Syllabus for Pre-Ph.D. Course Work in Electronic Science, 2023

Course Numbers ESL01.R.C to ESL04.R.C are compulsory to all candidates. Out of the remaining courses, the candidate shall select one course depending on the proposed area of research of the candidate. Any other Paper recommended by Departmental Research Council from MTech (EIS) can also be taken as elective paper.

General Course Framework & Structure

Total Credits- 16 & Core papers (C): 04; Elective Papers (E): 01

Course Code	Title of the Paper	Total Mark	Credit
ESL01.R.C	Research Methodology	100	4
ESL02.R.C	Mathematical Electronics	100	4
ESL03.R.C	Research and Publication Ethics	50	2
ESL04.R.C	Seminar Presentation	50	2
ESL05.R.E	Low Dimensional Semiconductor Materials and Devices	100	4
ESL06.R.E	Image Processing	100	4
ESL07.R.E	Advanced Microprocessor	100	4
ESL08.R.E	Soft Computing	100	4
ESL09.R.E	Broadband & Mobile Communication System	100	4
ESL10.R.E	Wireless Communication	100	4
ESL11.R.E	Microstrip Antenna	100	4
ESL12.R.E	High Frequency Measurement Techniques	100	4
ESL13.R.E	CAD for RF & Microwave Circuits	100	4
ESL14.R.E	Computational Electromagnetics	100	4
ESL15.R.E	Metamaterials	100	4
ESL16.R.E	Microelectronic Device and Circuit	100	4
ESL17.R.E	Convex Analysis and Optimization	100	4
ESL18.R.E	Computational Electromagnetics	100	4
ESL19.R.E	Advance Electromagnetics	100	4
ESL20.R.E	Computational and System Biology	100	4
ESL21.R.E	Advanced numerical methods	100	4
Total Marks/Credit [Core (3nos) +Elective (1no)]		400	16

Details of Syllabus

Course Name:	Research Methodology	**Course No.:** ESL01.R.C	
Credits:	04 (4-0-0)	**Core/Elective:** Core	

Course Details

Units	Contents
Unit 1	Meaning and objectives of Research, Types of Research, Significance of Research, Research Methods Vs methodology, Scientific method Vs Arbitrary Method, Criteria of good research, Research Design: (meaning of research design, need of research design, basic principle of research design, good design, different designs).
Unit 2	Means and methods of scientific research, Organization of scientific research, Literature : Search for existing literature, Review the literature selected, Develop a theoretical and conceptual framework, writing up the review. Scientific paper: How to prepare Title, Abstract, Introduction, Results, Discussion and References.
Unit 3	Chi-square Test: Applications, Steps Involved in Applying Chi-square Test, Alternative Formula, Conversion, important characteristic and limitation. Analysis of Variance and Covariance: Principle, Technical, Setting and coding.
Unit 4	Interpretation of Data and Paper Writing: Layout of a Research Paper, Journals in Electronic Science, Impact factor of Journals, When and where to publish? Ethical issues related to publishing, Plagiarism and Self-Plagiarism. Use of Encyclopedias, Research Guides, Handbook etc., Academic Databases for Electronic Science Discipline. Use of tools / techniques for Research: methods to search required information effectively, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX /MS Office, Software for detection of Plagiarism. Zotero/Mendeley, Software for paper formatting like LaTeX /MS

BOOKS & REFERENCES:

1. Business Research Methods –Donald Cooper & Pamela Schindler, TMGH, 9th edition
2. Business Research Methods –Alan Bryman & Emma Bell, Oxford University Press.3.
3. Research Methodology –C.R.Kothari
4. Select references from the Internet

Course Name:	Mathematical Electronics	**Course No.:** ESL02.R.C
Credits:	04 (4-0-0)	**Core/Elective:** Core

Course Details

Units	Contents
Unit 1	Fourier Series, Fourier Transform, Laplace's Transform, and their properties.
Unit 2	Z-Transform, DTFS, DTFT, DFT, FFT, and their properties

Units	Contents
Unit 3	Linear System, Impulse response, Response of a Linear System, Linear Time Invariant(LTI) System, Linear Time Variant (LTV) System, Transfer function of a LTI System, Filter characteristic of Linear System, Distortion less transmission through a system, Signal bandwidth, System Bandwidth, Ideal LPF, HPF, and BPF characteristics, Causality and Paley-Wiener criterion for physical realization, Relationship between Bandwidth and rise time, Convolution and Correlation of Signals, Concept of convolution in Time domain and Frequency domain.
Unit 4	Design of Experiments - Objectives, strategies, Factorial experimental design, Designing engineering experiments, basic principles- replication, randomization, blocking, guidelines for design of experiment; Analysis of variance- ANOVA- Basic principle, One way and Two-way technique; Analysis of Co-variance- ANOCOVA technique.

BOOKS & REFERENCES:

1. Digital Signal Processing Principles, Algorithms and Applications by J. Prokais and D. G. Manolakis (PHI 3rd edition)
2. Todd K.Moon and Wynn C. Stirling, Mathematical Methods and Algorithms for Signal Processing, Pearson Education.
3. Douglas C. Montgomery, Design and Analysis of Experiments, 5/e, Willey (India), 2007
4. Douglas C. Montgomery, and George C. Runger, Applied statistics and probability for Engineers, 3/e, Willey (India), 2007.

Course Name:	Research and Publication Ethics	**Course No.:** ESL03.R.C
Credits:	02 (2-0-0)	**Core/Elective:** Core

Course Details

Units	Contents
Unit 1 (Theory)	**Philosophy and ethics** Introduction to philosophy: definition, nature and scope, concept, branches Ethics: definition, moral philosophy, nature of moral judgements and reactions
Unit 2 (Theory)	**Scientific conduct** Ethics with respect to science and research, Intellectual honesty and research integrity, Scientific misconducts: falsification, fabrication and plagiarism (FFP) Redundant publications: duplicate and overlapping publications, salami slicing, Selective reporting and misrepresentation of data
Unit 3 (Theory)	**Publication ethics** Publication ethics: definition, introduction and importance, Best practices/standards setting initiatives and guidelines: COPE, WAME etc., Conflicts of interest, Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types, Violation of publication ethics,

Units	Contents
	authorship and contributorship, Identification of publication misconduct, complaints and appeals, Predatory publishers and journals
Unit 4 (Practice)	**Open access publishing** Open access publications and initiatives, SHERPA/RoMEO online resources to check publisher copyright & self-archiving policies, Software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester etc
Unit 5 (Practice)	**Publication misconduct** *A* *Group discussions* Subject specific ethical issues, FFP, authorship, Conflicts of interest, Complaints and appeals: examples and fraud from India and abroad *B* *Software tools* Use of plagiarism software like Turnitin, Urkund and other open source software tools
Unit 6 (Practice)	**Databases and research metrics** *A* *Databases* Indexing databases, Citation databases: Web of Science, Scopus etc. *B* *Research metrics* Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite score, Metrics: h-index, g index, i10 index, altmetrics

BOOKS & REFERENCES:

1. Bird, A. (2006). Philosophy of science. Routledge
2. MacIntyre, A. (1967) A short history of ethics. London.
3. Chaddah, P. (2018) Ethics in competitive research: Do not get scooped; do not get plagiarized.
4. National Academy of Sciences, National Academy of Engineering and Institute of Medicine (2009). On being a scientist: A guide to responsible conduct in research: third edition. National Academic Press.
5. Resnik, D.B. (2011) What is ethics in research and why is it important. National Institute of Environmental health Sciences, 1-10.
6. Beall, J. (2012) Predatory publishers are corrupting open access. Nature, 489 (7415), 179-179.
7. Indian National Science Academy (INSA), Ethics in science education, research and governance (2019).

Course Name:	Seminar Presentation	**Course No.:** ESL04.R.C
Credits:	02 (2-0-0)	**Core/Elective:** Core

Course Details

Units	**Contents**
	The student shall select 05 important research papers published in reputed Journals. At the end of the Semester, the student shall prepare a review report and make presentation based on this review report.

Course Name:	Low Dimensional Semiconductor Materials and Devices	**Course No.:** ESL05.R.E
Credits:	04 (4-0-0)	**Core/Elective:** Core

Course Details

Units	Contents
Unit 1	Semiconductor basic concepts: Electrons and holes, Direct and indirect band gap, Effective mass, Density of states, Fermi energy, Fermi-Dirac Distribution function, concentration of carriers at thermal equilibrium, Variation of energy bands with alloy composition. Graphene and its basic properties. Graphene Nanoribbons.
Unit 2	Heterostructures: General properties of heterostructures, Growth of heterostructures, Band engineering, layered structures: quantum wells and barriers, doped heterostructures, strained layers, Si-Ge, GaAs- InGaAs heterostructures, Wires and Dots, Optical confinement, Effective mass approximation, Effective mass theory of heterostructures.
Unit 3	Quantum wells and low dimensional systems: Square wells, Parabolic wells, Triangular wells, Low dimensional systems, Occupation of subbands, quantum wells in heterostructures. Tunneling transport: Potential step, T-matrices, Current and conductance, Resonant tunneling, Coherent transport with many channels.
Unit 4	Scattering rates: The golden rule: The golden rule for the static potential, Impurity scattering, phonon scattering, Optical absorption, interband absorption, absorption in a quantum well. The 2-Dimensional Electron Gas: Band diagram of modulation doped structures, Electronic structure of a 2 DEG, screening by the electron gas, Scattering by remote impurities, other scattering mechanisms.

BOOKS & REFERENCES:

1. John H. Davies, The Physics of Low Dimensional Semiconductors: An Introduction, Cambridge University Press.
2. Low dimensional semiconductor structures: fundamentals and devices, Ed. K. Barnham, D. D Vvedensky, Cambridge University Press.
3. Physics of low dimensional semiconductor structures, Ed. P.N. Butcher, N. H. March, and M. P. Tosi, Springer Nature.
4. B. R. Nag, Physics of quantum well devices, Springer Nature.
5. S. Shafraniuk, Graphene: Fundamentals, Devices and Applications, Jenny Stanford Publishing

Course Name:	Image Processing	**Course No.:** ESL06.R.E	
Credits:	04 (4-0-0)	**Core/Elective:** Core	

Course Details

Units	Contents
Unit 1	Digital image fundamentals:Introduction: Digital Image- Steps of Digital Image Processing Systems-Elements of Visual Perception - Connectivity and Relations between Pixels. Simple Operations- Arithmetic, Logical, Geometric Operations. Mathematical Preliminaries - 2D Linear Space Invariant Systems - 2D Convolution - Correlation 2D Random Sequence - 2D Spectrum.
Unit 2	Image transforms and enhancement:Image transforms and enhancement Image Transforms: 2D Orthogonal and Unitary Transforms-Properties and Examples. 2D DFT- FFT – DCT - Hadamard Transform - Haar Transform - Slant Transform - KL Transform -Properties and Examples. Image Enhancement: - Histogram Equalization Technique- Point Processing-Spatial Filtering-In Space and Frequency - Nonlinear Filtering-Use of Different Masks.
Unit 3	Image restoration and construction:Image Restoration: Image Observation and Degradation Model, Circulant And Block Circulant Matrices and Its Application in Degradation Model - Algebraic Approach to Restoration- Inverse by Wiener Filtering – Generalized Inverse-SVD And Interactive Methods - Blind Deconvolution-Image Reconstruction from Projections.
Unit 4	Image compression & segmentation:Image Compression: Redundancy and Compression Models -Loss Less and Lossy. Loss Less- Variable-Length, Huffman, Arithmetic Coding - Bit-Plane Coding, Loss Less Predictive Coding, Lossy Transform (DCT) Based Coding, JPEG Standard - Sub Band Coding. Image Segmentation: Edge Detection - Line Detection - Curve Detection - Edge Linking and Boundary Extraction, Boundary Representation, Region Representation and Segmentation, Morphology-Dilation, Erosion, Opening and Closing. Hit and Miss Algorithms Feature Analysis

BOOKS & REFERENCES:

1. Digital Image Processing, Gonzalez.R.C & Woods. R.E., 3/e, Pearson Education, 2008.
2. Digital Image Processing, Kenneth R Castleman, Pearson Education,1995
3. Digital Image Procesing, S. Jayaraman, S. Esakkirajan, T. Veerakumar, McGraw Hill Education ,2009. Pvt Ltd, New Delhi
4. Fundamentals of Digital image Processing, Anil Jain.K, Prentice Hall of India, 1989.
5. Image Processing, Sid Ahmed, McGraw Hill, New York, 1995.

Course Name:	Advanced Microprocessor	**Course No.:** ESL07.R.E	
Credits:	04 (4-0-0)	**Core/Elective:** Elective	

Course Details

Units	**Contents**
Unit 1	Intel 20286 Microprocessor – Salient features of 80286, Architecture, Pin descriptions, Addressing mode, Protected virtual address mode, Special operations. 80286 bus interface – interfacing with memory& I/O devices, Interrupt sequencing, Instruction Set features, 80287 Math co-processor.
Unit 2	Intel 20386 Microprocessor –Architecture, Pin descriptions, Register Organization, Addressing modes, Data Types, Real Address Mode of 80386, Protected Mode of 80386, Segmentation Paging. Virtual 8086 mode, The co-processor 80387, The CPU with a Numeric Coprocessor - 80486.
Unit 3	Pentium Processor – Salient features of 80586 (Pentium), Architecture, Instruction Set, Pentium – II.

BOOKS & REFERENCES:

1. Intel Microprocessor 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium and Pentium Pro Processor – Architecture, Programming and Interfacing. Bary B. Brey.
2. Advanced Microprocessor & Peripherals. A. K. Roy & K. M. Bhurchandi

Course Name:	Soft Computing	**Course No.:** ESL08.R.E
Credits:	04 (4-0-0)	**Core/Elective:** Elective

Course Details

Units	**Contents**
Unit 1	**Evolutionary Computing** Basic Concepts of Genetic Algorithms (GA), Working Principle, Encoding methods, Fitness function, GA Operators- Reproduction; Crossover; Mutation, Convergence of GA, Multi-level Optimization, Real Life Problems. **Hybrid Systems** Sequential Hybrid Systems, Auxiliary Hybrid Systems, Embedded Hybrid Systems, Neuro- Fuzzy Hybrid Systems, Neuro-Genetic Hybrid Systems, Fuzzy-Genetic Hybrid Systems. **Evolutionary Design of Neural Networks:** Genetic Algorithm (GA) based Back propagation Networks, GA based weight determination, Fitness function, Reproduction, Convergence, and Recent Applications.
Unit 2	**Fuzzy Systems:** Fuzzy Set theory, Fuzzy Relation, Fuzzification, Minmax Composition, Defuzzification, Fuzzy Logic, Fuzzy Rule based systems, Fuzzy Decision Making, Fuzzy Control Systems, Fuzzy Classification **Neural Networks:** Basic Concept of Neural Network, Overview of Learning rules and activation functions, Single layer Perceptrons and Learning, Back Propagation networks- Architecture of Backpropagation (BP) Networks; Backpropagation Learning; Variation of Standard Backpropagation Neural Network, Introduction to Associative Memory, Adaptive Resonance Theory and Self Organizing Map, Recent Applications

Units	Contents
Unit 3	**Hybrid Systems:** Sequential Hybrid Systems, Auxiliary Hybrid Systems, Embedded Hybrid Systems, Neuro- Fuzzy Hybrid Systems, Neuro-Genetic Hybrid Systems, Fuzzy-Genetic Hybrid Systems. **Evolutionary Design of Neural Networks:** Genetic Algorithm (GA) based Back propagation Networks, GA based weight determination, Fitness function, Reproduction, Convergence, and Recent Applications. **Fuzzy Evolutionary Algorithms:** Introduction, Fuzzy control of Evolution, Evolutionary Algorithms with Fuzzy components, GA in Fuzzy Logic Controller, Recent Applications
Unit 4	**Neural Network Based Fuzzy Systems:** Neural Realization of Basic Fuzzy Logic Operators, Neural Network Based Fuzzy Logic Inference, Neural Network Driven Fuzzy Reasoning, Rule based Neural Fuzzy Modeling, Neural Fuzzy Relational Systems, Neuro- Fuzzy Controllers, Recent Applications. Fuzzy Logic Based Neural Network Models: Fuzzy Neurons, Fuzzy Perceptrons, Fuzzy Neural Networks, Fuzzy Backpropagation (BP) Networks, Fuzzy BP architecture, Learning in Fuzzy BP, Inference by Fuzzy BP, Fuzzy ARTMAP, Fuzzy Associative Memories, Recent Applications

BOOKS & REFERENCES:

1. Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis & Applications, S. Rajasekaran, G. A. Vijayalakshami, PHI.
2. Neuro-Fuzzy Systems, Chin Teng Lin, C. S. George Lee, PHI
3. Fuzzy Logic and Engineering Application, Tomthy Ross, TMH
4. Elements of Artificial Neural Network, KishanMehrotra
5. Genetic Algorithms: Search and Optimization, E. Goldberg
6. Select references from the Internet

Course Name:	Broadband and Mobile Communication System	**Course No.:** ESL09.R.E
Credits:	04 (4-0-0)	**Core/Elective:** Elective

Course Details

Units	Contents
	Introduction to broadband mobile communication systems, Mobile radio propagation modeling, Overview of 3G cellular comms, Modulation for broadband comms. & 3G cellular, Digital equalization, OFDM (Multi-tone comms) & 4G cellular, OFDM-CDMA comms, (Space-time) MIMO systems, OFDM-CDMA-MIMO comms & 4G cellular, Smart antennas, Smart antennas & 3G, 4G cellular.

BOOKS & REFERENCES:

1. T. Rappaport "Wireless Communications. Principles and Practice", 2nd ed., 2002, Prentice Hall
2. S. Haykin, M. Moher, "Modern Wireless Communications", 1st ed., 2005, Pearson Educ.
3. C.Liberti, T.S.Rappaport "Smart Antennas for wireless communications", 1st ed., 1999, Prentice Hall.
4. C. Smith, D. Collins, "3G Wireless Networks", 1st ed., 2002, McGraw-Hill.
5. S. Haykin "Communication Systems", 4th ed, 2001, Wiley
6. G. L. Stuber "Principles of Mobile Communication", 2nd ed., 2001, Kluwer.
7. . Any other prescribed by the module coordinator.

Course Name:	Wireless Communication	**Course No.:** ESL10.R.E	
Credits:	04 (4-0-0)	**Core/Elective:** Elective	

Course Details

Units	**Contents**
Unit 1	Antennas & Propagation – Antenna, Propagation Modes, LOS Transmission, Fading in mobile environment
Unit 2	Signal Coding Technique – Coding criteria, Digital Data Analog Signals (DDAS), ADDS.
Unit 3	Spread Spectrum – Concept, Frequency Hoping, Direct Sequence, CDMA, Generation of Spreading Sequence; Coding & Error Control – Error Detection, Block Error Correction Codes, Convolution Codes, ARR; Cellular Wireless Network – 1G, 2G and 3G; Cordless Systems & WLL; Mobile IP & WAP.

BOOKS & REFERENCES:

1. Wireless Communications & Networks – W. Stallings
2. Any other prescribed by Module Coordinator

Course Name:	Microstrip Antenna	**Course No.:** ESL11.R.E
Credits:	04 (4-0-0)	**Core/Elective:** Elective

Course Details

Units	**Contents**
	Microstrip and other printed antennas, Various types of feeding methods for microstrip antenna (Co-axial, Inset, Aperture/Slot Coupled, Proximity coupled and Corporate feeding for Arrays); Analysis of rectangular Patch Antenna: Transmission Line Technique, Cavity/ Modal Expansion Technique, equivalent circuit models, numerical techniques for Rectangular Patch Antenna: Spectral Domain Technique, FDTD Model; Techniques for broadband & multiband planner antennas; Planner antennas for circular polarization.

BOOKS & REFERENCES:

1. Microstrip Antenna Design Handbook – Garg, Bhartia, Bahl & Ittipiboon (Artech House)
2. Hand Book on Microstrip Antenna, J.R James & P.S Hall, (Peter Peregrinus)
3. Research Methodology –C.R.Kothari
4. Any other prescribed by Module Coordinator

Course Name:	High Frequency Measurement Technique	**Course No.:** ESL12.R.E
Credits:	04 (4-0-0)	**Core/Elective:** Elective

Course Details

Units	**Contents**
Unit 1	Review of measurement and instrumentation basics.
Unit 2	Principles and applications of various sensors used in characterization of RF materials, devices, circuits and system: acoustic, ultrasonic, magnetic, electrical, thermal, optical, radiation and smart sensors,

Units	Contents
Unit 3	Mechanical and thermal engineering issues for RF modules/ instruments.
Unit 4	Instrumentation concepts and measurement techniques in: Oscilloscopes, Spectrum analyzers, Network analyzer, Lock-in-amplifiers, Waveform generators, Bit- error rate measurement, S/N measurement Talemetry, Data recording and display, Recent advances in RF and Microwave measurement Techniques.

BOOKS & REFERENCES:

1. T&M Instrument Catalogs and application notes, Agilent
2. T&M Instrument Catalogs and application notes, Techtronix
3. T&M Instrument Catalogs and application notes, Keithley
4. T&M Instrument Catalogs and application notes, L.G.Electronics
5. Any other prescribed Module Coordinator

Course Name:	CAD for RF & Microwave Circuits	**Course No.:** ESL13.R.E	
Credits:	04 (4-0-0)	**Core/Elective:** Elective	

Course Details

Units	Contents
Unit 1	Transmission Line - Concepts of characteristic impedance, reflection coefficient, standing and propagating waves.
Unit 2	Network analysis: S, Z, and other multi-port parameters, impedance matching and tuning.
Unit 3	Planar transmission lines: Quasi-static analysis, Discontinuities, equivalent circuits.
Unit 4	Simple printed couplers, filters, power dividers.

BOOKS & REFERENCES:

1. Microwave Engineering – D. M. Pozar, Wiley Publication

2. Microwave Engineering – R. E. Collin, McGraw Hill Publication
4. 4.Select references from the Internet

Course Name:	Computational Electromagnetics	**Course No.:** ESL14.R.E
Credits:	04 (4-0-0)	**Core/Elective:** Elective

Course Details

Units	Contents
	Finite Difference Time Domain Method, Variational Method, Moment Methods Finite Element Method Transmission line Matrix Method, Method of Lines.

BOOKS & REFERENCES:

1. Numerical Techniques in Electromagnetics, Matthew N. O. Sadiku, CRC Press
2. Any other as prescribed by Module Coordinator.

Course Name:	Metamaterials	**Course No.:** ESL15.R.E	
Credits:	04 (4-0-0)	**Core/Elective:** Elective	

Course Details

Units	Contents
Unit 1	Electromagnetic waves in homogeneous material- permittivity of metals and dielectrics, magnetic permeability, Waves scattering on interfaces and thin slabs.
Unit 2	Introduction to Double Negative Media- Maxwell's equation and boundary conditions in DNG media, Scattering from DNG slab, Reversal of Snell's law, Doppler's effect and Goos-Hanchen's Effect.
Unit 3	Metamaterial Applications: Backward wave, Negative refraction, Invisibility Cloaks and Super lens.

BOOKS & REFERENCES:

1. Metamaterial, physics and engineering exploration, Nader Engheta and Richard W. Ziolkowski, John Wiley & Sons.

2. Electromagnetic Metamaterials: Transmission Line Theory and Microwave, Christophe Caloz, Tatsuo Itoh, John Wiley & Sons.

Course Name:	Microelectronic Device and Circuit	**Course No.:** ESL16.R.E
Credits:	04 (4-0-0)	**Core/Elective:** Elective

Course Details

Unit 1	Microelectronics; Moore's Law; Semiconductor basics: Intrinsic silicon, electrons, holes, charge neutrality; Doping: Donors, acceptors, compensation; Charge transport: Drift, drift current density, Ohm's law, velocity saturation; IC resistor: Lateral drift current, Non-linear resistor; Capacitance (interconnect); Approximate passive models: Extraction; Diffusion currents.
Unit 2	1-D Gauss's law and boundary conditions; Metal-metal capacitor layout; Charge, fields, and capacitance; pn Junctions: Thermal equilibrium; Depletion approximation; Potential vs. doping: The built-in potential; Charge, field, potential for pn junction; pn Junctions: Reverse bias, Forward bias, and Capacitance, Charge, field, potential in reverse bias: $q_J = f(v_D)$; pn Junction capacitance: $C_j = dq_J / dv_D$; pn Diode in forward bias: A first pass and the i-v relationship.
Unit 3	MOS Capacitors: Surface charge in thermal equilibrium; Depletion, accumulation, and inversion; $q_G = f(v_{GS})$ and $C_g = dq_G / dv_{GS}$; MOSFETs: Large-signal Model, Symbols and drain characteristics; Triode and saturation regions;

	Backgate effect, MOSFET Sample & Hold Circuit Graphical analysis; Analytical solution; SPICE, Common Source Amplifier (Resistive Load); Large-signal transfer curve; Small-signal operation: Motivate small-signal model.
Unit 4	MOSFET Small-Signal Model, Transconductance, including backgate output resistance, capacitances, Small-Signal Analysis; Body effect; PMOS model, MOSFET Current Sources (and Sinks), Diode-connected MOSFET as voltage source; Current mirror concept; Audio Digital-to-Analog Converter Example, Two-Port Models, Four amplifier types: Voltage, current, trans-G, trans-R tests to find amplifier parameters, Common-Drain Amplifier, Voltage gain, input and output resistances, Common-Gate Amplifier, Current gain, input and output resistances, Frequency Response, MOSFET ac Models, Transfer functions; Poles and zeroes; Bode plot techniques, Frequency Response, Phasor analysis for sinusoidal steady-state signals; Bode plots, Frequency Analysis, Second-Order Circuits, Amplifier Response, Unity gain frequency, gain-bandwidth product, Frequency-Domain Analysis Insight & Approximations, Feedforward zero Miller approximation; Method of time constants, Common Gate, Common Drain Frequency Response, Multi-Stage Amplifiers: The cascode, Two-port models; Current and voltage bias design; ac Analysis; Bootstrapping of gate-source capacitance;
Unit 5	Forward-Biased pn Junction, Bipolar Junction Transistor, Modes of operation of a BJT; Principle of operation, Transistor action; Ebers-Moll model; Large-signal model, Small-signal model; CE, CB, CC amplifiers; BJT versus MOSFET; Emitter degeneration, Frequency Dependence of Input and Output Impedances, Frequency response of CC amplifier; figures of merit (g_m/I_C, f_T).

Course Name:	Convex analysis and optimization	**Course No.:** ESL17.R.E
Credits:	04 (4-0-0)	**Core/Elective:** Elective

Course Details

Unit – 1	The role of convexity in optimization, Duality theory, Algorithms and duality; Convex sets and functions, Epigraphs, Closed convex functions, Recognizing convex functions; Differentiable convex functions, Convex and affine hulls, Caratheodory's theorem; Relative interior and closure, Algebra of relative interiors and closures, Continuity of convex functions, Closures of functions; Recession cones and lineality space, Directions of recession of convex functions, Local and global minima, Existence of optimal solutions; Nonemptiness of closed set intersections, Existence of optimal solutions, Preservation of closure under linear transformation, Hyperplanes
Unit – 2	Review of hyperplane separation, Nonvertical hyperplanes, Convex conjugate functions, Conjugacy theorem, Examples; Review of conjugate convex functions, Min common / max crossing duality, Weak duality, Special cases; Minimax problems and zero-sum games, Min common / max crossing duality for minimax and zero-sum games, Min common / max crossing duality theorems, Strong duality conditions, Existence of dual optimal solutions; Min common / max crossing Theorem III, Nonlinear Farkas' lemma / linear constraints, Linear programming duality, Convex programming duality, Optimality conditions; Review of convex programming duality / counterexamples, Fenchel duality, Conic duality; Subgradients, Fenchel inequality, Sensitivity in constrained optimization, Subdifferential calculus, Optimality conditions

Unit– 3	Problem structure, Conic programming; Conic programming, Semidefinite programming, Exact penalty functions, Descent methods for convex optimization, Steepest descent method; Subgradient methods, Calculation of subgradients, Convergence; Approximate subgradient methods, Approximation methods, Cutting plane methods; Review of cutting plane method, Simplicial decomposition, Duality between cutting plane and simplicial decomposition; Generalized polyhedral approximation methods, Combined cutting plane and simplicial decomposition methods
Unit – 4	Proximal minimization algorithm, Extensions; Proximal methods, Review of proximal minimization, Proximal cutting plane algorithm, Bundle methods, Augmented Lagrangian methods, Dual proximal minimization algorithm; Generalized forms of the proximal point algorithm, Interior point methods, Constrained optimization case: barrier method, Conic programming cases; Incremental methods, Review of large sum problems, Review of incremental gradient and subgradient methods, Combined incremental subgradient and proximal methods, Convergence analysis, Cyclic and randomized component selection; Review of subgradient methods, Application to differentiable problems: gradient projection, Iteration complexity issues, Complexity of gradient projection, Projection method with extrapolation, Optimal algorithms; Gradient proximal minimization method, Nonquadratic proximal algorithms, Entropy minimization algorithm, Exponential augmented Lagrangian method, Entropic descent algorithm; Convex analysis and duality, Convex optimization algorithms

https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-253-convex-analysis-and-optimization-spring-2012/lecture-notes/

Bertsekas, Dimitri. *Convex Optimization Theory*. Athena Scientific, 2009. ISBN: 9781886529311.
Chapter 6: Convex Optimization Algorithms
Summary of concepts and results (Courtesy of Athena Scientific. Used with permission.) chap 1-6

Additional References

1.1 Bertsekas, Dimitri, Angelia Nedic, and Asuman Ozdaglar. *Convex Analysis and Optimization*. Athena Scientific, 2003. ISBN: 9781886529458.
2 Rockafellar, Ralph. *Convex Analysis*. Princeton University Press, 1996. ISBN: 9780691015866.
3 Boyd, Stephen, and Lieven Vandenberghe. *Convex Optimization*. Cambridge University Press, 2004. ISBN: 9780521833783.

Course Name:	Computational Electromagnetics	**Course No.:** ESL18.R.E	
Credits:	04 (4-0-0)	**Core/Elective:** Elective	

Course Details

Unit – 1	Introduction to CEM; General concepts in CEM; Classification of methods; Maxwell's equations; Physical Boundary conditions; Preparing Maxwell's equations for CEM; Scaling properties of Maxwell's equations; Maxwell's Equations Predict Waves; Derivation of the Wave Equation; Solution to the Wave Equation; Fundamental Vs. Intuitive Parameters; Velocity , Frequency and Wavelength; Refractive Index; Wave Number and Wave Vector; Impedance; Dispersion relation; Index ellipsoids; Material properties explained by index ellipsoids; Definition of Electromagnetic Wave Polarization; Orthogonality & Handedness; Polarization Classification: Linear, Circular & Elliptical; Poincaré Sphere; Polarization Explicit Form; Dissection of a Plane Wave; Review of Linear Algebra; Complex Wave Vector; TE & TM Polarization; Index Ellipsoids: Electromagnetic Behaviour at an Interface, Phase matching at an interface, The Fresnel equations, Visualization; Image Theory

Unit – 2	One-Dimensional Structures in Electromagnetics; Formulation of 4×4 Matrix Equation; Transfer Matrices; Formulation of 2×2 Matrix Wave Equation; Scattering Matrices for Semi-Analytical Methods; Advanced Networking Concepts; Transfer Matrix Method Using Scattering Matrices; Parameter Sweeps; Solid State Electromagnetics; Calculation Examples of Periodic Structures; Concept of Diffraction From Gratings; The Grating Equation; The Plane Wave Spectrum; Perfectly Matched Layer
Unit – 3	Finite Difference Method; Maxwell's Equations on A Yee Grid; Maxwell's Equations in Matrix Form; Finite Difference Analysis of Waveguides; Finite Difference Frequency Domain (FDFD) Formulation; Finite Difference Frequency Domain (FDFD) Implementation; Finite-Difference Time-Domain (FDTD); Beam Propagation Method; Maxwell's Equations In Fourier Space; Matrix Form of Maxwell's Equations in Fourier Space; Formulation of PWEM; Implementation of PWEM
Unit – 4	Rigorous Coupled Wave Analysis Formulation; Rigorous Coupled Wave Analysis Implementation; Method of Lines; Slice Absorption Method; Introduction to Variational Methods; Finite Element Method; Method of Moments for Thin Wires; Method of Moments with RWG; Edge Elements; Spectral Domain Method; Optimization; Surface Propagation Methods;

Course Name:	Advance Electromagnetics	**Course No.:** ESL19.R.E	
Credits:	04 (4-0-0)	**Core/Elective:** Elective	

Course Details

Unit – 1	Preliminary topics in EM; Lorentz and Drude models; Nonlinear and anisotropic materials; Transmission lines in anisotropic media; Coupled-mode theory; Coupled-mode devices
Unit – 2	Theory of periodic structures; Calculation examples of periodic structures; Diffraction gratings; Subwavelength gratings; Guided mode resonance; Introduction to engineered materials
Unit – 3	Metamaterials; Photonic crystals; Homogenization and parameter retrieval; Spatial transforms; Holographic lithography; Spatially variant lattices
Unit – 4	Interfacing MATLAB with CAD; Frequency selective surfaces; Surface waves; Slow waves; Introduction to metasurfaces

Web Resources

https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-635-advanced-electromagnetism-spring-2003/lecture-notes/

Textbook:

Tsang, L., J. A. Kong, K. H. Ding, and C. O. Ao. *Scattering of Electromagnetic Waves*. New York, NY: John Wiley & Sons, 2001. ISBN: 0471388009

Course Name:	Computational and system biology	**Course No.:** ESL20.R.E
Credits:	04 (4-0-0)	**Core/Elective:** Elective

Course Details

Unit – 1	**Genomic Analysis** DNA Sequencing Technologies; Local Alignment (BLAST) and Statistics; Global

	Alignment of Protein Sequences (NW, SW, PAM, BLOSUM); Comparative Genomic Analysis of Gene Regulation; Library Complexity and Short Read Alignment (Mapping); Genome Assembly; ChIP-seq Analysis; DNA-protein Interactions; RNA-sequence Analysis: Expression, Isoforms
Unit – 2	**Modeling Biological Function** Modeling and Discovery of Sequence Motifs (Gibbs Sampler, Alternatives); Markov and Hidden Markov Models of Genomic and Protein Features; RNA Secondary Structure–Biological Functions and Prediction
Unit – 3	**Proteomics** Introduction to Protein Structure; Structure Comparison and Classification; Predicting Protein Structure; Predicting Protein Interactions
Unit – 4	**Regulatory Networks and Computational Genetics** Gene Regulatory Networks; Protein Interaction Networks; Logic Modeling of Cell Signaling Networks; Analysis of Chromatin Structure**;** Discovering Quantitative Trait Loci (QTLs); Human Genetics, SNPs, and Genome Wide Associate Studies; Synthetic Biology: From Parts to Modules to Therapeutic Systems; Causality, Natural Computing, and Engineering Genomes.

Web Resources
https://ocw.mit.edu/courses/biology/7-91j-foundations-of-computational-and-systems-biology-spring-2014/lecture-slides/

Textbook:
Zvelebil, Marketa J., and Jeremy O. Baum. *Understanding Bioinformatics*. Garland Science, 2007. ISBN: 9780815340249

Course Name:	Advanced numerical methods	**Course No.:** ESL21.R.E
Credits:	04 (4-0-0)	**Core/Elective:** Elective

Course Details

Unit – 1:	Newton's Method for Root-Finding; Square Roots via Newton's Method; Square Roots; Floating-Point Arithmetic;Myths about Floating-Point Arithmetic;Floating-Point Summation and Backwards Stability; Accuracy of Naive Summation; Backwards Stability of Recursive Summation; Norms on Vector Spaces and Equivalence of Norms; Condition Numbers; Numerical Methods for Ordinary Differential Equations;The SVD, its Applications, and Condition Numbers; Linear Regression and the Generalized SVD
Unit – 2:	Solving the Normal Equations by QR and Gram-Schmidt; Modified Gram-Schmidt and Householder QR;Householder Reflectors and Givens Rotations; Classical vs. Modified Gram-Schmidt; Matrix Operations, Caches, and Blocking; Ideal-Cache Terminology; Cache-Oblivious Algorithms and Spatial Locality; LU Factorization and Partial Pivoting; Cholesky Factorization and other Specialized Solvers. Eigenproblems and Schur Factorizations; Eigensolver Algorithms: Companion Matrices, Ill-Conditioning, and Hessenberg Factorization;
Unit – 3:	The Power Method and the QR Algorithm; Shifted QR and Rayleigh Quotients; Krylov Methods and the Arnoldi Algorithm; Arnoldi and Lanczos with restarting; The GMRES Algorithm and Convergence of GMRES and Arnoldi; Preconditioning Techniques. The Conjugate-Gradient Method; Convergence of Conjugate Gradient; Biconjugate Gradient Algorithms; Sparse-Direct Solvers; Sparse Matrix Algorithms

Unit – 4:	Overview of Optimization Algorithms; A Brief Overview of Optimization Problems; Adjoint Methods; Adjoint Methods for Eigenproblems and Recurrence Relations; Trust-Regions Methods and the CCSA Algorithm; Lagrange Dual Problems; Quasi-Newton Methods and the BFGS Algorithm; Derivation of the BFGS Update; Derivative-Free Optimization by Linear and Quadratic Approximations
Unit – 5:	Numerical Integration, the Convergence and the Redemption of the Trapezoidal Rule (Fourier Cosine Series Examples); Gaussian Quadrature; Adaptive and Multidimensional Quadrature; The Discrete Fourier Transform (DFT) and FFT Algorithms; FFT Algorithms and FFTW Clenshaw-Curtis Quadrature; Chebyshev Approximation; Integration with Weight Functions, and

Web Resources

https://ocw.mit.edu/courses/mathematics/18-335j-introduction-to-numerical-methods-spring-2019/resource-index/