-Hill, 1978, ISBN No. 007004452-X
- "Advanced Engineering Mathematics", Erwin Kreyszig, John Wiley ISBN-13: 978-0470458365

EN-5002 Random Processes

Objective:

To describe fundamental concepts of random signals and processes

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 processes, stationarity, ergodicity, correlation functions, spectral densities, random inputs to linear systems; Gaussian processes.

Recommended Books:

- "Probability, Random Variables, and Stochastic Processes", 4th Edition, Papoulis, McGraw-Hill, 2002, ISBN No. 0072817259.
- "Probability and Random Process for Electrical Engineering", 2nd Edition, Alberto Leon-Garcia, ISBN 81-317-0917-5
- "Probability, Random Variables, and Random Signal Principles", 4th Edition, Peyton Z. Peebles McGraw-Hill Science, ISBN 0073660078

EN-5003 Optimization Theory

Objective:
To acquire a systematic understanding of the theory and application of linear and non-linear optimization techniques

Optimization Methods in Engineering

This course will be covering two distinct areas: 1) Linear optimization and 2) Nonlinear optimization, techniques. Linear programming part will cover Introduction to convex sets, geometry of linear programming and duality theory. Variants of linear programming, examples of linear programming problems, linear algebra background. Nonlinear programming will cover, Convex optimization problems, quadratic optimization, geometric optimization, geometric interpretation, optimality conditions, dual decomposition, augmented Lagrangians and the method of multipliers, alternating direction method of multipliers, optimality condition and stopping criterion

Suggested Books:

- "Introduction to Linear Optimization", Dimitris Bertsimas and J. Tsitsiklis, Athena Scientific 1997
- "Linear and Nonlinear Optimization (2nd Ed)", I. Griva, S. G. Nash, A. Sofer, SIAM 2008
- "Convex Optimization", S. Boyd and L. Vandenberghe, Cambridge University Press
- "Handbook of Optimization", I. Zelinka, V. Sanasael, A. Abraham(Eds) Spring 2013

EN-5004 Electromagnetic Field Theory

Objective:

- To review Maxwell's equations and learn the principles of wave propagation in bounded and unbounded media, Introduction and application of electromagnetic theorems and applications

Course Outline:

- Time-varying and time harmonic electromagnetic fields, Maxwell's equations in differential and integral form, constitutive parameters and relations, circuit-field relations, boundary conditions, power and energy, electrical properties of matter, wave equation and its solution in rectangular, cylindrical and spherical coordinate system, wave propagation and polarization, transverse electromagnetic modes, uniform plane wave in unbounded lossless and lossy medium, linear circular and elliptical polarization, reflection and transmission of electromagnetic waves of multiple interfaces, auxiliary vector potentials, construction of solutions and radiation and scattering equations, Electromagnetic theorems and principles

Recommended Books:

- Constantine A. Balanis, "Advanced Engineering Electromagnetics" 2nd Ed 2012, John Wiley
- John D. Kraus, "Electromagnetics", 1991, McGraw Hill

MSc Elective Courses for Specialization in Electronic System Design

EN-5101 Advanced VLSI Design

Objective:

- Teach VLSI synthesis and design tools, languages for VLSI synthesis, algorithm simulation and code generation, and design tools for application specific instruction processors.

Course Outline:

- Design methodology for ASIC and FPGA implementations; high-level VLSI synthesis and design tools including Mentor Graphics; FPGA hardware structures and fabrics; languages for VLSI synthesis including VHDL; high-level DSP algorithm simulation and code (VHDL) generation using Xilinx StateCAD, LabVIEW FPGA, and ModelSim; design and analysis of algorithm-specific VLSI processor architectures; implementation of pipelined and systolic processor structure; techniques for mapping numerical algorithms onto custom processor arrays including application specific instruction processors (ASIPs); design tools for ASIPs including transport triggered architecture; high-level design frameworks for systems containing custom and general-purpose units.

Recommended Books:

- William J. Dally and John W. Poulton, "Digital Systems Engineering," 1998, Cambridge University Press, ISBN: 0521592925.
- Behzad Razavi, "Design of Analog CMOS Integrated Circuits," First Edition, 2001, McGraw-Hill, ISBN: 0072380322.
- Shih-Chii Liu, Jörg Kramer, Giacomo Indiveri, Tobias Delbrück and Rodney DouglasT, "Analog VLSI: Circuits and Principles," 2002, MIT Press, ISBN: 0262122553.
- Wayne Wolf, "FPGA-Based System Design," First Edition, 2004, Prentice Hall, ISBN: ISBN: 0131424610.
- Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic, "Digital Integrated Circuits," Second Edition, 2002, Prentice Hall, ISBN: 0130909963.

EN-5102 ASIC Design Methodology

Objectives:

- The aim of the course is to teach important concepts and methods related to design, testing and implementation of digital ASICs. The design process starts from a behavioural or structural description in VHDL. The main focus lies on synthesis from the register transfer level, but will also discuss design for testability, technology mapping and physical synthesis as well as give an introduction to formal verification. The course has a significant laboratory component. The aim of the laboratory course is to give some experience with the tasks of ASIC design and testing. VHDL will be used as specification language. Industrial tools are used for simulation and synthesis.

Course Outline:

- ASIC design flow, ASIC technologies, Classification and specification constraints for logic synthesis, Static timing analysis, State machine synthesis, Test and verification, Low power design and logic synthesis, Design for testability, Technology mapping, Physical design issues

Recommended Books:

- Advanced ASIC Chip Synthesis : Using Synopsys Design Compiler, Physical Compiler, and PrimeTime (Second Edition) Bhatnagar, Himanshu (Author) ISBN: 978079237644
- M.J.S. Smith, "Application-Specific Integrated Circuits", Addison-Wesley, ISBN 0-201-50022-1, 1997
- HimanshuBhatnagar, "Advanced ASIC Chip Synthesis Using Synopsys Design Compiler Physical Compiler and PrimeTime". 2001
- N. H. E. Weste and D. Harris, "CMOS VLSI Design: A Circuits and Systems Perspective", 3rd Edition Addison-Wesley, 2004
- J. Rabaey , A. Chandrakasan , B. Nikolic , "Digital Integrated Circuits: A Design Perspective" 2nd Edition, Prentice Hall, 2003
- W. Wolf, "Modern VLSI Design: System-on-Chip Design", 3rd Edition, Prentice Hall, 2002
- Thoman Kropf, Formal Hardware Verification, Springer 1999.
- Wayne Wolf, FPGA Based System Design, Prentice Hall, 2004
- Samir Palnitkar, "Verilog HDL," Second Edition, 2003, Prentice Hall, ISBN: 0130449113.

EN-5103 Mixed Signal Design

Objectives:

- Learn to design core mixed-signal IC blocks: comparators and data converters, Gain experience with system level design flow: top-down and bottom-up design methodologies

Course Outline:

- Gain mixed-signal design experience in Cadence CAD tools: mixed analog / digital (Verilog) simulation, digital synthesis and Place & Route, and final layout, DRC, and LVS
- Circuit Level Models and Sample Applications of MOS Technology Transistors
- MOSFET Biasing Strategies and Circuit Examples
- Canonic Analog MOSFET Cells at Low Frequencies
- Feedback Circuit and System Principles
- Signal Flow Analysis of Feedback Circuits
- Analog MOSFET Canonic Cells at High Frequencies
- Broadband CMOS Amplifiers: Theory and Circuit Examples
- System and Circuit Level Noise Models and Analysis
- Device and Circuit Level Noise Models and Analysis
- Sinusoidal Oscillators Circuits and Analysis
- Characteristics and Analysis of Phase-Locked Loops (PLLs)
- Principles and Examples of MOSFET Technology Biasing
- Basic Circuit Cells of Analog MOSFET Technology
- Distributed Circuit Architectures for Analog Signal Processing at Ultra High Frequencies
- Characterization of the Dynamic Range of Active Networks

Reference Books

- P. Allen, D. Holberg, *CMOS Analog Circuit Design, Second Edition* OXFORD (2002), ISBN 0-19-511644-5
- S. Palnitkar, *Verilog HDL: A Guide to Digital Design and Synthesis, Second Edition* Sun Microsystems Press / Prentice Hall (2003), ISBN 0-13-044911-3
- See Software page for Cadence tutorials and manuals
- Phillip E. Allen and Douglas R. Holberg, *CMOS Analog Circuit Design*. New York: Oxford University Press, 2002.
- Norman Balabanian and Theodore Bickart, *Linear Network Theory: Analysis, Properties, Design and Synthe-sis*. Beaverton, Oregon: Matrix Publishers, Inc., 1981.
- M. J. Buckingham, *Noise in Electronic Devices and Systems*. Chichester, United Kingdom: Ellis Horwood Limited Publishers, 1983.
- Mark Burns and Gordon Roberts, *An Introduction to Mixed-Signal IC Test and Measurement*. New York: Oxford University Press, 2001.
- Dan Clein, *CMOS IC Layout: Concepts, Methodologies, and Tools*. Boston: Butterworth-Heinemann (Newnes), 2000.
- Donald T. Comer, *Introduction To Mixed Signal VLSI*. Highspire, Pennsylvania: Array Publishing Co., 1994.
- J. A. Connelly and P. Choi, Macromodeling With SPICE. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1992.
- R. C. Dorf (editor), *The Electrical Engineering Handbook*. Boca Raton, Florida: CRC Press, 1993.
- Daniel P. Foty, *MOSFET Modeling With SPICE: Principles and Practice*. Upper Saddle River, New Jersey: Prentice Hall PTR, 1997.

EN-5104 System on Chip Design

Objectives:

- With technological advances that allow us to integrate complete multi-processor systems on a single die, Systems-on-Chip (SoCs) are at the core of most embedded computing and consumer devices, such as cell phones, media players and automotive, aerospace or medical electronics. This course will provide an understanding of the concepts, issues, and process of designing highly integrated SoCs following systematic hardware/software co-design & co-verification principles. Specifically, the class project involves FPGA prototyping platform using state-of-the-art synthesis and verification tools and design flows.

Course Outline:

- System-level and SoC design methodologies and tools
- HW/SW co-design: analysis, partitioning, real-time scheduling, hardware acceleration, SoC bus architecture (Standard buses, Network-on-Chip)
- Virtual platform models, co-simulation and FPGAs for prototyping of HW/SW systems
- Transaction-Level Modeling (TLM), Electronic System-Level (ESL) languages: VHDL, Verilog, SystemC
- High-Level Synthesis (HLS): allocation, scheduling, binding, resource sharing, pipelining
- SoC and IP integration, verification and test (Automatic test pattern generation, Scan test fundamentals, Memory test fundamentals)
- Low Power Design (System, RTL, Circuit & Gate Level)
- Reuse IP, SoC bus architecture

Reference Books:

- Modern VLSI Design: System-on-Chip Design (3rd Edition), Wayne Wolf
- Modern VLIS Design: IP-based Design (4th Edition), Wayne Wolf
- SoC Design Methodologies, Robert, M.; Rouzeyre, B.; Piguet, C.; Flottes, Springer publishers
- Embedded System Design – A Unified Hardware/Software Introduction by Frank Vahid and Tony Givargis, Wiley, 2002, ISBN: 0-471-38678-2
- Reuse methodology manual for system-on-a-chip designs by Michael Keating and Pierre Bricaud, 1998, Kluwer Academic Publishers, ISBN: 0-7923-8175-0.
- Co-Verification of Hardware and Software for ARM SOC Design, Jason, R. Andrews, Elsevier Inc. 2005, ISBN: 0-7506-7730-9
- Digital IC Design Flow Tutorial V1.0, CMC Microsystems, 2004

EN-5105 FPGA-based Design

Objective:

- This course introduces logic synthesis, implementation, and SoC design concepts. The course is project oriented where students will take designs from concept to VHDL/Verilog languages for verification using simulation and synthesis, and finally to programmable device implementation on an FPGA development board. During the first part of the course, students will implement a few projects, each more complex than the last, culminating in a complete SoC design incorporating an 8-bit microprocessor and peripherals.

Course Outline:

- This course introduces logic synthesis, implementation, and SoC design concepts. The course is project oriented where students will take designs from concept to Verilog HDL description to verification using simulation and synthesis, and finally to programmable device implementation on an FPGA development board. During the first part of the course, students will implement a fewT projects, each more complex than the last, culminating in a complete SoC design incorporating an 8-bit microprocessor and peripherals. The first project, a simple FSM, serves to introduce students to logic synthesis and FPGA implementation tools and methods, and how to use the input/outputs devices (such as buttons and LEDs) on the FPGA development board. The second project introduces SoC concepts such as on-chip processor, memory and peripheral interfacing, and hardware-

software trade-offs. The third project adds a graphics sub-system to the SoC enabling students to display their design results on a CRT monitor. This lab sequence goes in step with lectures on programmable chip architectures, logic synthesis, So concepts, and the Verilog synthesizable subset, including design, examples. During the final part of the course, after mid-semester examination, the students will work in teams of two to complete an advanced FPGA design project of their choice. The final project will be more complex than any of the three previously assigned projects. There will be no scheduled lectures during this portion of the course, but the instructors are required to be available to guide the students.

Reference Books:

- Wayne Wolf, "FPGA-Based System Design," 2004, Prentice Hall, ISBN: 0131424610.
- Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis," Second Edition, 2003, Prentice Hall, ISBN:0130449113.
- Michael D. Ciletti, "Advanced Digital Design with the Verilog HDL," First Edition, 2003, Prentice Hall, ISBN: 0130891614.

EN-5106 Digital System Synthesis

Objectives:

- To describe the design of complex digital systems using a (VHDL based) behavioural synthesis approach.
- To provide understanding of the algorithms which underpin behavioural synthesis including scheduling, allocation and binding.
- To gain hands-on experience in the application of behavioural synthesis to generate designs optimised for user-defined constraints.
- To describe digital design for testability techniques at the behavioural and RTL levels.
- To provide an overview of emerging SoC design and test methods.
- To describe system level low power design methods.

Course Outline:

- Review of hardware description languages and behavioural synthesis of digital systems.
- Behavioural synthesis data structures and algorithms
  - Data and control flow representations , Data flow graph (DFG) descriptions, Control data flow graph (CDFG) descriptions, Extended Petri-net models
- Synthesis and design space
  - Design space exploration, Constructive vs. transformational/iterative techniques, Behavioural optimization, Scheduling, allocation, module binding and controller synthesis
- Scheduling algorithms - constructive
  - Unconstrained scheduling: ASAP and ALAP algorithms, Constrained scheduling: list scheduling and force-directed scheduling
  - Scheduling of multicycled and pipelined functional modules
- Allocation and binding algorithms
  - Lifetime analysis of registers, Variable-to-register mapping using the left edge algorithm
- Interconnect allocation and optimisation
- Transformational/iterative approaches
  - Cost functions, Transformations , Simulated annealing, Genetic algorithms
- Test synthesis for digital systems
  - Design for testability: scan-based and built-in-self-test (BIST) techniques, Test scheduling, Test controllers, On-line test
- Related areas
  - Analogue synthesis, HW/SW codesign, Design confidence (design verification, online test), Optimisation with respect to power dissipation, routability, interconnect delay, testability, Logic optimisation
- Low power design of IP core for SoC applications, development of a high-level synthesis system.

Reference Books:

- Andrew Rushton, VHDL for logic synthesis, Wiley, ISBN 0-471-98352-X
- Mark Zwolinski, Digital system design with VHDL, Prentice-Hall, ISBN 0-201-360362
- Giovanni De Micheli, Synthesis and optimisation of digital circuits, McGraw Hill, ISBN 0-07016333-2
- Sabih Gerez, Algorithms for VLSI design automation, , Wiley, ISBN 0-471-98489-2
- John P Elliott, Understanding behvioural synthesis, , Kluwer, ISBN 0-7923-8542-X

EN-5107 Microprocessor based System Design

Objectives:

- Advanced Microprocessor Design provides a comprehensive guide for Embedded System designers and Computer Engineers. It provides a broad and in-depth overview of important topics ranging from Computer Architecture and Operating System design to PCB Layout and manufacturing guidelines. It is a fast paced course intended for graduate and post graduate students in Electrical and Computer Engineering, as well as the Embedded System professional.

- Topics in the course include: hardware and software design methodologies, use of CAD and simulation tools, assemblers, compilers, debuggers, and programmers. Microprocessor architectures from Motorola, Intel, and ARM will be discussed and evaluated, as well as Operating Systems such as uC-Linux and PalmOS. Computer interfaces such as USB, PCI, Ethernet, and Bluetooth will also be discussed in detail.

- Includes techniques for developing software and hardware for microprocessor-based systems, computer aided design using a multistation logic development system, use of components commonly found in microprocessor-based systems

Course Outline:

- Operating Systems / Linux Review
- Intel, PIC, ARM etc. Architectures
- Assemblers, Compilers, and Debuggers. ELF debug output and object files. Debugging techniques and pitfals. Emulators, simulators, and programmers.
- Code Density
- Computer Architecture, Microprocessors, memory and IO design, cache, RAM, nvRAM, Flash, Real, Protected and Shadow memory, wait-states and chip-selects, Interrupts and bus structures
- Power / Energy Concerns
- Floating Point / GPU, Ethernet, USB, PCI, Serial Communication, I2C, Blue tooth etc.

Reference Books:

- David J. Comer, “Microprocessor-based System Design,” 1996, Oxford University Press, ISBN: 0030637813.
- Muhammad Ali Mazidi and Janice Gillispie-Mazidi, “80X86 IBM PC and Compatible Computers: Assembly Language, Design, and Interfacing Volumes I & II,” Fourth Edition, 2003, Prentice Hall, ISBN: 013061775X
- Memory Systems: Cache, DRAM, Disk. Jacob, Ng and Wang.
- Computer Architecture: A Quantitative Approach. Hennessy and Patterson.
- UNIX Systems for Modern Architectures. Schimmel

EN-5108 Network-on-Chip Design

Objectives:

- Explain the importance of an efficient system-on-chip communication infrastructure to cope with SoC design complexity.
- Categorize properties of different bus architectures.
- Compare bus-based and network-on-chip based architectures and point out strength and weaknesses.
- Motivate how topology, routing mechanisms and flow control influence the performance of a Network-on-Chip.
- Describe the design process for complex systems-on-chip.

Course Outline:

- Trends in System-on-Chip design, Coping with design complexity, Uses of Interconnection Networks, Processor memory interconnects, I/O interconnect, Network basics, Topology, Nomenclature (channels, nodes, Direct and indirect networks, cut and bisections, paths), Traffic Patterns, Butterfly Networks, Torus Networks, Non-Blocking Networks, Unicast and Multicast routing, Slicing and Dicing, Routing, Oblivious Routing, Adaptive Routing, Routing Mechanics, Flow control basics, Buffered flow control, Deadlock and livelock, Quality of service, Router Architecture, Router Data-path components, Error control, Performance Analysis.

Books:

- William James Dallary, Brian Towles, "Principles and Practices of Interconnection Networks", The Morgan Kaufmann publishers Inc., 2010
- Sudeep Pasricha; Nikil Dutt, "On-Chip Communication Architectures", The Morgan Kaufmann publishers Inc, 2010

EN-5109 Integrated Circuit Design

Objective:

- To describe fundamental concepts of Analog and Digital IC design**.**

Course Outline:

- Analysis and optimized design of monolithic operational amplifiers and wide-band amplifiers; methods of achieving wide-band amplification, gain-bandwidth considerations; analysis of noise in integrated circuits and low noise design. Precision passive elements, analog switches, amplifiers and comparators, voltage reference in NMOS and CMOS circuits, Serial, successive-approximation, and parallel analog-to-digital converters. Switched-capacitor and CCD filters. Applications to codecs, modems. Introduction to Manufacturing Process, Manufacturing CMOS ICs, Packaging ICs, Perspective-Trends in Process Technology, Diodes, MOS Transistors, Perspective-Technology Scaling, CMOS Inverter, Static CMOS Inverter, Performance of CMOS Inverter, Power, Energy, Energy Delay, Designing Comb, Logic Gates in CMOS, Static CMOS Design, Dynamic CMOS Design, Designing Sequential Logic Circuits, Static Latches & Registers, Dynamic Latches & Registers,

Registers, Non-bistable Sequential Circuits, Design Memories & Array Structures, RAM, ROM, Memory Peripheral Circuitry, Design & Testability

Reference Books:

- Analog Circuit Design, M. Steyaert, A.H.M. van Roermund, J.H. Huijsing, Springer Publisher
- Analog Circuits, World Class Design, R. A. Pease, Newnes Publisher
- Analog Circuits Cookbook, 2nd Ed., I. Hickman, Newnes Publisher
- Digital Integrated Circuits: A Design Perspective, 2nd Edition, Jan M. Rabaey, Anantha Chandarakasan, Borivoje Nikolic, Pearson Prentice Hall
- Integrated Electronics, Jacob Millman, Mc Graw Hill,
- Electronic Principles, 6th Edition, Alberto Malvino, Mc Graw Hill

EN-5110 System-on-Chip Testing and Verification

Objectives:

- Understanding the methodology and techniques of SoC Testing & Verifications

Course Outlines:

- SoC Testing Methodology, SoC Testing Challenges, Core level test, SoC level test
- Modes for Embedded Core tests
- SoC Testing design flow, IEEE P1500 Test Standards, Automatic test equipments, Virtual Scan
- Testing Techniques: Test Access Mechanism, Boundary Scan Methods, Design for Test, Joint Test Action Group, Automatic Test Pattern Generator, Self Test, Built in Self Test etc.
- Fault Models
- Verification Techniques: Simulation technique, Static technique, Formal technique etc.

Reference Books:

- Testing Digital Systems, N. Jha, S. Gupta, Cambridge University Press

EN-5111 Special Topics in Electronics System Design

- Advanced topics to be chosen by the instructor

MSc Elective Courses for Specialization in Semiconductor Materials, Devices and Design

EN-5201 Solid-State Electronics

Course Objective

- To provide a solid foundation in the physics of semiconductors so that students will be able to not only understand current devices and exploit them in novel applications, but also appreciate the workings of new semiconductor devices as they materialize and evolve in future years.
- The material is presented rigorously, and this is not a survey course. Specific topics to be covered include crystal and bonding properties, energy band theory, carrier distribution and recombination, theory of transport and scattering, theory of p-n junction, and operation of majority carrier diodes and transistors.
- Emerging technologies includes the excessive use of superconductor and a major portion of fast, low power and reliable electronics consists of superconducting electronics, an introduction to the field of superconductivity and its application will also be covered with modern electronic components in the field.

Course Outline:

- Introduction to Materials
- Metal, Semiconductor, Insulator and Superconductors
- Bonding in materials and their characteristics
- Crystal Structures
- Amorphous, Poly crystalline and Crystalline, Crystal structures, Planes and directions in crystal structures
- Introduction to Crystal Growth Techniques
- Bulk crystal formation, Thin film fabrication, Crystal Defects
- Introduction to Quantum Mechanics
- Principles of Quantum Mechanics, Schrodinger's Wave Equation, Applications of Schrodinger's Wave Equation, Tunneling
- Allowed and Forbidden Energy Bands
- Formation of Energy Bands, Direct and Indirect Semiconductors, Variation of energy bands with Alloy composition
- Homogeneous Semiconductors in Thermodynamic Equilibrium
- Charge Carriers in Semiconductors, Dopant Atoms and Energy Levels, The Extrinsic Semiconductor, Statistics of Donors and Acceptors, Charge Neutrality, Position of Fermi Energy Level
- Carrier Transport Phenomena in Semiconductors
- Carrier Drift, Carrier Diffusion, Graded Impurity Distribution
- Principles of Semiconductor Devices
- Homo Junction, Metal Semiconductor Junctions, Hetero Junctions
- Properties of interest for device applications
- Surface morphology, IV characteristics, Resistivity, conductivity, band gap, doping concentration, Type of doping etc.
- Introduction to superconductivity and superconducting devices
- Definition and critical quantities, Types of Superconductor, General Applications Areas, Superconducting Electronics : Josephson tunnel Junction , Superconducting Quantum Interference Devices (SQUID), Rapid Single-Flux-Quantum (RSFQ), Infrared detectors

References Books:

- S.O. Kasap, "Principles of electronics materials and devices", 3rd Edition Mc Graw Hill, 2006
- Donald A. Neamen, "Semiconductor Physics and devices", 3rd Edition Mc graw Hill, 2003
- Ben G. Streetman, "Solid State Devices", 4th Edition, Prentice Hall, 1995
- S. M. Sze, "Physics of Semiconductor Device", Wiley Interscience.
- Charles kittel, "Introduction to soild state physics", 8th Edition, John Wiley and Son Inc., 2005.
- J.B. Ketterson and S. N. Song, "Superconductivity", Cambridge University, 1999.
- Robert F. Pierret, **"**Advanced Semiconductor Fundamentals"**,** Prentice Hall

EN-5202 Semiconductor Devices and Technology

Objective:

- To provide a solid foundation in the physics of semiconductors so that students will be able to not only understand current devices and exploit them in novel applications, but also appreciate the workings of new semiconductor devices as they materialize and evolve in future years.
- The material is presented rigorously, and this is not a survey course. Specific topics to be covered include crystal and bonding properties, energy band theory, carrier distribution and recombination, theory of transport and scattering, theory of p-n junction, and operation of majority carrier diodes and transistors.
- Emerging technologies includes the excessive use of superconductor and a major portion of fast, low power and reliable electronics consists of superconducting electronics, an introduction to the field of superconductivity and its application will also be covered with modern electronic components in the field.

Course Outline:

- Introduction to Materials
  - Metal, Semiconductor, Insulator and Superconductors
  - Bonding in materials and their characteristics
  - Crystal Structures
    - Amorphous, Poly crystalline and Crystalline, Crystal structures, Planes and directions in crystal structures
  - Introduction to Crystal Growth Techniques
    - Bulk crystal formation, Thin film fabrication, Crystal Defects
- Introduction to Quantum Mechanics
  - Principles of Quantum Mechanics
  - Schrodinger's Wave Equation
  - Applications of Schrodinger's Wave Equation
  - Tunneling
  - Allowed and Forbidden Energy Bands
    - Formation of Energy Bands , Direct and Indirect Semiconductors, Variation of energy bands with Alloy composition
- Homogeneous Semiconductors in Thermodynamic Equilibrium
  - Charge Carriers in Semiconductors, Dopant Atoms and Energy Levels, The Extrinsic Semiconductor, Statistics of Donors and Acceptors, Charge Neutrality, Position of Fermi Energy Level
- Carrier Transport Phenomena in Semiconductors
  - Carrier Drift, Carrier Diffusion, Graded Impurity Distribution
- Principles of Semiconductor Devices
  - Homo Junction, Metal Semiconductor Junctions, Hetero Junctions
- Properties of interest for device applications
  - Surface morphology, Group IV characteristics, Resistivity, conductivity, band gap, doping concentration, Type of doping etc.
- Introduction to superconductivity and superconducting devices
  - Definition and critical quantities, Types of Superconductor, General Applications Areas, Superconducting Electronics : Josephson tunnel Junction , Superconducting Quantum Interference Devices (SQUID), Rapid Single-Flux-Quantum (RSFQ), Infrared detectors

Reference Books:

- S.O. Kasap, "Principles of electronics materials and devices", 3rd Edition Mc Graw Hill, 2006
- Donald A. Neamen, "Semiconductor Physics and devices", 3rd Edition Mc graw Hill, 2003
- Ben G. Streetman, "Solid State Devices", 4th Edition, Prentice Hall, 1995

- S. M. Sze, "Physics of Semiconductor Device", Wiley Interscience.
- Charles kittel, "Introduction to soild state physics", 8th Edition, John Wiley and Son Inc., 2005.
- J.B. Ketterson and S. N. Song, "Superconductivity", Cambridge University, 1999.
- Robert F. Pierret, **"**Advanced Semiconductor Fundamentals"**,** Prentice Hall

EN-5203 Compound Semiconductor Devices

Objective:

- Teach the physics, electronic properties, and processing of compound semiconductors (III-V and II-VI).

Course Outline:

- Direct and indirect bandgap semiconductors; physics of compound semiconductors (III-V and II-VI); electronic properties and their importance to compound semiconductors; optical processes in compound semiconductors; importance of III-V and II-VI devices in photonics; optoelectronics devices and integrated circuits; preparation and processing of compound semiconductors; techniques for preparation of p- and n-type materials of compound semiconductors; theory of heterojunctions, quantum structures and pseudomorphic strained layers; metal-semiconductor field effect transistors (MESFETs); heterojunction field-effect transistors (HFETs) and bipolar transistors (HBTs); photodiodes, quantum well heterostructure lasers, and other optoelectronic devices.

Recommended Books:

- Paul H. Holloway and Gary E. McGuire, "Handbook of Compound Semiconductors - Growth, Processing, Characterization, and Devices," 1995, Noyes Publications, ISBN: 0815513747.
- Joachim Piprek, "Semiconductor Optoelectronic Devices: Introduction to Physics and Simulation," 2003, Academic Press, ISBN: 0125571909.

EN-5204 Optoelectronic Devices

Objective:

- Teach optoelectronic devices including lasers, optical detectors, optical fiber couplers, optical modulators, and optical amplifiers.

Course Outline:

- Fundamentals of semiconductor devices; *p-n* junctions; hetrojunction and double hetrojunction; basics of laser physics: spontaneous and stimulated emission, Einstein relation, population inversion, optical pumping, light amplification, resonators and modes; light sources; light emitting diodes (LEDs); laser diodes; different types of semiconductor laser sources; optical detectors: *p-n* junction diodes, PIN diodes, avalanche photodiodes, optical switches, optical fiber couplers; noise considerations and performance parameters; optical modulators, for example, electro-optical and acousto-optic modulators; optical amplifiers; GRI lenses.

Recommended Books:

- Bhattacharya "Semiconductors Optoelectronic Devices," Second Edition, Pearson Education India, ISBN 817758166X.
- Gerd Keiser, "Optical Fiber Communications," Third Edition, 2000, McGraw-Hill, ISBN: 0072360763.
- John M. Senior, "Optical Fiber Communications: Principles and Practice", 2nd Edition, 1992, Prentice Hall, ISBN: 0136354262.

EN-5205 Modelling and Simulation of Semiconductor Devices

Objective: Review semiconductor physics and basic semiconductor equations, and teach the development of models to simulate various semiconductor devices.

Course Outline:

Review of semiconductor physics; basic semiconductor equations; numerical methods applied for scaling of variables and parameters: Newton-Raphson method of solving nonlinear algebraic equations, iterative and other methods; error estimation; Monte Carlo simulation: Boltzmann transport equation; electron motion in the momentum space; scattering processes; mean velocity; device modeling and simulation of *p-n* junctions: potential barriers, static properties, reverse-biased junctions, avalanche and zener breakdowns, Shockley-Hall-Read Model, *I-V* characteristics, charge storage and transients, numerical simulation of *p-n* junctions; device modeling and
simulation of BJT: Early effect, emitter biases, base transit timecharge control model, simulation of BJTs; device modeling and simulation of MOS: model of charges in gate oxides, modeling of
charges in accumulations, depletion, and inversion conditions, capacitance, threshold voltage adjustment; device modeling and simulation of MOSFET: basic theories and models, MOSFET
parameters, short and narrow channel effects, hot carriers, simulation of MOSFET characteristics, adjustment of threshold voltage, model design of MOSFET; modeling and simulation of CMOS characteristics, CMOS design; HBT: bandgap engineering, material parameters, modeling of HBT characteristics.

Recommended Books:

- Richard S. Muller and Theodore I. Kamins, "Device Electronics
- for Integrated Circuits," Third Edition, 2003, John Wiley & Sons,
- ISBN: 0471593982.
- Christopher M. Snowden, "Introduction to Semiconductor Device
- Modelling," 1987, World Scientific Publishing Company, ISBN:
- 9971501422.

EN-5206 Semiconductor Material Characterization

Objective:

- Teach the techniques for structural, optical, and other characterization of semiconductor materials.

Course Outline:

- Techniques for structural characterization of semiconductor materials, x-ray scattering, low-energy electron diffraction (LEED), electron microscopy, scanning electron microscope, scanning probe microscope, techniques for optical and other characterization of semiconductor materials, photoluminescence, x-ray photoelectron scattering (XPS), Auger electron scattering (AES), secondary ion mass scattering (SIHS).

Recommended Book:

- Dieter K. Schroder, "Semiconductor Material and Device Characterization," 1998, John Wiley & Sons, ISBN: 0071402144.

EN-5207 MEMS Design and Micro-machining

Objective:

- Teach the principles of operation, design, modeling, micromachining, and fabrication of MEMS devices.

Course Outline:

- MEMS devices: MEMS operating principle (electrostatic, piezoresistive, thermal), applications, accelerometers/combdrive, RF switch, micromirror. Design: Scaling issues, system-level design

(behavioral modeling) using SPICE, 2D layout design (L-Edit Layout tool, design rule checking, design verification), 3D modeling with process emulation, physical level simulation and analysis (Finite Element Analysis) using ANSYS. Micromachining (micro-fabrication) technologies: Micromachining techniques (deposit, etch, photolithography), CMOS compatible bulk micromachining, surface micromachining. A surface micromachining technology PolyMUMPs will be studied with description of technology file development in L-Edit layout tool. Various MEMS devices will be fabricated in PolyMUMPs process.

Recommended Books:

- Chang Liu, "Foundation of MEMS," First Edition, 2006, Prentice Hall, ISBN: 0131472860.
- Stephen D. Senturia, "Microsystem Design," First Edition, 2000, Kluwer Academic Publishers, ISBN: 0792372468.
- Marc J. Madou, "Fundamentals of Microfabrication: The Science of Miniaturization," Second Edition, 2002, CRC Press, ISBN: 0849308267.
- Tai-Ran Hsu, "MEMS and Microsystems: Design and Manufacture," First Edition, 2001, McGraw-Hill, ISBN: 0072393912.
- M. Elwenspoek and H. Jansen, "Silicon Micromachining," 1998, Cambridge University Press, ISBN: 052159054X.
- Nadim Maluf and Kirt Williams, "An introduction to Microelectromechanical Systems Engineering," 2004, Artech House Publishers, ISBN: 1580535909.

EN-5208 Nanotechnology

Objectives:

- Understand the underlying operating principles of nanodevices
- Explain how nanodevices are fabricated
- Demonstrate specialised practical and theoretical knowledge in the use of particular nanodevices in its context
- Understand the inter-relation between different technologies in the design of integrated devices operational principles of MOSFET's

Course Outline:

- MOSFET and Logic functionality
- (nano)MOSFET scaling: Transistors, Circuits, Architecture
- Schottky Barrier MOSFET and SpinFET
- Carbon Nanotube: Material, Applications, Silicon Nanowire: Material and Applications
- Single Electron Transistor and Logic, Resonant Tunneling Devices , Molecular Electronics

Book References:

- Nanoelectronics and Information Technology, Second, Corrected Edition (Edt R. Waser), 2005
- Introduction to nanoelectronics: science, nanotechnology, engineering, and applications, by Vladimir Vasil'evichMitin, VïacheslavAleksandrovichKochelap, Michael A. Stroscio,Cambridge University Press, 2008
- Quantum nanoelectronics: an introduction to electronic nanotechnology and quantum computing, Edward L. Wolf, Wiley-VCH, 2009
- Nanoelectronics and nanosystems: from transistors to molecular and quantum devices, K. Goser, Peter Glösekötter, Jan Dienstuhl, Springer, 2004
- Molecular and nano electronics: analysis, design and simulation, J. M. Seminario, Elsevier, Dec 11, 2006
- Current at the nanoscale: an introduction to nanoelectronics, ColmDurkan, Imperial College Press, 2007
- Nanoelectronics: Principles and Devices (Nanotechnology), Mircea Dragoman, Daniela Dragoman, ISBN-10: 1580536948 | ISBN-13: 978-1580536943

EN-5209 Nano-Fabrication and Characterization

Objectives:

- This course will examine techniques for controlling fabrication and final packaging. Monitoring techniques will be discussed. Basic electrical measurements will be stressed. Mechanical, electrical, chemical, and biological characteristics will be considered. The student will learn about manufacturing issues involved in subjects, such as interconnects isolation, final assembly, and packaging.

Course Outline:

- Introduction to IC technology and fabrication
- Microelectronic Materials
- Process monitoring techniques
    - Residual gas analysis (RGA), Optical emission spectroscopy (OES), Laser interferometry
- Surface analysis techniques
    - Ellipsometry, Profilometery
- Oxide electrical characterization, Transistor characterization
- Yield analysis techniques, Electron Microscopy
- MEM and biomedical devices characterization and testing
- Interconnect metallization, Planarization, Packaging, Reliability issues

Reference Books:

- Nanofabrication Fundamentals & Applications, A. A. Tseng
- Nanofabricaton, Principles Capabilities & Limits, C. Zheng, Springer
- Advances in Nanodevices and Nanofabrication: Selected Publications from Symposium of Nanodevices and Nanofabrication in ICMAT2011

EN-5210 Organic Electronics Devices

Objectives:

- The course aims to give an introduction to organic electronics.

Course Outline:

- Integrate knowledge in modern physics, mathematics and soft materials
- Explain and use basic models for electronic structure in organic electronic materials
- Explain and use basic models for optical absorption and luminescence in organic electronic materials
- Explain and use basic models for charge transport in organic electronic materials
- Explain and use basic models for charge injection in organic electronic materials
- Explain and use basic models for magnetoresistance in organic electronic materials and devices
- Explain and use basic models for electric and optical effects in organic electronic photovoltaic, electroluminescent and electrochromic devices
- Explain and use the interdependency of structural, electronic and optical properties in organic electronic materials

Recommended Books:

- “Organic Electronics”, Graciela Nall.
- “Organic Electronics: Materials, Manufacturing, and Applications”, Hagen Klauk.
- “Organic Optoelectronics”, Wenping Hu.

EN-5211 Special Topics in Semiconductor Materials and Devices

- Advanced topics to be chosen by the instructor

MSc Elective Courses for Specialization in Bio-Electronics

EN-5301 Biomedical Materials and Sensors

Objective: Teach biomedical materials, selection and design of biomedical materials for implants, and design and analysis of biomedical sensing and transducing components.

Course Outline:

Molecular structure-property relationships in biomaterials; focus on polymers, metals, ceramics, composites, and biodegradable materials; selection, design and function of biomedical materials for implants: bioelectrical and biomechanical concepts; biomedical imaging for flow properties of blood and material-tissue interaction; sensors and their characteristics; design of artificial biomaterials for biosensors; principles of biologically-based sensing elements and interfacing techniques; design and analysis methods of biosensing and transducing components.

Recommended Books:

1. Gabor Harsanyi, "Sensors in Biomedical Applications: Fundamentals, Technology and Applications," 2000, CRC Press, ISBN: 1566768853.
2. Roderic S. Lake and Joon B. Park, "Biomaterials: An introduction," Second Edition, 1992, Kluwer Academic/Plenum Publishers, ISBN: 0306439921.
3. P. I. Haris and D. Chapman, "New Biomedical Materials," 1998, IOS Press, ISBN: 905199365X.
4. Joon B. Park and Joseph D. Bronzino, "Biomaterials: Principles and Applications," 2002, CRC Press, ISBN: 0849314917.
5. John G. Webster, "Bioinstrumentation," 2003, John Wiley & Sons, ISBN: 0471452572.

EN-5302 Modelling and Simulation of Physiological Systems

Introduction: Model Human, an engineering point of View, mathematical Model, types and variation of models.

Cell Physiology and transport: Gibbs-Donnan Equilibrium, Carrier Mediated Transport action potential, Energetics of Muscle Contraction.

Motion: Electrical analogy of steady Flow, Newton law of viscosity, Laminar flow and Viscosity of Blood, general form of equation of motion, sheer stress and endothelial cells.

Signal Processing: Overview, signal acquisition and it's processing.

Human Modeling: Techniques for Physiological system, Autoregressive modeling, time frequency analysis, physiology of autonomic nervous system and heart rate variability, Measurement of Physiological stress, cardiac rhythm, EMG and Its spectral analysis and mean power frequency , and EEG and Its spectral analysis & coherence. Modeling of respiratory System.

Recommended Books:

1. The Biomedical Engineering Handbook. Bronzio Joseph D. .

EN-5303 Bio-Instrumentation Design

Objective: Teach methods for the measurement and analysis of biological systems including cardiopulmonary support, blood pressure and sound measurements, blood flow and volume measurements, respiratory system measurements, biotelemetry, and microprocessor based biomedical instrumentation.

Course Outline:

Theory of measurement and analysis of biological systems; characteristics of bioelectric signals; recording electrodes; biopotential amplifiers; basic sensors; chemical, pressure, sound, and flow transducers; electrophysiology and electromyography, and interpretation; instrumentation; cardiopulmonary support; blood pressure and sound measurement; blood flow and volume measurement; respiratory system measurements; biotelemetry: transmission and reception aspects of biological signals; aspects of patient care monitoring; electronic circuit design and construction; analog/digital signal acquisition and processing; microprocessor based biomedical instrumentation; basic principles of hardware and software designs for interfacing biomedical sensors to microprocessors; signal transduction and transfer functions; measurement principles; biological signals: temperature, displacement and force; flow measurements; blood volume; bio-potential: ECG, EMG, EEG; bio-potential electrode; spectroscopic methods for analysis of molecule in biomedicine; oxygenation and pulse oximeter; microscopy; data reduction; surface analysis; fluorescence measurements; single-molecule detection.

Recommended Books:

1. R. S. Khandpur, "Biomedical Instrumentation: Technology and Applications," First Edition, 2005, McGraw-Hill, ISBN: 0071447849.
2. John G. Webster, "Medical Instrumentation: Application and Design," Third Edition, 1997, John Wiley & Sons, ISBN: 0471153680.
3. L. A. Geddes and L. E. Baker, "Principles of Applied Biomedical Instrumentation," Third Edition, 1989, John Wiley & Sons, ISBN: 0471608998.

EN-5304 Bio-Electric Signal Processing and Signal Modelling

Objective: Teach theory and methods of signal processing in the context of bio-electronics

Course Outline:

This course focuses on linear systems and stochastic processes and their application in estimation, detection and filtering of bioelectrical signals. Methods include ARMA model, harmonic analysis, linear discriminant analysis, ICA, PCA, Wiener, Kalman and matched filters, and HMM. All methods will be developed in the context of various biomedical signals like ECG, EMG, EEG, Ultrasound etc.. The theoretical concepts will be reinforced using data analysis assignments in MATLAB.

Recommended Books:

- Biomedical Signal Processing and Signal Modeling, Eugene N. Bruce John Wiley & Sons, 2000.
- Fundamentals of Statistical Signal Processing, Steven Kay, Prentice Hall, 1998.
- Statistical Digital Signal Processing and Modeling, Monson H. Hayes, John Wiley & Sons, 1996
- Basic Stochastic Processes: Iranpour, R. and Chacon, P., The Mark Kac Lectures, MacMillan, 1988

EN-5305 Bio-Electric Signal Analysis and Interpretation

Objective: Teach bio-electric signal processing and analysis, biomedical signal characterization in time and frequency domain, short-time Fourier transform, chaotic models, and chaotic time series analysis.

Course Outline: Theoretical concepts and experimental approaches used to characterize electric phenomena in live cells and tissues; excitable membrane; action potential generation; cable theory; equivalent dipoles and volume conductor fields; introduction to bio-electric signal processing and analysis; fundamental techniques to analyze and process signals that originate from biological sources such as ECGs, EMGs, EEGs, blood pressure signals; physiological knowledge with the information useful for physiologic investigation, medical diagnosis and processing; biomedical signal characterization in time and frequency domain; deterministic and stochastic signal analysis methods; short-time Fourier transform; spectrogram; wavelet signal decomposition; characterization of signal dynamics: chaotic, stochastic, fractal (self similar); introduction to simple chaotic models; chaotic time series analysis techniques based on delayed coordinate embedding; concept and measures of signal complexity; statistical analysis techniques; probability density functions; moments; concept of stochastic process and nonstationarity; linear/nonlinear systems identification and modeling; Volterra and Wiener series.

Recommended Books:

1. Eugene N. Bruce, "Biomedical Signal Processing and Signal Modeling," 2001, John Wiley & Sons, ISBN: 0471345407.
2. D. C. Reddy, "Biomedical Signal Processing: Principles and Techniques," 2005, Tata McGraw-Hill, ISBN: 0070583889.
3. Isak Gath and Gideon F. Inbar, "Advances in Processing and Pattern Analysis of Biological Signals," 1996, Springer, ISBN: 0306452154.
4. Metin Akay, "Detection and Estimation Methods for Biomedical Signals," 1996, Academic Press, ISBN: 0120471434.
5. Metin Akay, "Time Frequency and Wavelets in Biomedical Signal Processing," 1998, IEEE Press, ISBN: 0780311477.

EN-5306 Diagnostic Imaging Systems

Objective: Teach medical imaging techniques and their applications, concepts and instrumentation of modern medical imaging modalities, and recent advances in digital diagnostic maging systems.

Course Outline:

Introduction to physical and mathematical bases of medical imaging techniques and their applications; underlying concepts and instrumentation of modern medical imaging modalities; design and operation of diagnostic imaging systems including fluoroscopy, digital subtraction angiography, mammography, computed tomography (CT), positron emission tomography (PET), magnetic resonance imaging (MRI), computed radiography, ultrasound; recent advances in digital diagnostic imaging systems including digital subtraction angiography (DSA) methods of producing three-dimensional images.

Recommended Books:

1. Jerry L. Prince and Jonathan Links, “Medical Imaging Signals and Systems,” First Edition, 2005, Prentice Hall, ISBN: 0130653535.
2. Macovski, “Medical Imaging Systems,” First Edition, 1983, Prentice Hall, ISBN: 0135726859.
3. Z. H. Cho, Joie P. Jones and Manbir Singh, “Foundations of Medical Imaging,” 1993, John Wiley & Sons, ISBN: 0471545732.
4. Rafael C. Gonzalez and Richard E. Woods, “Digital Image Processing,” Second Edition, 2002, Prentice Hall, ISBN: 0201180758.

EN-5307 Medical Microsystems

Objectives: To familiarize and study medical microsystems

Course Outline:

Fundamental and advanced fabrication process for integrating materials into microstructures and microdevices. Micropatterning, molding, sensing, and actuation technologies. Research concepts and applications of Microsystems at the molecular and cellular level. Applications such as DNA micro-arrays, drug and gene delivery, micro-sensors, actuators for research, microstructures for implants and micro-devices for prostheses.

EN-5308 Design of Medical Devices

Course Outline:

Design of medical device, Problem identification, specifications, preliminary design, review, iteration, testing, marketing and economic considerations for manufacturing, Regulation, Controls and Clinical trials. Medical device system safety analysis and human factors. Medical product liability and malpractice.

EN-5309 Medical Informatics

Objectives: To understand the principles of medical informatics

Course Outline: History of Patient Record, Introduction to Computer Based Patient Record (CPR), Data from Patients, Coding and Classification, Strategies for Data Entry, Representation of Time and Clinical Use of the CPR, Clinical Departmental and Support Systems. Scope of Hospital Information System (HIS), Challenges for the Health Care Sector, State of Transition, Objectives and Requirements, Planning, Modeling, Development, Architecture and Clinical Uses of HIS. Decision Support Models, Medical Reasoning, Quantitative & Qualitative Methods, Performance & steps involved, Uncertainty in Medical Judgment, Probability Theory and Decision Analysis. Characteristics & Implementing of Decision Support Systems.

Recommended Books:

- “Medical Informatics: Computer Applications in Health Care and Biomedicine”, Edward H. Shortliffe, Leslie E. Perreault, (Eds.).

EN-5310 Telemedicine

Objectives: To familiarize the student with fundamentals and trends in telemedicine

Course Outline: Introduction & Benefits of telemedicine. Communication infrastructure-LAN and WAN technology. Satellite, Mobile, Internet technology for telemedicine. Video and audio conferencing. Medical information storage and management for telemedicine, patient information, medical history, test reports, medical images, diagnosis and treatment. Hospital information systems, Doctors, paramedics, facilities. Pharmaceutical, Security and Confidentially of medical records and access control. · Cyber laws, Access to health Care Services, Health Education and Self Care. Bio-modeling, medical data coding and compression, Functions of DICOM, PACS and HIS for Telemedicine.

Recommended Books:

- Richard Wootton, John Craig, Victor Patterson(Eds), "Introduction to telemedicine". Second edition. The Royal Society of Medicine Press Ltd, 2006

EN-5311 Pattern Recognition

Objectives: To study and understand fundamental principles of pattern recognition

Course Outline: Theoretical foundations of classification and pattern recognition. Applications in Object, Speech, Texture Recognition, Biomedical Patterns. Image sensing and measuring objects, features and patterns. Data acquisition, preprocessing, invariants, and representation issues. Feature Reduction, Classification. Classifier complexity, bias variance, local and global error, error estimations, rejects, ROC. Bayesian approaches, Discriminant Functions for Normal Class Distributions, Parameter Estimation, Non-parametric Techniques (nearest neighbor rules, Parzen kernel rules, tree classifiers), Linear Discriminant Functions. Supervised learning (Perceptron, LMS algorithms, support vector machines, Back propagation), unsupervised learning and clustering, Neural networks, Combining Classifiers. Support Vector Machines, Hidden Markov Models. Applications of Pattern Recognition to Gene patterns and Biomedical problems.

- "Statistical Pattern Recognition", (3rd Ed) Andrew R. Webb and Keith D. Copsey, Wiley 2011
- "Pattern Classification", (2nd Ed) Richard O. Duda , Peter E. Hart, David G. Stork, Wiley-Interscience, 2000

EN-5312 Special Topics in BioElectronics

- Advanced topics to be chosen by the instructor