# NATIONAL INSTITUTE OF TECHNOLOGY SRINAGAR
## Electronics & Communication Engineering Department

## M. Tech. (MICROELECTRONICS)

### Scheme of Courses

| Paper No | Subject | Number of credits |
|---|---|---|
| **Core Courses:** | | |
| **Autumn Session** | | |
| ECEM-159 | Embedded System | 3 |
| ECEM-164 | VLSI Technology | 3 |
| ECEM-168 | Analog CMOS Design | 3 |
| ECEM-187 | Physical Electronics I | 3 |
| ECEM-186 | Mixed Signal Design | 3 |
| ECEM-106 | Laboratory I (HDL) | 2 |
| **Spring Session** | | |
| ECEM- 155 | VLSI Design | 3 |
| ECEM-111 | Laboratory II (VLSI Design) | 1 |
| ECEM-224 | Physical Electronics I I | 3 |
| ECEM-107 | Advanced Design Techniques<br>(Laboratory Course based on simulation tools) | 2 |
| ECEM-112 | Communication skills & Research Techniques | Compulsory Audit |
| **Seminar & Project (Credits: 16):** | | |
| ECEM-201 | Seminar | 1 |
| ECEM-202 | Project (Dissertation) – I | 3 |
| ECEM-203 | Project (Dissertation) – II | 12 |
| **Electives** | | |
| ECEM-103 | Wireless Communication | 3 |
| ECEM-104 | Advanced Computer Architecture | 3 |
| ECEM-151 | DSP Processors and Architecture | 3 |
| ECEM-153 | Advanced microprocessors | 3 |
| ECEM-158 | Special Topics in Applied Mathematics | 3 |
| ECEM-160 | Real Time Operating System | 3 |
| ECEM-170 | ESD reliability | 3 |
| ECEM-171 | RF IC Design | 3 |
| ECEM-172 | System Design | 3 |
| ECEM-181 | Smart Materials & Applications | 3 |
| ECEM-183 | Fuzzy Logic & Neural Networks | 3 |
| ECEM-188 | Testing, Fault Tolerance & Verification in VLSI | 3 |
| ECEM-189 | Memory Design & Technology | 3 |
| ECEM-191 | Issues in Deep Submicron CMOS Design | 3 |

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| ECEM-192 | Nanoelectronics | 3 |
| ECEM-193 | Computer Aided VLSI Design | 3 |
| ECEM-194 | MEMS Design | 3 |
| ECEM-195 | Simulation of Circuits & Devices | 3 |
| ECEM-196 | Introduction to Nanophotonics and Nanostructures | 3 |
| ECEM-197 | Special Topics in Microelectronics | 3 |
| ECEM-198 | Organic Materials in VLSI | 3 |
| ECEM-199 | Introduction to Quantum Devices & Computing | 3 |
| ECEM-200 | Power Semiconductor Devices | 3 |
| ECEM-204 | Semiconductor Optoelectronic Devices | 3 |
| ECEM-205 | Research Seminar | 3 |
| ECEM-212 | Research Methodologies and Techniques | 3 |
| ECEM-218 | Simulation and Modeling Techniques | 3 |
| MTHM-103 | Function spaces and Wavelet Analysis | 3 |
| MTHM-104 | Operations Research | 3 |
| MTHM-105 | Advanced Engineering Mathematics | 3 |

The students can also take the course of the PG programmes from the sister Departments (only EE at present) of the Institute as Electives.

## Syllabus

# CORE

### Course: ECEM 159 (Embedded Systems)

Embedded system concepts, Hardware organization and architecture, Micro-controllers, Technological aspects of embedded systems, ADC/DAC, Input/ Output devices, Memory devices, Synchronous/Asynchronous data transfer. Serial/parallel communication ports, programming embedded systems. Embedded board level design concepts, DSP core and its building blocks, Introduction to RTOS, RFID, MEMS.

**References:**


1. S. Ball, Embedded Microprocessor Systems: Real World Design, Third Edition, Elsevier/ Newnes.
2. A. S. Berger, Embedded Systems Design: An Introduction to Processes, Tools and Techniques, CMP Books.
3. A. Hollabaugh, Embedded Linux: Hardware, Software, and Interfacing, Addison-Wesley, 2002.
4. Q. Li and C. Yao, Real-Time Concepts for Embedded Systems, CMP Books.
5. R. Niemann and P. Marwedel, Hardware/Software Co-Design for Data Flow Dominated Embedded Systems, Kluwer.
6. P. Raghavan, A. Lad and S. Neelakandan, Embedded Linux System Design and Development, Auerbach.
7. K. Yaghmour, Building Embedded Linux Systems, ORA.
8. T-Y. Yen and W. Wolf, Hardware/Software Co-Synthesis of Distributed Embedded Systems, Kluwer.
9. Raj Kamal, Microcontrollers: Architecture, Programming, Interfacing, and System Design , PE.
10. Morton, Embedded Microcontrollers, PE.
11. Mazidi, The 8051 Microcontroller and Embedded Systems, PE.


### Course: ECEM 164 (VLSI Technology)

Clean room Technology and safety requirements, Wafer cleaning processes and wet chemical etching techniques, Solid State diffusion modeling and technology; Ion Implantation modeling, technology and damage annealing; characterization of Impurity profiles, Oxidation: Kinetics of Silicon dioxide growth both for thick, thin and ultra-thin films. Oxidation technologies in VLSI and ULSI; Characterization of oxide films; High k and low k dielectrics for ULSI, Photolithography, E-beam lithography and newer lithography techniques for mask generation, CVD techniques for deposition of polysilicon, silicon dioxide, silicon nitride and metal films; Epitaxial growth of silicon; modeling and technology, Metal film deposition : Evaporation and sputtering techniques. Failure mechanisms in metal interconnect; Multi-level metallization schemes, Plasma and Rapid Thermal Processing: PECVD, Plasma etching and RIE techniques; RTP techniques for annealing, growth and deposition of various films for use in ULSI.

Process integration for NMOS, CMOS, Bipolar and BICMOS circuits

**References:**


1. S. K. Gandhi, VLSI Fabrication Principles: Silicon and Gallium Arsenide, Second Edition, Wiley.
2. G. S. May and S. M. Sze, Fundamentals of Semiconductor Fabrication, Wiley.

3. J. D. Plummer, M. D. Deal and P. B. Griffin, Silicon VLSI Technology: Fundamentals, Practice and Modeling, Pearson/PH.
4. P. Van Zant, Microchip Fabrication: A Practical Guide to Semiconductor Processing, Fifth Edition.
5. C. Y. Chang and S. M. Sze, ULSI Technology, McGraw-Hill.
6. S. M. Sze, VLSI Technology, McGraw-Hill.

## Course: ECEM 168 (Analog CMOS Design)

Introduction to analog VLSI and mixed signal issues in CMOS technologies, Basic MOS models, SPICE Models and frequency dependent parameters. Basic NMOS/CMOS gain stage, cascade and cascode circuits. Frequency response, stability and noise issues in amplifiers. CMOS analog blocks: Current Sources and Voltage references. Differential amplifier and OPAMP design. Frequency Synthesizers, Voltage Controlled Oscillators and Phased lock-loop. Non-linear analog blocks: Comparators, Analog Interconnects. Analog Testing and Layout issues. Low Voltage and Low Power Circuits. Introduction to RF Electronics. Basic concepts in RF design.

**References:**

1. A. Agarwal and J. Lang, Foundations of Analog and Digital Electronic Circuits, Elsevier/MK.
2. P. E. Allen and D. R. Holberg, CMOS Analog Circuit Design, Second Edition, OUP.
3. Enz and E. Vittoz, Charge-Based MOS Transistor Modeling: The EKV Model for Low-Power and RF IC Design, Wiley.
4. P. Gray, P. Hurst, S. Lewis and Meyer, Analysis and Design of Analog Integrated Circuits, Wiley.
5. R. Gregorian and G. C. Temes, Analog MOS Integrated Circuits for Signal Processing, Wiley.
6. Hastings, The Art of Analog Layout, Second Edition, Prentice-Hall.
7. Johns and K. Martin, Analog Integrated Circuit Design, Wiley.
8. K. R. Laker and W. M. C. Sansen, Design of Analog Integrated Circuits and Systems, McGraw-Hill.
9. T. H. Lee, Design of CMOS Radio Frequency Integrated Circuits, Second Edition, OUP.
10. B. Razavi, Design of Analog CMOS Integrated Circuits, McGraw-Hill.

## Course: ECEM -187 (Physical Electronics I)

Introduction to quantum effects, and Band theory of solids, The physical principles of semiconductors, both silicon and compound materials; Operating principles and device equations, Homojunctions and Heterojunction, The fundamental operation of semiconductor devices and overview of applications, p-n Junction diode, Photo-detectors, LED, LASERS, Solar Cells etc.

Characterization Techniques for semiconductors: Four probe and Hall measurement; CVs for dopant profile characterization; Capacitance transients and DLTS.

**References:**

1. J. P. McKelvey, Solid State and Semiconductor Physic, Robert E. Krieger Publishing.
2. B. L. Anderson and R. L. Anderson, Fundamentals of Semiconductor Devices, MG-Hill.
3. B. G. Streetman and S. Banerjee, Solid State Electronic Devices, Sixth Edition, PHI.
4. N. Dasgupta and A. Dasgupta, Semiconductor Devices: Modelling and Technology, PHI.
5. D. Nagchoudhary, Microelectronic Devices, Pearson.
6. D. J. Roulston, Bipolar Semiconductor devices, McGraw Hill.
7. M. Shur, Physics of Semiconductor Devices, Prentice-Hall.
8. S. M. Sze, Modern Semiconductor Device Physics, Wiley.

## Course: ECEM -186 (Mixed Signal Design)

Analog and discrete-time signal processing, Analog integrated continuous-time and discrete-time (switched-capacitor) filters. Switched Capacitor Amplifiers, Basics of Analog to digital converters (ADC), Basics of Digital to analog converters (DAC), Performance Parameters of Data Converters, ADC and DAC Architectures and Design, Charge-pump circuits and Multipliers., Mixed-Signal layout, Interconnects, Phase locked loops, Delay locked loops.

**References:**


1. P. E. Allen and D. R. Holberg, CMOS Analog Circuit Design, Second Edition, OUP,.
2. P. Gray, P. Hurst, S. Lewis and Meyer, Analysis and Design of Analog Integrated Circuits, Wiley.
3. R. Gregorian and G. C. Temes, Analog MOS Integrated Circuits for Signal Processing, Wiley.
4. Hastings, The Art of Analog Layout, Second Edition, Prentice-Hall.
5. B. Razavi, Design of Analog CMOS Integrated Circuits, McGraw-Hill.
6. J. Baker, CMOS: Cicuit Design, Layout and Simulation, Second Edition, Wiley.
7. .J. Van de Plassch, Integrated A-D and D-A Converters, Second Edition, Springer/Kluwer.


## Course: ECEM-106 (Hardware Description Language)

Basic concepts of hardware description languages. Hierarchy, Concurrency, Logic and Delay modeling. Structural, Data-flow and Behavioural styles of hardware description. Architecture of event driven simulators.

Syntax and Semantics of VHDL. Variable and signal types, arrays and attributes. Operators, expressions and signal assignments. Entities, architecture specification and configurations. Component instantiation. Concurrent and sequential constructs. Use of Procedures and functions, Examples of design using VHDL.

Introduction to Verilog. Comparison with VHDL

**References:**


1. J. Armstrong and F. G. Gray, VHDL Design Representation and Synthesis, Second Edition.
2. P. J. Ashenden, The Designer's Guide to VHDL, Second Edition, Elsevier/MK.
3. J. Bhasker, A VHDL Primer, Third Edition, Prentice-Hall.
4. J. Bhasker, A VHDL Synthesis Primer, Second Edition, Star Galaxy.
5. S. Ghosh, Hardware Description Languages: Concepts and Principles, PHI.
6. S. Sjoholm and L. Lindh, VHDL for Designers, Prentice-Hall.
7. S. Yalamanchili, Introductory VHDL : From Simulation to Synthesis, Prentice-Hall.
8. S. Yalamanchili, VHDL : A Starter's Guide, Second Edition, Prentice-Hall.
9. M. G. Arnold, Verilog Digital Computer Design : Algorithms to Hardware, Prentice- Hall
10. J. Bhasker, A Verilog HDL Primer, Third Edition, Star Galaxy.
11. J. Bhasker, Verilog HDL Synthesis: A Practical Primer, Star Galaxy.
12. D. J. Lilja and S. S. Sapatnekar, Designing Digital Computer Systems with Verilog, OUP.
13. S. Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Second Edition, Prentice-Hall.
14. D. E. Thomas and P. R. Moorby, The Verilog Hardware Description Language, Kluwer.
15. R. M. Zeidman, Verilog Designer's Library, Prentice-Hall.
16. J. Bhasker, A System C Primer, Second Edition, Star Galaxy.
17. S. Sutherland, S. Davidmann and P. Flake, System Verilog for Design, Springer.

## Course: ECEM 155 (VLSI Design)

Review of MOS transistor models. CMOS logic families including static, dynamic and dual rail logic, Integrated Circuit Layout: Design Rules, Parasitics. Building blocks: ALU's, FIFO's, Counters. VLSI system design, Data and control path design, Floor planning, Design methodology: Logic, Circuit and Layout Verification, Logical Effort: Design examples.

**References:**


1. N. Weste and K. Eshraghian, Principles of CMOS VLSI Design, Addison Wesley
2. R. J. Baker, CMOS: Circuit Design, Layout and Simulation, Second Edition, Wiley.
3. J-P. Deschamps, G. J. A. Bioul and G. D. Sutter, Synthesis of Arithmetic Circuits: FPGA, ASIC and Embedded Systems, Wiley.
4. S-M. Kang and Y. Leblebici, CMOS Digital Integrated Circuits: Analysis and Design, Third Edition.
5. J. M. Rabaey, A. Chandrakasan and B. Nikolic, Digital Integrated Circuits: A Design Perspective, Pearson/PH.
6. J. P. Uyemura, Introduction to VLSI Circuits and Systems, Wiley.
7. J. P. Uyemura, CMOS Logic Circuit Design, Second Edition, Kluwer.
8. N. Weste and D. Harris, CMOS VLSI Design: A Circuits and Systems Perspective.
9. W. Wolf, Modern VLSI Design: Systems-on-Chip Design, Third Edition, Pearson/PH.
10. W. Wolf, FPGA-based System Design, PH/Pearson.
11. Sutherland, Sprout, and Harris, Logical Effort, Morgan Kaufmann.


## Course: ECEM 224 (Physical Electronics II)

The bipolar transistor: Ebers-Moll model; charge control model; small-signal and switching characteristics; Graded-base and graded-emitter transistors; High-current and high- frequency effects; Heterojunction bipolar transistors;

The MOS transistor: Pao-Sah and Brews models; Short channel effects in MOS transistors. Hot-carrier effects in MOS transistors; Quasi-static compact models of MOS transistors; Measurement of MOS transistor parameters; Scaling and transistors structures for ULSI; Silicon-on-insulator transistors; High-field and radiation effects in transistors.;

Junction FETs; JFET, MESFET and heterojunction FET

**References:**


1. N. Arora, MOSFET Models for Circuit Simulation, Springer Verlag.
2. Y. Taur and T. H. Ning, Fundamentals of Modern VLSI Devices, CUP.
3. Y. P. Tsividis, Operation and Modeling of the MOS Transistor, McGraw-Hill.
4. D. J. Roulston, Bipolar Semiconductor devices, McGraw Hill.
5. M. Shur, Physics of Semiconductor Devices, Prentice-Hall.


## Course: ECEM 107 (Advanced Design Techniques)

1. Installation of Scilab with the basic information of Scilab workspace and working directory, Creating matrices and some simple matrix operations , Statistics and working with polynomials , Scilab Programming language-looping and branching, Script files and function files, Writing Scilab functions , Graphics and Plotting- 2D graphs, 3D graphs, Creating Histogram, animations, Working with Applications-XCOS with examples in signal processing Matlab to Scilab convertor Working with Atoms- Image processing module (SIVP), METANET.
2. Any other simulator on which the student will be working, for M. Tech Thesis.

### Course: ECEM-111: (Laboratory II VLSI Design)
Spice models
Circuit simulation
Layout design and post layout simulations

### Course: ECEM-112 (Communication skills & Research Techniques)
Basics of communication, communication skills, public speaking, communication methods and media, e-mail & beyond, learning through internet, multimedia presentations, effective meetings, professional care of your voice, group discussions & interviews, literature survey, research techniques, optimizations of research parameters, making video films, basic elements of ETV production, distance education.

**References:**
1. Meera Banerji,Developing Communication Skills
2. M Ashraf Rizvi Effective Technical Communication

# Elective Courses:

### Course: ECEM 103 (Wireless Communication)
Cellular concepts, frequency reuse, co channel interference, Cell splitting. Radio propagation characteristics; models for path loss, shadowing and multipath fading (delay spread, coherence bandwidth coherence time. Doppler spread). Jakes' channel model. Digital modulation for mobile radio; analysis under fading channels; diversity techniques and Rake demodulator. Introduction to spread spectrum communication. Multiple access techniques used in mobile wireless communications: FDMA/TDMA, CDMA. The cellular concept: Frequency reuse; the basic theory of hexagonal cell layout; spectrum efficiency. FDM/TDM Cellular systems; channel allocation schemes. Handover analysis. Cellular CDMA; soft capacity. Erring capacity comparison of FDM/TDM systems and cellular CDMA. Discussion of GSM standards; signaling and call control; mobility management; location tracing. Wireless data networking; packet error modeling on fading channels, performance analysis of link and transport layer protocols over wireless channels; mobile data networking (mobile IP); wireless data in GSM, IS-95, and GPRS.

**References:**
1. Rappa Port, Wireless Communication, Principals and Practice, PH
2. Vijay K Garg, Wireless Communication and Networks, Morgan Kaufman
3. Andrea Goldsmith, Wireless Communication, OUP

### Course: ECEM 104 (Advanced Computer Architecture)
Different types of Architectures

Performance of Computers and Significance of bench marks

Pipelining and pipeline hazards, Hazard removal, State diagrams, etc.

Types of Parallel Architectures SISD, SIMD, and MIMD architectures

Interconnection Networks

Latest trends in Computer Architecture

**References:**

1. G. A. Blaauw and F. P. Brooks, Computer Architecture: Concepts and Evolution, Pearson/AW.
2. V. P. Heuring and H. F. Jordan, Computer Systems Design and Architecture, Second Edition, PHI.
3. D. A. Patterson and J. L. Hennessy, Computer Architecture: A Quantitative Approach, Fourth Edition, Elsevier /MK.
4. D. A. Patterson and J. L. Hennessy, Computer Architecture: A Quantitative Approach, Third Edition, Elsevier/MK.
5. D. A. Patterson and J. L. Hennessy, Computer Organization and Design: Hardware/ Software Interface, Third Edition, Elsevier/MK.
6. W. Stallings, Computer Organization and Architecture: Designing for Performance, Pearson/PH.
7. A. S. Tanenbaum, Structured Computer Organization, Fifth Edition, Pearson/PH.
8. W. Wolf, Modern VLSI Design: Systems-on-Chip Design, Third Edition, Pearson/PH.

## ECEM-151 (DSP Processors and Architecture)

Introduction, A Digital signal-processing system, Decimation and interpolation, Analysis and Design tool for DSP Systems MATLAB, DSP using MATLAB

Computational accuracy in DSP implementations:

Number formats for signals and coefficients in DSP systems, Dynamic Range and Precision, Sources of error in DSP implementations, A/D Conversion errors, DSP Computational errors, D/A Conversion Errors, Compensating filter.

Architectures for programmable DSP devices:

Basic Architectural features, DSP Computational Building Blocks, Bus Architecture and Memory, Data Addressing Capabilities, Address Generation Unit, Programmability and Program Execution, Speed Issues, Features for External interfacing.

Execution control and pipelining:

Hardware looping, Interrupts, Stacks, Relative Branch support, Pipelining and Performance, Pipeline Depth, Interlocking, Branching effects, Interrupt effects, Pipeline Programming models.

Programmable digital signal processors:

Commercial Digital signal-processing Devices, Data Addressing modes of TMS320C54XX DSPs, Data Addressing modes of TMS320C54XX Processors, Memory space of TMS320C54XX Processors, Program Control, TMS320C54XX instructions and Programming, On-Chip Peripherals, Interrupts of TMS320C54XX processors, Pipeline Operation of TMS320C54XX Processors.

Implementations of basic DSP algorithms:

The Q-notation, FIR Filters, IIR Filters, Interpolation Filters, Decimation Filters, PID Controller, Adaptive Filters, 2-D Signal Processing.

Implementation of FFT algorithms:

An FFT Algorithm for DFT Computation, A Butterfly Computation, Overflow and scaling, Bit-Reversed index generation, An 8-Point FFT implementation on the TMS320C54XX, Computation of the signal spectrum.

Interfacing memory and I/O peripherals to programmable DSP devices:

Memory space organization, External bus interfacing signals, Memory interface, Parallel I/O interface, Programmed I/O, Interrupts and I/O, Direct memory access (DMA). A

Multichannel buffered serial port (McBSP),McBSP Programming, a CODEC in interface circuit, CODEC programming, A CODEC-DSP interface example.

**References:**


1. Digital Signal Processing by Avtar Singh and S Srinivasan
2. VLSI Digital Signal Processing Systems -Design & Implementation by K.K Parhi
3. Digital Processor Fundamentals, Architectures & Features – by Lapsley


## Course: ECEM 153 (Advanced Microprocessors)

Pin configuration, Architecture, Memory and I/O space of 8086 microprocessor. Addressing modes and Instruction set. Introduction to assembly language of 8086 microprocessor and example programs. Input/output processor, Interfacing of memories, I/O operations. Programmable interrupt controller, Programmable communication interface, Programmable Keyboard/Display interface. Floppy disk controller, DMA controller, USART controller, Pointer Controllers, etc. Introduction to 8088 and Pentium series.

**References:**


1. M. Johnson, Superscalar Microprocessor Design, Prentice-Hall.
2. Brey, The Intel Microprocessor: Architecture Programming and Interfacing, PHI.
3. W. C. Wray, J. D. Green_eld and R. Bannatyne, Using Microprocessors and Microcomputers: The Motorola Family, Fourth Edition, Prentice-Hall.
4. E. O. Hwang, Digital Logic and Microprocessor Design with VHDL, Thomson.
5. M. Rafiquzzaman, Microprocessor theory and Applications, PHI.


## Course: ECEM 158 (Special Topics in Applied Mathematics)

Syllabus will be framed as per student's requirement

## Course: ECEM 160 (Real Time Operating Systems)

Operating system and function, Evolution of operating system, Batch, Interactive, Time Sharing and Real Time System, System protection. Operating Systems types, Process Concept. Concurrency and Synchronization, Mutual Exclusion and Deadlock Problems. Process Management. Process States, Process scheduling Algorithms and Implementation. Storage Management. Concepts and implementation of Real and Virtual Storage. File Management, File Organization, File Systems, Protection and security Performance Evaluation, Case study of the UNIX Operating Systems, Basic issues in Multiprocessor and Distributed Operating Systems.

**References:**


1. Bic and Shaw, Operating System
2. A. Silberschatz, P. B. Galvin and G. Gagne, Operating System Concepts, Wiley.
3. A. S Tanenbaum and A. S Woodhull, Operating Systems Design and Implementation, Third Edition, Pearson/PH.
4. J. W. S. Liu, Real-Time Systems, Prentice-Hall/PE.


## Course: ECEM 170 (ESD Reliability)

Basics of ESD, ESD models, Testing, Characterization, and failure mechanisms, ON-Chip ESD protection. Advanced ESD protection Design, ESD protection for embedded and high frequency design

**References:**


Semenov, Oleg,and Sarbishaei, ESD Protection Device and Circuit Design


**Current on-line Literature**

## Course: ECEM 171 (RF IC Design)

Introduction to RF and Wireless Technology: Complexity, design and applications. Choice of Technology. Basic concepts in RF Design: Nonlinearly and Time Variance, intersymbol Interference, random processes and Noise. Definitions of sensitivity and dynamic range, conversion Gains and Distortion. Analog and Digital Modulation for RF circuits: Comparison of various techniques for power efficiency. Coherent and Non coherent defection. Mobile RF Communication systems and basics of Multiple Access techniques. Receiver and Transmitter Architectures and Testing heterodyne, Homodyne, Image-reject, Direct-IF and sub-sampled receivers. Direct Conversion and two steps transmitters. BJT and MOSFET behavior at RF frequencies Modeling of the transistors and SPICE models. Noise performance and limitation of devices. Integrated Parasitic elements at high frequencies and their monolithic implementation. Basic blocks in RF systems and their VLSI implementation : Low Noise Amplifiers design in various technologies, Design of Mixers at GHz frequency range. Various Mixers, their working and implementations, Oscillators: Basic topologies VCO and definition of phase noise. Noise-Power trade-off. Resonator-less VCO design. Quadrature and single-sideband generators, Radio Frequency Synthesizes: PLLS, Various RF synthesizer architectures and frequency dividers, Power Amplifiers design. Linearization techniques, Design issues in integrated RF filters.

**References:**


1. T. H. Lee, Design of CMOS Radio Frequency Integrated Circuits, Second Edition, OUP.
2. Ludwig, RF Circuit Design PE.
3. Bosco Leung, VLSI for Wireless Communication.
4. Robert G. whinch, Telecommunication Transmission Systems, Second edition, TMH.


## Course: ECEM 172 (System Design)

Basics of system hardware design. Hierarchical design using top-down and bottom-up methodology. System partitioning techniques, interfacing between system components. Handling multiple clock domains, Synchronous and asynchronous design styles. Interface between synchronous and asynchronous blocks. Meta-stability and techniques for handling it. Interfacing linear and digital systems, data conversion circuits. Design of finite state machines, state assignment strategies. Design and optimization of pipelined stages. Use of data flow graphs, Critical path analysis, retiming and scheduling strategies for performance enhancement. Implementation of DSP algorithms. Signal integrity and high speed behaviour of interconnects: ringing, cross talk and ground bounce. Layout strategies at IC and board level for local and global signals. Power supply decoupling.

**References:**


3. J-P. Deschamps, G. J. A. Bioul and G. D. Sutter, Synthesis of Arithmetic Circuits: FPGA, ASIC and Embedded Systems, Wiley.
4. S-M. Kang and Y. Leblebici, CMOS Digital Integrated Circuits: Analysis and Design, Third Edition, McGraw-Hill.
5. M. J. S. Smith, Application Specific Integrated Circuits, Pearson/AW.
6. W. Wolf, FPGA-based System Design, PH/Pearson.
7. P. Marwedel, Embedded System Design, Springer.
8. F. Vahid and T. Givargis, Embedded System Design: A Unified Hardware/Software Introduction, Wiley.
9. W. Wolf, Computers as Components: Principles of Embedded Computer System Design, Second Edition, Elsevier/MK.
10. S. H. Hall, G.W. Hall and J. A. McCall, High-Speed Digital System Design: A Handbook of Interconnect Theory and Design Practices, Wiley/IEEE.
11. W. J. Dally and J. W. Poulton, Digital Systems Engineering, CUP.

12. W. J. Dally and B. P. Towles, Principles and Practices of Interconnection Networks, Elsevier/MK.
13. 105. H. W. Johnson and M. Graham, High Speed Digital Design : A Handbook of Black
14. Y. N. Patt and S. J. Patel, Introduction to Computing Systems: From Bits and Gates to C and Beyond, Second Edition, McGraw-Hill.
15. R. J. Tocci, N. S. Widmer and G. L. Moss, Digital Systems: Principles and Applications, Tenth Edition, Prentice-Hall.
16. A. K. Sharma, Semiconductor Memories: Technology, Testing and Reliability, Wiley/ IEEE.

## ECEM 181 (Smart Materials and Applications)

Overview of smart materials technology, Characteristics of smart materials such as piezoelectric, Structural modeling and design. Dynamics and control for smart structures. Integrated system analysis., Thermal Management.

Smart Sensor, Actuator and Transducer Technologies:

Smart Sensors: Accelerometers, Force Sensors, Load Cells, Torque Sensors, Pressure Sensors, Microphones, Impact Hammers, MEMS Sensors, Sensor Arrays, Smart Actuators, Displacement Actuators, Force Actuators, Power Actuators, Vibration, Dampers, Shakers.

Smart Transducers:

Ultrasonic Transducers, Sonic Transducers, Air Transducers, Measurement, Signal Processing, Drive and Control Techniques, Quasi-Static and Dynamic Measurement Methods, Signal-Conditioning Devices, Constant Voltage, Constant Current and Pulse Drive Methods, Calibration Methods, Passive, Semi-Active and Active Control; Feedback and Feed forward Control Strategies. Design, Analysis, Manufacturing and Applications of Engineering, Smart Structures and Products

Detailed case studies incorporating design, analysis, manufacturing and application issues involved in integrating smart materials and devices with signal processing and control capabilities to engineering smart structures and products.

**References:**

1. D. G. Alciatore and M. B. Histand, Introduction to Mechatronics and Measurement Systems, Third Edition, McGraw-Hill.
2. J. Billingsley, Essentials of Mechatronics, Wiley.
3. S. Cetinkunt, Mechatronics, Wiley.
4. V. Varadan, K. J. Vinoy and S. Gopalakrishnan, Smart Material Systems and MEMS Design and Development Methodologies, Wiley.
5. A. Vassighi and M. Sachdev, Thermal and Power Management of Integrated Circuits, Springer.
6. A. Dhawan, Medical Image Analysis, Wiley.
7. A. G. Webb, Introduction to Biomedical Imaging, Wiley.
8. S. Mann, Intelligent Image Processing, Wiley/IEEE.

## ECEM 183 (Fuzzy Logic and Neural Networks)

Fuzzy Set Theory: Fuzzy sets, operations on fuzzy sets, intersections and unions, fuzzy relations, fuzzy compositions. Fuzzy Systems: Extension Principle, fuzzy numbers, arithmetic operations, approximate reasoning, fuzzy inference, linguistic model of complex systems, firing of rules.

Introduction to Fuzzy Control: Fuzzy control basics, Construction of knowledge base, Mamdani and Sugeno fuzzy, knowledge base controls, fuzzy, nonlinear simulation, genetic algorithms, tuning of fuzzy systems.

Introduction to Neural Networks: What is a Neural Network. Models of a Neuron. Network Architectures. Learning Processes. Single Layer Perceptrons: Unconstrained Optimization Techniques, Linear Least-Squares Filters. Least-Mean-Square Algorithm. Multilayer Perceptrons: Back-Propagation Algorithm. XOR Problem. Generalization. Approximations of Functions. Self-Organizing Maps: Self-Organizing Map algorithm. Learning Vector Quantization.

**References:**


1. P. Liu, Hong-Xing Li, Fuzzy Neural Networks, theory and Applications, World Scientific.
2. R. R. Yager, L. Askar Zadeh, Fuzzy Logic and Soft Computing, World Scientific.
3. S. V. Kartapoulos, Understanding Neural Networks and Fuzzy Logic basic concepts and Applications, PHI.
4. T. J. Ross, Fuzzy Logic with Engineering Applications, Wiley.
5. Fausett, Fundamentals of Neural Networks, PE.
6. Yen, Fuzzy Logic, PE.
7. Freeman, Neural Networks, PE.
8. Haykin, Neural Networks: A comprehensive foundation, PE.


**Course: ECEM 188 (Testing, Fault Tolerance and Verification in VLSI)**

Scope of testing and Verification in VLSI design process. Issues in test and verification of complex chips, embedded cores and SOCs.

Fundamentals of VLSI testing. Fault models. Automatic test pattern generation, Design for testability, Scan design. Test interface and boundary scan. System testing and test for SOCs. Iddq testing. Delay fault testing. BIST for testing of logic and memories. Test automation.

Design verification techniques based on simulation, analytical and formal approaches. Functional verification. Timing verification. Formal Verification. Basics of equivalence checking and model checking. Hardware emulation

**References:**


1. M. Abramovici, M. A. Breuer and A. D. Friedman, Digital Systems Testing and Testable Design, IEEE Press.
2. M. L. Bushnell and V. D. Agrawal, Essentials of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits, Springer/Kluwer.
3. N. K. Jha and S. Gupta, Testing of Digital Systems, CUP.
4. A. Miczo, Digital Logic Testing and Simulation, Second Edition, Wiley.
5. L-T. Wang, C-W. Wu and X. Wen, VLSI Test Principles and Architectures, Elsevier/ Newnes.
6. G. D. Hachtel and F. Somenzi, Logic Synthesis and Verification Algorithms, Springer.
7. V. N. Yarmolik, Fault Diagnosis of Digital Circuits, Wiley.
8. R. J. Feugate and S. M. McIntyre, Introduction to VLSI Testing, Prentice-Hall.
9. H. Bleeker, P. van den Eijnden and F. de Jong, Boundary-Scan Test: A Practical Approach, Kluwer.
10. Chakraborty, Fault tolerance and Reliability techniques for high density random access memories, PE.


## Course: ECEM-189 (Memory Design & Technology)

Random Access Memory Technologies, Nonvolatile Memories, Memory Fault Modeling, Testing, And Memory Design For Testability And Fault Tolerance, Semiconductor Memory Reliability And Radiation Effects, Advanced Memory Technologies And High-Density Memory Packaging Technologies.

**References:**
1. A. K. Sharma, Semiconductor Memories: Technology, Testing and Reliability, Wiley/ IEEE.
2. A. K. Sharma, Advanced Semiconductor Memories: Architectures, Designs, and Applications, Wiley.
3. Prince, Semiconductor Memories: A Handbook of Design, Manufacture and Application, Wiley.
4. Prince, High Performance Memories: New Architectures DRAMs and SRAMs, Wiley.
5. B. Keeth and R. J. Baker, DRAM Circuit Design: A Tutorial, Wiley/IEEE.
6. Chakraborty, Fault tolerance and Reliability techniques for high density random access memories, PE.

## Course: ECEM-191 (Issues in Deep Submicron CMOS Design)

Scaling issue, interconnect issues, Mixed Signal Design of Deep Submicron Devices ESD reliability of Deep submicron devices, Power Dissipation and Thermal problems, Design of Heat Sinks for Deep submicron IC's.

**References:**

**Current on-line Literature**

## Course: ECEM-192 (Nanoelectronics)

Shrink-down approaches: Introduction, CMOS Scaling, The nanoscale MOSFET, Finfets, Vertical MOSFETs, limits to scaling, system integration limits (interconnect issues etc.), Resonant Tunneling Transistors, Single electron transistors, new storage, optoelectronic, and spintronics devices.

Atoms-up approaches: Molecular electronics involving single molecules as electronic devices, transport in molecular structures, molecular systems as alternatives to conventional electronics, molecular interconnects; Carbon nanotube electronics, band structure & transport, devices, applications.

**References:**
1. K. E. Drexler, Nanosystems: Molecular Machinery, Manufacturing, and Computation, Wiley.
2. Dragoman, Nanoelectronics Principals and Devices.
3. Supriyo Datta, Electronic Transport in Mesoscopic Systems, OUP
4. Kristof (EDT) Sienicki Molecular Electronics and Molecular Electronic Devices, CRC
5. J. James, M. Halls and J. de Mello, Molecular Semiconductors: An Introduction, Wiley.

## Course: ECEM-193 (Computer Aided VLSI Design)

Matrices: Linear dependence of vectors, solution of linear equations, bases of vector spaces, orthogonality, complementary orthogonal spaces and solution spaces of linear equations.

Graphs: representation of graphs using matrices; Paths, connectedness; circuits, cutsets, trees; Fundamental circuit and cutset matrices; Voltage and current spaces of a directed graph and their complementary orthogonality.

Algorithms and data structures: efficient representation of graphs; Elementary graph algorithms involving bfs and dfs trees, such as finding connected and 2- connected components of a graph, the minimum spanning tree, shortest path between a pair of vertices in a graph; Data structures such as stacks, linked lists and queues, binary trees and heaps. Time and space complexity of algorithms.

**References:**
1. M. D. Birnbaum, Essential Electronic Design Automation (EDA), Prentice-Hall, 2003. May.

2. G. De Micheli, Synthesis and Optimization of Digital Circuits, McGraw-Hill.
3. S. H. Gerez, Algorithms for VLSI Design Automation, Wiley.
4. S. M. Sait and H. Youssef, VLSI Physical Design Automation: Theory and Practice, WSP.
5. M. Sait and H. Youssef, Iterative Computer Algorithms with Applications in Engineering: Solving Combinatorial Optimization Problems, Wiley/IEEE.
6. N. Sherwani, Algorithms for VLSI Physical Automation, Third Edition, Kluwer.
7. Proceedings of the IEEE (Special Issue on VLSI CAD Tools), February.

## Course: ECEM-194 (MEMS Design)

Historical Background: Silicon Pressure sensors, Micromachining, Micro Electro-Mechanical Systems,

Microfabrication and Micromachining: Integrated Circuit Processes, Bulk Micromachining: Isotropic Etching and Anisotropic Etching, Wafer Bonding, High Aspect-Ratio Processes (LIGA)

Physical Microsensors: Classification of physical sensors, Integrated, Intelligent, or Smart sensors, Sensor Principles and Examples: Thermal sensors, Electrical Sensors, Mechanical Sensors, Chemical and Biosensors

Microactuators: Electromagnetic and Thermal microactuation, Mechanical design of microactuators, Microactuator examples, microvalves, micropumps, Micromotors-Microactuator systems: Success Stories, Ink-Jet printer heads, Micro-mirror TV Projector

Surface Micromachining: One or two sacrificial layer processes, Surface micromachining requirements, Polysilicon surface micromachining, Other compatible materials, Silicon Dioxide, Silicon Nitride, Piezoelectric materials, Surface Micro-machined Systems: Success Stories, Micro-motors, Gear trains, Mechanisms

Application Areas: All-mechanical miniature devices, 3-D electromagnetic actuators and sensors, RF/Electronics devices, Optical/Photonic devices, Medical device e.g. DNA-chip, micro-arrays.

**References:**

1. C. Liu, Foundations of MEMS, Pearson/PH.
2. J. Billingsley, Essentials of Mechatronics, Wiley.
3. S. Cetinkunt, Mechatronics, Wiley.
4. G. M. Rebeiz, RF MEMS: Theory, Design, and Technology, Wiley.
5. D. Shetty and R. Kolk, Mechatronics System Design, Thomson.
6. M. W. Spong, S. Hutchinson and M. Vidyasagar, Robot Modeling and Control, Wiley.

## Course: ECEM-195 (Simulation of Circuits & Devices)

Formulation of network equations: Nodal, mesh, modified nodal and hybrid analysis equations. Sparse matrix techniques; Solution of nonlinear networks through Newton-Raphson technique. Multistep methods: convergence and stability; Special classes of multistep methods: Adams-bashforth, Adams-Moulton and Gear's methods; Solution of stiff systems of equations; Adaptation of multistep methods to the solution of electrical networks; General purpose circuit simulators.

Review of semiconductor equations (Poisson, continuity, drift-diffusion, trap rate). Finite difference formulation of these equations in 1D and 2D. Grid generation.

Physical/empirical models of semiconductor parameters (mobility, lifetime, band gap, etc.).

Computation of characteristics of simple devices (p-n junction, MOS capacitor, MOSFET, etc.); Small-signal analysis.

**References:**

1. N. Arora, MOSFET Models for VLSI Circuit Simulation, Springer Verlag.

2. N. Dasgupta and A. Dasgupta, Semiconductor Devices: Modelling and Technology, PHI.
3. D. Nagchoudhary, Microelectronic Devices, Pearson.
4. D. J. Roulston, Bipolar Semiconductor devices, McGraw Hill.
5. Y. Taur and T. H. Ning, Fundamentals of Modern VLSI Devices, OUP.
6. Y. P. Tsividis, Operation and Modeling of the MOS Transistor, McGraw-Hill.
7. J. S. Yuan and J. J. Liou, Semiconductor Device Physics and Simulation, Plenum.
8. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, Introduction to Algorithms, Second Edition, MIT Press.
9. J. D. Foley, A. van Dam, S. K. Feiner and J. F. Hughes, Computer Graphics: Principles and Practice in C, Second Edition, Pearson/AW.
10. A. V. Levitin, Introduction to the Design and Analysis of Algorithms, Second Edition, Pearson/AW.
11. P. Shirley, Fundamentals of Computer Graphics, AK Peters.
12. R. J. Wilson and J. J. Watkins, Graph : An Introductory Approach, Wiley.
13. E. Balagurusamy, Numerical Methods, Tata McGraw-Hill.
14. S. Boyd and L. Vandenberghe, Convex Optimization, OUP.
15. S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, Fifth Edition, McGraw-Hill.
16. W. J. Cook, W. H. Cunningham, W. R. Pulleyblank and A. Schrijver, Combinatorial Optimization, Wiley.

## Course: ECEM-196 (Introduction to Nanophotonics and Nanostructures)

This course will present an overview of fundamental principles and recent progress in representative areas of Nanoscience and nanotechnology. It will deal with materials/structures with size less than 100 nm. More specifically, it will cover the following subjects: When does size matter? How does one engineer the properties of a material through size control? How does one synthesize Nanomaterials and/or fabricate nanostructures? What are the challenges in these newly developed areas? What are the unique applications of Nanomaterials and nanostructures in areas such as electronics, photonics, and biotechnology?

**References:**

1. K. E. Drexler, Nanosystems: Molecular Machinery, Manufacturing, and Computation, Wiley.
2. Lynn E. Foster, Nanotechnology: Science, Innovation, and Opportunity, Prentice Hall.
3. Mark A. Ratner & Daniel Ratner Nanotechnology: A Gentle Introduction to the Next Big Idea, PE.
4. James M Tour, Molecular Electronics Commercial Insights, Chemistry, Devices, Architecture and Programming, World Scientific.
5. Zhang, Macro-, Maso-, Micro-, and Nano-Mechanics of Materials
6. V. Balzani Molecular Devices and Machines: A Journey into Nano world, Wiley
7. Hadis Morkog, Advanced semiconductor and Organic Nano-Techniques, Academic Press
8. K. E. Geckeler & E Rosenberg, Functional Nanomaterials.

## Course: ECEM-197 (Special Topics in Microelectronics)

This course will be based on the latest trends and Developments taking place in the field of MICROELECTONICS DEVICES, CIRCUITS, and SYSTEMS.

**References:**

**Current On-Line Literature**

## Course: ECEM-198 (Organic Materials in VLSI)

Over the past few decades, computer system performance has been driven by improvements in silicon fabrication technology. However, within the foreseeable future, improvements in conventional fabrication will be limited by basic physics, as devices become small enough that the bulk assumptions used in analyzing their performance become incorrect. A number of promising organic candidates for new basic technologies have been demonstrated in the lab, including single-molecule organic switches and nanotube electron conduits. This course will focus on considering how these new basic devices will impact VLSI and computer architecture, and how we may design systems to take advantage of the opportunities they offer. The goal of this course is to provide a broad understanding of the organic materials that are involved in electronic nanotechnology.

**References:**


1. J. James, M. Halls and J. de Mello, Molecular Semiconductors: An Introduction, Wiley.
2. H. Klauk, Organic Electronics: Materials, Manufacturing and Applications, Wiley.
3. K. Mullen and U. Scherf, Organic Light Emitting Devices: Synthesis, Properties and Applications, Wiley,
4. V. Balzani Molecular Devices and Machines: A Journey into Nano world, Wiley
5. R. A. Pethrick, Modern Techniques for Polymer characterization
6. Joel Fried, Polymer Science and Technology, Prentice Hall International


## Course: ECEM-199 (Introduction to Quantum Devices & Computing)

**Fundamental Physical Limits**: Quantum & relativistic limits on information density & processing rates

Relativistic & quantum limits on communication bandwidth flux & latencies, Thermodynamic limits on energy dissipation.

The Future of Semiconductor Technology: Semiconductor scaling trends, Semiconductor engineering limits Energy dissipation limits

Potential Future Device Technologies: Mesoscale bulk electronics: Quantum Dots, Single-Electron Transistors, *etc.*, Superconducting logic, Molecular electronics: Buckytubes, Tour wires, *etc.*, Miscellaneous contenders: Nanomechanical rod logic, biochemical/DNA computing.

New Models of Computing

Classical Reversible Computing: Fundamentals of adiabatic processes, Adiabatic operation of present & future logic devices, Reversible logic circuit families, Analysis of the scaling advantages of reversibility, Reversible architectures, programming languages, algorithms

Quantum Computing: Quantum logic gates, Quantum logic circuits, Physical implementations, Quantum computing algorithms, Quantum information & communication

Cosmological Limits of Computing

**References:**


**On-Line Literature**


## Course: ECEM-200 (Power Semiconductor Devices)

Basic device models: Theory of bipolar and MOS transistors. Small-Signal models of bipolar and MOS transistors, Gummel-Poon model.

High current effects in diodes: Dependence of lifetime on high-level injection, non-uniform current distribution under high current injection.

Power bipolar transistors: Onset of high-current effects in transistors; Theories of Kirk effect, crowding, pinch-in effects, second breakdown, etc; Emitter geometries for high current and HF operation.

SCR: Theories of operation; Relation between shorted emitter and dv/dt ratings; Gate turn-off devices, inverter grade SCRs, special diffusion techniques for SCRs. Power VMOS devices. Heat transfer in power devices; Power MOS devices: VMOS & DMOS device structure and models; device packaging.

**References:**


1. Baliga Power Semiconductor Devices, Springer
2. D. J. Roulston, Bipolar Semiconductor devices, McGraw Hill.
3. Kano, Semiconductor Devices, PE.
4. F. Ran, J. C. Zolper, Wide energy band Electronic devices, World Scientific.
5. Rashid, Power Electronics: Circuits, Devices, Applications, PE.
6. H. Beneking, High Speed Semiconductor Devices, Circuits aspects and fundamental behavior, Springer.
7. R. W. Erickson, D. Maksimovic, Fundamentals of Power Electronics, Springer.
8. B. G. Streetman and S. Banerjee, Solid State Electronic Devices, Sixth Edition, PHI.


## Course: ECEM-204 (Semiconductor Optoelectronic Devices)

Optoelectronic devices, heterostructures, optical absorption and emission, optical detectors, optical modulators, Semiconductor lasers

**References:**


1. B. Razavi, Design of Integrated Circuits for Optical Communications, McGraw-Hill.
2. K. F. Brennan, The Physics of Semiconductors with Applications to Optoelectronic Devices, OUP.
3. Bhattacharya, Semiconductor Optoelectronic Devices, Tata McGraw Hill.
4. Mitsuo Fukuda Optical semiconductor devices, John Wiley.
5. Daniela Dragoman, Mircea Dragoman, Advanced Optoelectronic Devices, Springer.
6. Magnus Willander, Ying Fu, Physical Models of Semiconductor Quantum Devices, Springer.


## Course: ECEM-205 (Research Seminar)

The student shall independently do an exhaustive research work on a particular topic, under the supervision of a faculty member. The student will be examined at the end of the semester for 3 credits, with oral as well as written examination.

## Course code: ECEM-212 (Research Methodologies and Techniques)

Definition and objectives of Research – Types of research, Various Steps in Research process, Mathematical tools for analysis, Developing a research question-Choice of a problem

Literature review, Surveying, synthesizing, critical analysis, reading materials, reviewing, rethinking, critical evaluation, interpretation, Research Purposes, Ethics in research – APA Ethics code. Quantitative Methods for problem solving**:** Statistical Modeling and Analysis, Time Series Analysis Probability Distributions, Fundamentals of Statistical Analysis and Inference, Multivariate methods, Concepts of Correlation and Regression, Fundamentals of Time Series Analysis and Spectral Analysis, Error Analysis, Applications of Spectral Analysis.Tabular and graphical description of data**:** Tables and graphs of frequency data of one variable, Tables and graphs that show the relationship between two variables , Relation between frequency distributions and other graphs, preparing data for analysis Soft Computing**:** Computer and its role in research, Use of statistical soft ware SPSS, GRETL etc in research. Introduction to evolutionary algorithms - Fundamentals of Genetic algorithms, Simulated Annealing, Neural Network based optimization, Optimization of fuzzy systems.

Structure and Components of Research Report, Types of Report, Layout of Research Report, Mechanism of writing a research report, referencing in academic writing

**References:**

1. C.R. Kothari Research Methodology Methods and Techniques
2. Donald H.McBurney, Research Methods

## Course code: ECEM-218 (Simulation and Modeling Techniques)

Handling Stepped and Event-based Time in Simulations Discrete versus Continuous Modeling Numerical Techniques Sources and Propagation of Error Graph or Network Transitions Based Simulations Actor Based Simulations Mesh Based Simulations Hybrid Simulations Partitioning the Data Partitioning the Algorithms Handling Inter-partition Dependencies Introduction to Queues and Random Noise Random Variates Generation Sensitivity Analysis Display Forms: Tables, Graphs, and Multidimensional Visualization Terminals, X and MS Windows, and Web Interfaces Validation of Model Results

**References:**

1. Ledin, Jim, Simulation Engineering: Building Better Embedded Systems Faster
2. Bronson, Richard and Naadimuthu, Govindasami, Schaum's Outline of Theory and Problems of Operations Research
3. Neyland, David, Virtual Combat, A Guide to Distributed Interactive Simulation

## Course: ECEM 202~203 (Project)

The project will involve the following activities, review of related work, specification, design and implementation, evaluation and presentation. It will be assessed on the basis of skill demonstrated in the application of design and evaluation techniques, ingenuity, originality and mastery of the chosen field, volume of work achieved, enthusiasm and diligence in its conduct, quality of outcome as shown by effectiveness as system or quality of the experimental results, completeness, coherence, organization, readability, comprehensibility. The students will be encouraged to publish at least one paper in any international journal of repute, besides presenting their work in conferences/workshops.