OVERALL CREDIT STRUCTURE AND COURSE SYLLABI

FOR

POSTGRADUATE PROGRAM

M. Tech (Civil Engineering) specialization in Structural Engineering
OVERALL CREDIT STRUCTURE

S. No	Category	Symbol	M. Tech (Credits)
1	**PG Core**	**PC**	**30**
1.1	Departmental Core	DC	13
1.2	Project Phase-I	P1	05
1.3	Project Phase-II	P2	10
1.4	Seminar	SM	02
2	**PG Elective**	**PE**	**25**
2.1	Specialization Electives	SE	19
2.2	Open Courses	OC	06
	TOTAL REQUIREMENT		**55 (Minimum)**

Postgraduate Core (PC)		**L-T-P**	**Credit**
CED501	Project Phase –I	-	05
CED502	Project Phase-II	-	10
CED503	Seminar	-	02
CEL506	Finite Element Method	3-0-0	03
CEL507	Numerical Methods in Civil Engineering	3-0-0	03
CEL508	Optimization Technique in Civil Engineering	3-0-0	03
CEL509	Advanced Civil Engineering Materials	3-0-0	03
CEP501	Advanced Civil Engineering Materials Lab	0-0-2	01
Specialization Elective (SE)		**L-T-P**	**Credit**
CEL501	Continuum Mechanics-I	3-0-0	03
CEL502	Earthquake Resistance Design of Structure	3-0-0	03
CEL503	Theory of Plate and Shells	3-0-0	03
CEL504	Theory of Plasticity	3-0-0	03
CEL505	Stability of Structures	3-0-0	03
CEL510	Modeling, Analysis and Simulation	3-0-0	03
CEL511	Theory of Elasticity	3-0-0	03
CEL512	Advanced Mathematics for Civil Engineers	3-0-0	03
CEL513	Concepts of Green Building Design	3-0-0	03
CEL514	Reliability Analysis and Reliability Based Design of Structures	3-0-0	03
CEL515	Continuum Mechanics-II	3-0-0	03
CEL516	Forensic Engineering and Rehabilitation of Structures	3-0-0	03
CEP502	Forensic Engineering and Rehabilitation of Structures Lab	0-0-2	01

M. Tech (Civil Engineering) specialization in Transportation Engineering
OVERALL CREDIT STRUCTURE

S. No	Category	Symbol	M. Tech (Credits)
1	**PG Core**	**PC**	**30**
1.1	Departmental Core	DC	13
1.2	Project Phase-I	P1	05
1.3	Project Phase-II	P2	10
1.4	Seminar	SM	02
2	**PG Elective**	**PE**	**25**
2.1	Specialization Electives	SE	19
2.2	Open Courses	OC	06
	TOTAL REQUIREMENT		**55 (Minimum)**

Postgraduate Core (PC)		**L-T-P**	**Credit**
CED501	Project Phase –I	-	5
CED502	Project Phase-II	-	10
CED503	Seminar	-	2
CEL506	Finite Element Method	3-0-0	3
CEL507	Numerical Methods in Civil Engineering	3-0-0	3
CEL508	Optimization Technique in Civil Engineering	3-0-0	3
CEL509	Advanced Civil Engineering Materials	3-0-0	3
CEP501	Advanced Civil Engineering Materials Lab	0-0-2	1
Specialization Elective (SE)		**L-T-P**	**Credit**
CEL510	Modeling, Analysis and Simulation	3-0-0	3
CEL512	Advanced Mathematics for Civil Engineers	3-0-0	3
CEL517	Transportation Planning	3-0-0	3
CEL518	Airport Planning and Design	3-0-0	3
CEL519	Geometric Design of Transportation Facilities	3-0-0	3
CEL520	Planning, Design and Construction of Rural Roads	3-0-0	3
CEL521	Pavement Materials and Evaluation	3-0-0	3
CEL522	Pavement Analysis and Design	3-0-0	3
CEL523	Traffic Flow Theory	3-0-0	3
CEL524	Transport Economics	3-0-0	3
CEL525	Traffic Engineering Design and Management	3-0-0	3
CEL526	Traffic Safety	3-0-0	3
CEL527	Ground Improvement Techniques	3-0-0	3
CEL528	Advanced Soil Mechanics	3-0-0	3
CEL529	Hill Roads Construction	3-0-0	3
CEP503	Pavement Materials and Evaluation Lab	0-0-2	1

Course Syllabi (Post Graduate)
Department of Civil Engineering

Course Code: CEL501
Course Title: CONTINUUM MECHANICS-I
Structure (L-T-P): 3-0-0
Prerequisite: CEL257
Contents:
Mathematical Preliminaries, Vector spaces, Index notations, Change of frames, Transformation, Tensor algebra, Tensor calculus. Kinematics, Motion of a body: Description of motion, Lagrangian and Eulerian descriptions, Material Derivative, Co-ordinate system and Bases, Change of description. Deformation and measure of strain: Change in length, strain and rotation, Spin, circulation and vorticity, Deformation of volume and area, Invariants of strain tensor, physical meaning of strains, Discussion on frames of reference. Definitions and measures of stresses: Cauchy stress tensor, Contravariant, covariant stress tensors, Piola-Kirchhoff stress tensor. Rate of Deformation, Area, volume, strain rate tensor, spin tensor, convected time derivative of stress and strain tensor. Conservation and balance laws: Conservation of mass, Transport theorem, balance of linear and angular momenta, Laws of thermodynamics, Clausius-Duehm inequality
Text Book:
1. Surana, K. S. (2016). Advanced mechanics of continua. CRC Press.

Reference Books:
1. Fung, Y.C. First course in continuum mechanics. Englewood Cliffs: Prentice-Hall, 1977.
2. Lai, W. Michael, Rubin, David and Krempl, Erhard. Introduction to continuum mechanics. Pergamon Press, Oxford, 1993.
3. Gurtin, Morton E. Introduction to continuum mechanics. Academic Press, Boston, 1981.
4. Spencer, A. J. M. Continuum mechanics. Courier Dover Publications, 2004.

Course Code: CEL502
Course Title: EARTHQUAKE RESISTANCE DESIGN OF STRUCTURES
Structure (L-T-P): 3-0-0
Prerequisite: CEL453
Contents:
Seismic performance of structures and structural components during earthquakes; Ground motion parameters; Response spectrum, design Spectrum. Concept of strength, over-strength and ductility; ductile detailing of reinforced concrete structures., Concept of equal displacement and equal energy principles, capacity design; Codal provisions; seismic design consideration; Equivalent static analysis, response spectrum analysis, mode superposition method; Time history analysis; Modelling concept of reinforced concrete building. Seismic resistant properties of reinforced concrete; Seismic behaviour and design of linear reinforced concrete elements; Seismic behavior of planar reinforced concrete elements, ordinary, intermediate and special moment resisting frame; concentrically and eccentrically braced frames. Introduction to earthquake resistant design of masonry structure.
Text Book:
1. Agrawal, P. and Shrikhande, Manish; Earthquake resistance design of structures.
2. IS 1893, Criteria for Earthquake Resistant Design of Structures (General provisions and buildings), 2016.
3. IS 13920, Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces, 2016.

Reference Books:
1. Pauley, T. and Priestley, M.J.N. Seismic Design of Reinforced Concrete and Masonry Buildings.John-Wiley & Sons.
2. Penelis, George G., and Kappos, Andreas J. Earthquake Resistant Concrete Structure. E & F. N., Spon.
3. Drysdale, R.G., Hamid, A. H. and Baker, L.R. Masonry Structure: Behaviour and Design. Prentice Hall, Englewood Cliffs.
4. Booth, Edmund. Concrete Structure in earthquake regions –Design & Analysis.Longman Scientific & Technical.

Course Code: CEL 503
Course Title: THEORY OF PLATES AND SHELLS STRUCTURE
Structure (L-T-P): 3-0-0
Prerequisite: CEL511
Contents:
Thin and thick plate theories. Bending of long rectangular plate to a cylindrical surface. Prismatic folded plate systems. Pure and symmetric bending of plates. Small and large deflections of plates. Special and approximate methods in theory of plates. General theory of cylindrical shells. Shell equations. Approximate solutions of plates and shells equations. Analysis and design of cylindrical shells. Approximate design methods for doubly curved shells. Stress analysis methods in spherical shells. Spherical shell of constant thickness. Symmetrical bending of shallow spherical shells. Conical shells.
Text Book:
1. S. P. Timoshenko and S. W. Krieger, Theory of Plates and Shells, McGraw-Hill, 1959.

Reference Books:
1. R. Szilard, Theory and Analysis of Plates: Classical and Numerical Methods, Prentice Hall, New York, 1974.
2. N. K. Bairagi, Shell Analysis, Khanna Publishers, New Delhi, 1990.
3. V.V. Novozhilov, Thin Shells, Groringen Publications, Netherlands, 1959.
4. Ramaswamy, G. S "Design of Concrete Shells", Krieger Publ. Co, 1984.

Course Code: CEL504
Course Title: THEORY OF PLASTICITY
Structure (L-T-P): 3-0-0
Prerequisite: CEL501
Contents:
Stresses and Strains: Introduction, analysis of stress, Mohr's Representation of Stress, Strain Rate. Foundations of Plasticity: The Criterion of Yielding, Strain-Hardening Postulates. The Rule of Plastic Flow, The Total Strain Theory, Theorems of Limit Analysis, Uniqueness Theorems, Extremum Principles. Elastoplastic Bending: Plane Strain Compression and Bending, Pure Bending of Prismatic Beams, Bending of Beams Under Transverse Loads. Plastic Analysis of Beams and Frames: Limit Analysis of Beams, Limit Analysis of Plane Frames, Displacements in Plane Frames, Variable Repeated Loading, Minimum Weight Design, Influence of Axial Forces. Theory of the Slipline Field: Formulation of the Plane Strain Problem, Properties of Slipline Fields and Hodographs, Stress Discontinuities in Plane Strain, Construction of Slipline Fields and Hodographs, Analytical and Matrix Methods of Solution, Explicit Solutions for Direct Problems, Superposition of Slipline Fields.
Text Book:
1. Chakrabarty, Jagabanduhu. Theory of plasticity. Butterworth-Heinemann, 2012.

Reference Books:
1. Lubliner, Jacob. Plasticity theory. Courier Corporation, 2008.
2. Dixit, P.M. and Dixit, U.S. Plasticity Fundamentals and Applications. CRC Press

3. Kachanov, Lazar′Markovich. Fundamentals of the Theory of Plasticity. Courier Corporation, 2004.
4. Hill, Rodney. The mathematical theory of plasticity. Vol. 11. Oxford university press, 1998.
5. Khan, Akhtar, S., and Sujian Huang. Continuum theory of plasticity. John Wiley & Sons, 1995

Course Code: CEL505
Course Title: STABILITY OF STRUCTURES
Structure (L-T-P): 3-0-0
Prerequisite: CEL453
Contents:
Introduction: Buckling of steel and concrete structures; Conservative and non-conservative loads. Elastic buckling of columns and beam columns: Static, dynamical and energy-based approaches. Viscoelastic and elastoplastic buckling. Torsional buckling. Flexural-torsional and lateral buckling. Plate and frame buckling. Imperfection sensitivity; Post-buckling theory. Snap-through. Dynamic stability: Divergence, flutter and parametric resonance. Nonlinear dynamical systems theory; Bifurcations. Recent trends.
Text Book:
1. S P Timoshenko and J M Gere, 1963, Theory of elastic stability, McGraw Hill, London.
2. A Chajes, 1974, Principles of elastic stability, Prentice Hall, NJ.
3. Z P Bazant and L Cedolin, 1990, Stability of structures, Oxford University Press, Oxford.
4. G J Simitses, 1976, An introduction to the elastic stability of structures, Prentice Hall, NJ.
Reference Books:
1. T V Galambos, 1998, Guide to stability design criteria for metal structures, Wiley, NY.
2. R D Cook, D S Malkus and M E Plesha, 1989, Concepts and applications of finite element analysis, Wiley, NY.
3. W McGuire, R H Gallagher and R D Zieman, 2000, Matrix structural analysis, John Wiley, NY.
4. V V Bolotin, 1964, Dynamic stability of elastic systems, Holden-Day, San Fransisco.
5. H Ziegler, 1968, Principles of structural stability, Blaisdel Publishing Company, Waltham.
6. A H Nayfeh and D T Mook, 1979, Nonlinear oscillations, John Wiley, NY.

Course Code: CEL506
Course Title: FINITE ELEMENTS ANALYSIS
Structure (L-T-P): 3-0-0
Prerequisite: CEL465
Contents:
Review of principles of virtual work and minimum potential energy. Elements of theory of elasticity. Finite element (FE) techniques for linear and static problems. Developing various types of finite elements: 1-D, 2-D, and 3-D. Formulating displacement and shape functions. Variational and weighted residual techniques. Higher order Isoparametric formulation for truss, beam, frame, plate, and shell elements. Numerical solution procedures and computational aspects. Applications to structures such as dams, frames, shear walls, grid floors, rafts etc. Algorithms for FE problem solving and commercial software modeling issues. Application of FE methods to solve thermal problems.
Text Books:
1. Bathe, K.J., Finite Element Procedures, Prentice Hall of India, 2010.
2. Krishnamoorthy, C.S., Finite Element Analysis: Theory and Programming, Tata McGraw Hill, NewDelhi, 1987.
Reference Books:
1. Reddy, J. N., An Introduction to Finite Element Method, 3rded., McGraw Hill Company,2012.
2. R D Cook, D S Malkus and M E Plesha, 1989, Concepts and applications of finite element analysis, Wiley, NY.
3. Trupathi, R C. andBelegundu,A.D., Introduction of Finite Elements in Engineering, 3rded., Prentice Hallof India, 2012.
4. Seshu, P., Text book of Finite Element Analysis, Prentice Hall of India, 2012.
5. Zienkiewicz,O.C., Taylor,R.L. and Zhu, J.Z., Finite Element Method: Its Basis and Fundamentals, 6thed., Elsevier Butterworth Heinemann, Oxford, 2005.
7. Desai, Y. M., Eldho, T. I. and Shah, A. H., Finite Element Method with Applications in Engineering, Pearson, 2011.

Course Code: CEL507
Course Title: NUMERICAL METHODS IN CIVIL ENGINEERING
Structure (L-T-P): 3-0-0
Pre-requisite: NIL
Contents:
Introduction: Mathematical foundations of structural theory. Linear algebra: vector spaces and linear transformations. Linear differential equations and function spaces. Partial differential equations; Elliptic, parabolic and hyperbolic PDEs. Nonlinear differential equations. Gaussian Elimination; Factorization Techniques - LU, Cholesky; Iterative Methods of Solution of Linear Simultaneous Equations. Properties of Eigenvalues and Eigenvectors; Similarity Transforms; Diagonalization and Numerical Techniques to Compute Eigenvalues - Vector Iteration, QR algorithm, Jacobi Method. Time Marching Schemes (Step by Step Solutions); Euler's Method; Runge Kutta Method; Newmark Beta Method. Numerical Solution of Boundary Value Problems – Finite Difference Method, Explicit and Implicit Approaches; Method of Weighted Residuals, Galerkin's Method. Numerical Integration: Gauss- Legendre Method, Newton-Cotes Method. Regression Analysis and Curve Fitting. Applications of mathematical and numerical methods to static, dynamic and stability analysis of elastic structures and cables.
Text Book:
1. Chapra, Steven C., and Raymond P. Canale. Numerical methods for engineers. Fifth Edition, New York: McGraw-Hill, 2012.
Reference Books:
1. Wilkinson, J. H. The Algebraic Eigenvalue Problem. Oxford University Press, London, 1965.
2. Atkinson, K.E. An Introduction to Numerical Analysis. John Wiley and Sons, New York, 1989.
3. Golub G. E. and Loan, C.F. Van. Matrix Computations. Johns Hopkins University Press, Baltimore, 1989.

Course Code: CEL508
Course Title: OPTIMIZATION TECHNIQUES FOR CIVIL ENGINEERING
Structure (L-T-P): 3-0-0
Pre-requisite: NIL
Contents:
Linear Programming: Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Elementary operations; Graphical method for two variable optimization problem; Examples; Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Simplex criterion; Minimization versus maximization problems; Revised simplex method; Duality in LP; Primal-dual relations; Dual Simplex method; Sensitivity or post optimality analysis; other algorithms for solving LP problems – Karmarkar's projective scaling method. Use of software for solving

linear optimization problems using graphical and simplex methods; Examples for transportation, assignment, water resources, structural and other optimization problems. Dynamic Programming: Sequential optimization; Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality; Recursive equations – Forward and backward recursions; Computational procedure in dynamic programming (DP); Discrete versus continuous dynamic programming; Multiple state variables; curse of dimensionality in DP. Problem formulation and applications for Design of continuous beam, Optimal geometric layout of a truss, Water allocation as a sequential process, Capacity expansion, Reservoir operation etc. Integer Programming: Formulating integer programming problems, the branch-and-bound algorithm for pure integer programs, the branch-and-bound algorithm for mixed integer programs, Non-linear Programming: Introduction to non-linear programming (NLP), Convex and concave functions, NLP with one variable, Line search algorithms, Multivariable unconstrained problems, constrained problems, Lagrange Multiplier, The Karush-Kuhn-Tucker (KKT) conditions, The method of steepest ascent, Convex combination method, penalty function methods, Quadratic programming, Dynamic programming, Evolutionary algorithms such Genetic Algorithm, concepts of multi-objective optimization, Markov Process, Queuing Models.

Text Book:

1. Rao, S. Optimisation, Theory and Applications. 2nd Edition, Wiley Eastern Ltd., New Delhi, 1991.

Reference Books:

1. Hillier, H. and Liberman, G. J. Introduction to Operations Research. Tata McGraw-Hill, 2010.
2. Morris, J. (Editor). Foundations of Structural Optimisation - A Unified Approach.John Wiley and Sons, Chichester, 1982.
3. Winston, L. Operations Research: Applications and Algorithm. 4th Edition, Cengage Learning, 1994.
4. Arora, S. Introduction to Optimum Design. McGraw-Hill International Edition, New York, 1989.
5. Reklaitis, V., Ravindran, A. and Ragsdell, K.M. Engineering Optimisation Methods and Applications. John Wiley, New York, 1983.

Course Code: CEL509
Course Title: ADVANCED CIVIL ENGINEERING MATERIALS
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Hydration of cements and microstructural development, Mineral additives, Chemical admixtures, Rheology of concrete, Creep and relaxation, Shrinkage, cracking and volume stability, deterioration processes, special concretes, Advanced characterization techniques, sustainability issues in concreting, Modelling properties of concrete. Nanotechnology in construction: Concrete, Structural composite, Coatings, Glass, Nano sensors, Plastics.

Text Book:

1. Mehta, P.K. and Monteiro, P.J.M. Concrete Microstructure, Properties and Materials. Third Edition, Tata McGraw Hill, 2006.
2. Neville, A.M. Properties of Concrete. PITMAN.

Reference Books:

1. Holland, T.C. Specifications for Silica Fume for Use in Concrete. CANMET/ACI. 1995
2. Neville, A.M. and Brooks, J.J. Concrete Technology. ELBS.
3. Newman, John &Choo, Ban Sang. Advanced Concrete Technology-Constituent Materials.Elsevier, 2003.
4. Newman, John &Choo, Ban Sang. Advanced Concrete Technology-Concrete Properties.Elsevier 2003.
5. Newman, John &Choo, Ban Sang. Advanced Concrete Technology-Processes. Elsevier 2003.
6. Newman, John &Choo, Ban Sang. Advanced Concrete Technology-Testing and Quality. Elsevier 2003.
7. Shah, S.P., and Ahmad, S.H. High Performance Concrete and Applications. Edward Arnold. 1994.

Course Code: CEL510
Course Title: MODELING, ANALYSIS AND SIMULATION
Pre-requisite: 3-0-0
Pre-requisite: NIL
Contents:

Taxonomy of model types, steps in model building, Simulation, Algorithms and Heuristics, Simulation languages. Relationships via physical laws, Relationships via Curve fitting, Parameter estimation problems, State transition models. Collection and presentation of data, Measures of Central tendency, Elementary probability theory, Random events, Bay's theorem, Random variables and distributions, Derived distributions, Moments and Expectations, Common probabilistic models, Statistical inference, Estimation of parameters, Tests of hypotheses and significance, Goodness of fit tests, Regression and Correlation analysis, Multivariate analysis and applications, Time services. Neighborhood and distances, Cluster analysis, Individual and group preference patterns. Graphical models and matrix models, Input-Output type models, Decomposition of large systems, routing problems. Block diagram representation, State space models, Stability, System Control. Discrete and continuous growths, Limits to growth, Competition among species, Growth process and integral equations, Discrete event approach, Population planning.

Text Book:

1. Law, Averill M. Simulation Modeling and Analysis. 4th edition, McGraw Hill Education (India) Private Limited, 2007.

Reference Books:

1. May, A. D. Traffic Flow Fundamentals. Prentice–Hall, 1990.
2. Bolstad, William M. Introduction to Bayesian Statistics. John Wiley &Sons, 2013.

Course Code: CEL 511
Course Title: THEORY OF ELASTICITY
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Introduction to the general theory of elasticity with assumptions and applications of linear elasticity. Analysis of stress, stress tensors. Two-dimensional state of stress at a point, principal stresses in two dimensions, Cauchy's stress principle, direction cosines, stress components on an arbitrary plane with stress transformation. Principal stresses in three dimensions, stress invariants, equilibrium equations, octahedral stresses, Mohr's stress circle, construction of Mohr Circle for two and three-dimensional stress systems, equilibrium equations in polar coordinates for two-dimensional state of stresses. General state of stress in Three-Dimensions in cylindrical coordinate System. Introduction to analysis of strain, types of strain, strain tensors, strain transformation. Principal strains, strain invariants, octahedral strains, Mohr's Circle for Strain, equations of Compatibility for Strain, strain rosettes. Stress-strain relations, generalized Hooke's law, transformation of compatibility Condition from Strain components to stress components. Strain energy in an elastic body, St. Venant's principle, uniqueness theorem. Two dimensional problems in Cartesian coordinate system, plane stress and plane strain problems. Stress function, stress function for plane stress and plane strain cases. Solution of two-dimensional problems with different loading conditions by the use of polynomials. Two dimensional problems in polar coordinate system, strain-displacement relations, compatibility equation, stress- strain relations, stress function and biharmonic equation. Axisymmetric problems, thick-walled cylinders, rotating disks of uniform thickness, stress concentration, effect of circular holes on stress distribution in plates. Winkler's - Bach theory, stresses in closed rings. Torsion of prismatic bars, general solution of the torsion problem, stress function, torsion of circular and elliptic cross sections. Prandtl's membrane analogy, torsion of thin walled and multiple cell closed sections. Introduction to elastic solutions in

geomechanics. Solutions to the problems of Kelvin, Boussinesq, Flamant, Cerrutti, and Mindlin.

Text Books:

1. Y. C. Fung, "Foundations of Solid Mechanics", Prentice - Hall Publishers.
2. S.P.Timoshenko and J.N. Goodier, "Theory of Elasticity", McGraw-Hill Book Company.

Reference Books:

1. C.T. Wang, "Applied Elasticity", McGraw-Hill Book Company.
2. G. Sitharam and L.GovindaRaju, "Applied Elasticity", Interline Publishers, Bangalore.

Course Code: CEL512
Course Title: ADVANCED MATHEMATICS FOR CIVIL ENGINEERS
Structure (L-T-P): 3-0-0
Pre-requisite: NIL
Contents:

Homogeneous Linear Equations of Second Order; Second-Order Homogeneous Equations with Constant Coefficients; Case of Complex Roots, Complex Exponential Function; Nonhomogeneous Equations; Solution by Undetermined Coefficients; Solution by Variation of Parameters. Fourier Integrals and Transforms: Fourier Integrals; Fourier Cosine and Sine Transforms; Fourier Transform. Partial Differential Equations: Basic Concepts; Modeling: Vibrating String, Wave Equation; Separation of Variables, Use of Fourier Series; Modeling: Membrane, Two-Dimensional Wave Equation and Heat Equation; Rectangular Membrane, Use of Double Fourier Series. Linear Algebra: Rank of a Matrix, Linear Independence, Vector Space; Solutions of Linear Systems: Existence, Uniqueness, General Form; Vector Spaces, Inner Product Spaces, Linear Transformations; Eigenvalues, Eigenvectors; Similarity of Matrices, Basis of Eigenvectors, Diagonalization. Data Analysis, Probability Theory: Random Variables, Probability Distributions; Mean and Variance of a Distribution; Binomial, Poisson and Hypergeometric Distributions; Normal Distribution; Distributions of Several Random Variables. Mathematical Statistics: Introduction, Random Sampling; Estimation of Parameters; Confidence Intervals; Testing of Hypotheses, Decisions; Goodness of Fit, Chi-Square Test; Regression Analysis, Fitting Straight Lines; Correlation Analysis.

Text Book:

1. Kreyszig, E. Advanced Engineering Mathematics. 10th Edition, John Wiley & Sons, 1999.

Reference Books:

1. Greenberg, M. Foundation of Applied Mathematics. Dover Publication, 2014.
2. Benjamin, J.R. and Cornell, C.A. Probability, Statistics, and Decision for Civil Engineers. 1st Edition, McGraw-Hill, 1970.
3. Wylie, C.R. and Barrett, L.C. Advanced Engineering Mathematics. 6th Edition, McGraw-Hill, 1995.
4. Dasgupta, B. Applied Mathematical Methods. 1st Edition, Pearson, 2006.
5. Wilkinson, J. H. The Algebraic Eigenvalue Problem. Oxford University Press, London, 1965.
6. Atkinson, K.E. An Introduction to Numerical Analysis.John Wiley and Sons, New York, 1989.
7. Golub, G. E. and Loan, C.F. Van. Matrix Computations. Johns Hopkins University Press, Baltimore, 1989.

Course Code: CEL513
Course Title: CONCEPTS OF GREEN BUILDING DESIGN
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Introduction to Green Building: issues and goals in the green building field, including energy efficiency, “LEED”, “Build Green” and “Energy Star” programs, the HERS Energy Rating System. Introduction to Renewable Energy: an introduction to several Renewable Energy systems for heating or generating electricity, including Solar Electric, Solar Thermal, “Small Wind”, Geo-Thermal Heat Pumps and Passive Solar. Design Elements: fundamentals of sustainable and energy efficient building design, by focusing on Building envelopes, Alternative Building Materials: pros and cons of different building methods and materials used for wall systems, and relation to green building and energy efficiency, focusing on five “alternative” building systems. Building systems and operations (HVAC, lighting, water supply, sewage, garbage disposal, recycling and composting) strategies, solutions and systems for harvesting the water, active and passive systems, storage and distribution. Principles of solar gain, design for optimal heating and cooling, and common mistakes, Solar Thermal or “Hydronics” systems, Energy Efficient Re-modeling: strategies for energy efficient re-modeling with economic efficiency, key components of building systems, new technology, and materials.

Text Book:

1. Keeler, Marian and Burke, Bill. Fundamentals of Integrated Design for Sustainable Building. John Wiley & Sons, 2009

Reference Books:

1. Mendler, Sandra F., Odell, William, and Lazarus, Mary Ann. The HOK Guidebook to Sustainable Design.Second Edition. John Wiley & Sons, 2005
2. Snell, Clarke and Callahan, Tim. Building Green: A Complete How-To Guide to Alternative Building Methods Earth Plaster, Straw Bale, Cordwood, Cob, Living Roofs. Lark Crafts, 2009
3. Yudelson, Jerry. Green Building A to Z: Understanding the Language of Green Building. New Society Publishers, 2007
4. Kibert, Charles J. Sustainable Construction: Green Building Design and Delivery. John Wiley & Sons.
5. McHarg, Ian L. Design with Nature. First edition.John Wiley & Sons, 2005.
6. Mazria, Edward. The Passive Solar Energy Book. Rodale Press, 1980.
7. Kwok, Alison and Grondzik, Walter. The Green Studio Handbook: Environmental Strategies for Schematic Design. Second edition, Architectural Press, 2011.
8. Indian Green Building Council: www.igbc.inIGBC Green Homes Abridged Reference Guide.

Course Code: CEL514
Course Title: RELIABILITY ANALYSIS AND RELIABILITY BASED DESIGN OF STRUCTURES
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Fundamentals of set theory and probability, probability distribution, regression analysis, hypothesis testing. Stochastic process and its moments and distributions, concepts of safety factors, Safety, reliability and risk analysis, first order and second order reliability methods, simulation based methods, confidence limits and Bayesian revision of reliability, reliability based design, examples of reliability analysis of structures.

Text Books:

1. Haldar, A., and Mahadevan, S. (2000). Probability, reliability and statistical methods in engineering design. John Wiley and Sons, New York.
2. Andrzej S. Nowak & Kevin R. Collins, "Reliability of Structures", CRC Press.

Reference Books:

1. A H S Ang & W H Tang, 1984, Probability concepts in engineering planning and design, Volume II Decision, Risk & reliability, John Wiley, NY.
2. Haldar, A., and Mahadevan, S. (2000). Reliability assessment using stochastic finite element analysis. John Wiley and Sons, New York.

3. Ranganathan, R. (1999). Structural reliability analysis and design.Jaico Publishing House, Mumbai.
4. Seung-Kyum Choi, Ramana V. Grandhi, Robert A. Canfield, Reliability-based Structural Design, Springer, 2007.
5. J R Benjamin and C.A. Cornell, 1970, Probability, statistics and decisions for civil engineers, John Wiley, New York.
6. Robert E. Melchers, "Structural Reliability Analysis and Prediction", John Wiley & Sons.

Course Code: CEL515
Course Title: CONTINUUM MECHANICS-II
Structure (L-T-P): 3-0-0
Prerequisite: CEL501
Contents:

General considerations in the constitutive theories for solids and fluids: Axioms of constitutive theory, Preliminary considerations in the constitutive theories, approach of deriving constitutive theories. Ordered rate constitutive theories for thermoelastic solids: Entropy inequality, Constitutive theories for thermoelastic, Rate of strain energy and strain energy density function, Constitutive theories for the heat vector, Stress Tensor. Ordered rate constitutive theories for thermoviscoelastic solids without memory: Constitutive theories using Helmholtz free energy density, Constitutive theories using Gibbs potential. Ordered rate constitutive theories for thermoviscoelastic solids with memory: Constitutive theories using Helmholtz free energy density, Constitutive theories using Gibbs potential. Ordered rate constitutive theories for thermofluids: Dependent variables in the constitutive theories and their arguments, compressible thermofluids, compressible generalized Newtonian and Newtonian thermoviscousfluids. Ordered rate constitutive theories for Thermo hypo-elastic solids: thermo hypo-elastic solids, compressible thermo hypo-elastic solids, compressible generalized thermo hypoelastic solids. Mathematical models with thermodynamic relations: Thermodynamic pressure, Mechanical pressure, Specic internal energy, Variable transport properties. Principle of virtual work: Hamilton's principle, Euler-Lagrange equation.

Text book:

1. Surana, K. S. Advanced mechanics of continua, CRC Press, 2016.

Course Code: CEL 516
Course Title: FORENSIC ENGINEERING AND REHABILITATION OF STRUCTURES
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Failure of Structures: Review of the construction theory – performance problems – responsibility and accountability – case studies – learning from failures – causes of distress in structural members – design and material deficiencies – over loading.

Diagnosis andAssessment of Distress: Visual inspection – non-destructive tests – ultrasonic pulse velocity method – rebound hammer technique – ASTM classifications – pullout tests – Bremor test – Windsor probe test – crack detection techniques – case studies – single and multi-storey buildings – Fiber-optic method for prediction of structural weakness. Environmental Problems and Natural Hazards: Effect of corrosive, chemical and marine environment – pollution and carbonation problems – durability of RCC structures – damage due to earthquakes and flood strengthening of buildings – provisions of BIS 1893 and 4326. Modern Techniques of Retrofitting: Structural first aid after a disaster – guniting - jacketing – use of chemicals in repair – application of polymers – Ferro cement and fiber concretes as rehabilitation materials – rust eliminators and polymer coating for rebars- foamed concrete- mortar repair for cracks- shoring and underpinning - strengthening by pre-stressing. Case studies – buildings - heritage buildings- high rise buildings- water tanks – bridges and other structures Study of non-destructive testing methods; Studies on simple building system components

Text Books:

1. Raikar, R.N., Learning from failures – Deficiencies in Design, Construction and Service R&D Centre (SDCPL), RaikarBhavan, 1987.
2. Dovkaminetzky, Design and Construction Failures, Galgotia Publication, New Delhi, 2001.
3. Shen-En Chen, R. Janardhanam, C. Natarajan, Ryan Schmidt, Ino-U.S. Forensic Practices - Investigation Techniques and Technology, ASCE, U.S.A., 2010.

Reference Books:

1. C. Natarajan, R. Janardhanam, Shen-En Chen, Ryan Schmidt, Ino-U.S. Forensic Practices - Investigation Techniques and Technology, NIT, Tiruchirappalli, 2010.
2. Gary L. Lewis, Guidelines for Forensic Engineering Practice, ASCE, U.S.A., 2003.
3. Handbook on “Seismic Retrofit of Buildings” , Central Public Works Department , Indian Building Congress and Indian Institute of Madras , Narosa Publishing House, 2009
4. Bungey, S., Lirrard , G. and Grantham, M.G., “ Testing of Concrete in Structures” , Taylor and Francis , 4th edition, 2006

Course Code: CEL517
Course Title: TRANSPORTATION PLANNING
Structure (L-T-P): 3-0-0
Pre-requisite: CEL255, CEL460
Contents:

Overview of transportation systems, nature of traffic problems in cities, Goals and objectives of Transportation planning. Survey Methodology Design, Data types and sources, Revealed and Stated Preference Data, Data collection techniques (Household and non-household based) to collect revealed and stated preference data, Sample size, and sampling techniques. Transportation demand and supply, Transportation cost analysis, consumer surplus, Elasticity. Trips, trip classification, Four-stage sequential travel demand modeling: Trip generation (Regression and category analysis), Trip distribution (Growth factor and Gravity Models), Modal split including behavioural analysis based on Random Utility Theory, and Trip assignment (Single and multi-path route assignments). Planning for pedestrians, bicyclists and public transport systems.

Text Book:

1. Kadiyali, L.R., Traffic Engineering and Transport Planning, 6th ed., Khanna Publishers, 2012

Reference Books:

1. Ortuzar, J.D. and Willumsen, L.G., Modelling Transport, 4th ed., John Willey and Sons, 2011.
2. Morlok, E.K., Introduction to Transportation Engineering and Planning, Tata McGraw Hill, 1978.
3. Hutchinson, B. G., Principles of Urban Transport Systems Planning, Scripta Book Co., Washington, 1974.

Course Code: CEL 518
Course Title: AIRPORT PLANNING AND DESIGN
Structure (L-T-P): 3-0-0

Pre-requisite: NIL

Contents:

History and organization of air transport, Aircraft characterizes related to airport design, Airport configuration, Airport planning and air travel demand forecasting, Geometric design of the airside, Structural design of airfield pavements, airport drainage, Airport airside capacity and delay, Planning and design of the terminal area, Airport access, Passenger terminal system and its components. Design considerations: terminal demand parameters, facility classification, level of service criteria. Terminal planning process: overall space requirements, concept development, horizontal distribution concepts, vertical distribution concepts. Apron gate system: number of gates, ramp charts, gate size, aircraft parking type, apron layout, apron circulation, passenger conveyance to aircraft, apron utility requirements, Airport lighting and marking, Financial strategies for implementation, Environmental impacts of airports.

Text Book:

1. Kumar, V., and Chandra, S. Air Transportation Planning and Design. Galgotia Publications Pvt. Ltd., New Delhi, India, 1999.

Reference Books:

1. Neufville, R. D., and Odoni, A. Airport Systems: Planning, Design, and Management. McGraw-Hill, New York, USA, 2003.
2. Khanna, S. K., Arora, M. G., and Jain, S. S. Airport planning and Design. Sixth Edition, Nem Chand and Bros, Roorkee, India, 2012.
3. Horonjeff, R. and Mckelvey, F. X. Planning & Design of Airports. 5th Edition, McGraw Hill, New York, 2010.
4. Ashford, N., Mumayiz, S. and Wright, P. H. Airport Engineering. 4th Edition, John Wiley, New York, 2011.

Course Code: CEL519

Course Title: GEOMETRIC DESIGN OF TRANSPORTATION FACILITIES

Structure (L-T-P): 3-0-0

Pre-requisite: CEL255, CEL460

Contents:

Geometric design of highways: Design controls - Topography and physical features, traffic, vehicular characteristics, speed and safety ; Design Elements; Space standards for urban, rural and hill roads, Sight distance requirements, Access controls; Geometric standards for Mobility and Accessibility; Cross section Elements- Single lane, Two lane, Multi-lane highways, Expressways, Urban roads; Street design concepts, bicycle tracks, pedestrian facilities- Pedestrian q-k-v Relationships – Walkway Widths – LOS for Walkways – Subways and Over Bridges – Pedestrian Precincts – Passenger Conveyors., bikeway facilities, Street furniture, Design of Speed Breaker; Alignment : Horizontal Alignment - Curve design, Super-elevation design, Transition curve design, Attainment of super-elevation, Pavement widening, Sight distance on horizontal curves; Vertical Alignment - Gradients, Grade compensation, Design of vertical curves, Combination of horizontal and vertical alignment, vertical clearance for underpasses and elevated structures; Intersection Geometry: Visibility requirements, Principles of channelization, Layout design for types of intersections, on-ramps and off-ramps (flyovers and access controlled facilities), Acceleration and deceleration lanes, Two-way turn lanes; Design of Facilities: Design of on-street and off-street parking facilities, multi-storied Parking; Design of bus shelters and bus lay-bye, Bus terminal, Truck terminals and truck lay-bye, Foot-over bridge and sky-walk.

Text Book:

1. Veeraragavan, Khanna, S.K and Justo, C.E.G. Highway Engineering. Nem Chand & Brothers, 2014.

Reference Books:

1. Wright, P. H. Highway Engineering. John Wiley & Sons, 1996.
2. Rogers, M. Highway Engineering. Blackwell Publishing, 2003.
3. May, A.D. Traffic Flow Fundamentals. Prentice Hall, 1st Edition, 1989.
4. Mannering, Fred L., Washburn, Scott S., and P., Kilareski Walter. Principles of Highway Engineering and Traffic Analysis. Wiley India Pvt Ltd., 4th Edition, 2011.
5. Institute of Transportation Engineers, Traffic Engineering Hand Book. 4th Edition, Prentice Hall., 1991.
6. Fruin, Pedestrian Planning and Design, McGraw Hill Publication, 1987.

Course Code: CEL520

Course Title: PLANNING, DESIGN AND CONSTRUCTION OF RURAL ROADS

Structure (L-T-P): 3-0-0

Pre-requisite: CEL255

Contents:

Introduction, Overview of Development of Rural Roads, rural roads plan, road alignment and surveys, governing factors for route selection, Materials and Construction Technology, Network Planning and Design of Rural Roads, Construction of Rural Roads, Preparation of DPR, Alternatives to reduce cost of rural road construction, Use of locally available materials, Maintenance and Management of Rural Roads, Environmental and Social Safeguard Issues, Road Safety Issues in Relation to Rural Roads, Culverts and Small Bridges: Geometric standards for culverts, Design loading, design of culverts, types of culverts, causeways and submersible bridge.

Text Book:

1. Chatburn, G. R. Highway Engineering-Rural Roads and Pavements. John Wiley and Sons, Inc. Publication, 2010.

Reference Books:

1. Rural Road Manual: IRC: SP:20–2002, Indian Roads Congress. Ministry of Rural Development, New Delhi.
2. Quality Assurance Handbook for Rural Roads, Volume-I, 2007, Published by National Rural Roads Development Agency, Ministry of Rural Development Government of India.
3. Cook, J. R., Petts, R C and Rolt, J. Low Volume Rural Road Surfacing and Pavements- A Guide to Good Practice. OTB Engineering UK LLP, 2013

Course Code: CEL521

Course Title: PAVEMENT MATERIALS AND EVALUATION

Structure (L-T-P): 3-0-0

Pre-requisite: CEL255

Contents:

Subgrade functions, Importance of subgrade soil properties on pavement performance. Aggregates: Classification, Properties of aggregates, design of aggregate gradation, texture, polishing and skid resistance. Bituminous road binders: Straight- run bitumen, emulsions, Cutback and modified binders. Rheology of bituminous binders, modified binders – adhesion and stripping, penetration index, viscosity, temperature susceptibility of viscosity. Additives and their suitability, Fillers. Design of Bituminous mixes: Marshall method. Design of emulsified mixes, Visco-elastic and fatigue properties of bituminous mixtures, resilient modulus of pavement materials. Requirements of paving concrete, design of mixes: IRC, absolute volume, Vibrated Concrete mix design, design of DLC and SFRC mixes, Soil stabilization techniques. Application of waste and locally materials for construction of pavements, quality control and assurance practices. Introduction to Super pave grading system, Super pave mix designs of different types of mixes.

Text Book:

1. Papagiannakis, A.T. and Masad, E.A. Pavement Design and Materials. John Wiley and Sons, New Jersey, USA, 2008.

Reference Books:

1. IRC: 44-2008, Guidelines for Cement Concrete Mix Design for Pavements. The Indian Roads Congress, New Delhi, India, 2008.
2. Khanna, S. K. and Justo, C. E. G. Highway Material Testing. Nem Chand & Bros., 1999.
   Sherwood, P.T. Alternative materials in road construction. Thomas Telford, New York, USA, 1997.
3. Papagiannakis, A.T. and Masad, E.A. Pavement Design and Materials. John Wiley and Sons, New Jersey, USA, 2008.
4. Asphalt Institute. Mix Design Methods – For Asphalt Concrete and Other Hot-Mix Types Manual Series No. 2 (MS-2). Asphalt Institute, Kentucky, USA, 1997.

Course Code: CEL522
Course Title: PAVEMENT ANALYSIS AND DESIGN
Structure (L-T-P): 3-0-0
Pre-requisite: CEL255
Contents:
Types and component parts of pavements, materials used in pavements. Layered system concepts, Stress solution for one, two and three layered systems, Fundamental design concepts, Stress analysis in flexible pavements using KENLAYER. Stresses in Rigid Pavements: Westergaard's theory and assumptions, Stresses due to curling, stresses and deflections due to loading, frictional stresses, Stresses in dowel bars and tie bars, Stress analysis in rigid pavements using KENSLABS. Design of Flexible Pavements: IRC method of flexible pavement design, Asphalt Institute's methods with HMA and AASHTO method of flexible pavement design. Design of Rigid Pavements: IRC methods of rigid pavement design, AASHTO method of rigid pavement design, Design of rigid pavement shoulders.

Text Book:
1. Huang, Y.H. Pavement Analysis and Design. Second Edition, Dorling Kindersley (India) Pvt. Ltd., New Delhi, India, 2008.

Reference Books:
1. Yoder, E.J. and Witczak, M.W. Principles of Pavement Design. Second Edition, John Wiley and Sons, New York, USA, 1975.
2. Yang, N.C. Design of Functional Pavements. McGraw-Hill Book Company, New York, USA, 1972.
3. Croney, D. and Croney, P. The design and performance of road pavements. McGraw-Hill Book Company, London, UK, 1991.
4. IRC: 37-2012 Guidelines for the Design of Flexible Pavements. The Indian Roads Congress, New Delhi, India, 2012.
5. Ministry of Road Transport and Highways. Specifications for Road and Bridge Works. Fifth Edition, Indian Roads Congress, New Delhi, India, 2013.
6. IRC: 58-2011 Guidelines for the Design of Plain Jointed Rigid Pavements for Highways. The Indian Roads Congress, New Delhi, India, 2011.

Course Code: CEL523
Course Title: TRAFFIC FLOW THEORY
Structure (L-T-P): 3-0-0
Pre-requisite: CEL255, CEL460
Contents:
Traffic Stream Models: Stream flow fundamentals; individual models; family of models, pedestrian stream models. Highway capacity analysis: Capacity and level of service concepts; Factors affecting capacity and LOS; capacity of rural highways, Urban arterials; Signalised intersections; Un-signalized intersections; HCM and IRC standards. Signal Coordination: Methods of signal coordination, time-space diagram; vehicle detectors and their placement; Hydrodynamic & Kinematic Analysis of Traffic: Continuity equation; Waves in traffic, Traffic fluid state considerations, Quantitative analysis; platoon diffusion, Heat flow analysis. Shockwave Analysis: Shock wave equations; Shock waves at signalised intersections; Shock waves along a highway Queueing Analysis: Deterministic Queuing analysis; Stochastic queuing analysis; Single channel; Multiple channels; Moving queues.

Text Book:
1. Pignataro, L. J. Traffic Engineering: Theory and Practice. Prentice hall, Inc, 1973.

Reference Books:
1. Kadiyali, L.R. Traffic Engineering and Transportation Planning. Khanna Publishers, 2011.
2. Kerner, Boris S. Introduction to Modern Traffic Flow Theory and Control. Springer, 1st Edition.Edition, 2009.
3. Drew, D.R. Traffic flow theory and control. McGraw Hill Book Company, 1976.
4. Highway Capacity Manual, Transportation Research Board, Washington, D.C., 2010.
5. Roess, Roger P., Prassas, E. S. and McShane, W. R. Traffic Engineering. Prentice Hall, 4th edition, 2010.
6. Currin. Introduction to Traffic Engineering: Manual F/data Collect & Analysis, CL Engineering, 2nd Edition, 2012

Course Code: CEL524
Course Title: TRANSPORT ECONOMICS
Structure (L-T-P): 3-0-0
Pre-requisite: CEL255
Contents:
Economic significance of transport, Demand for transport – influencing factors, temporal and spatial variations, elasticity of demand, Supply of transport Costs – Long – term and short – term Costs, fixed and variable costs, and marginal costs, Pricing of services, Road User Costs, Evaluation of transport projects – Cost – benefit ratio, first year rate of return, net present value and internal – rate of return methods, Indirect Costs and benefits of transport projects, Project ownership and financing, Highway finance and Taxation.

Text Book:
1. Winfrey, Robley. Economic Analysis for Highway. International Textbook, Co., Pennsylvania, USA, 1969.

Reference Books:
1. Kadiyali, L.R. Traffic Engineering and Transportation Planning. Khanna Publishers, 2011.
2. Fair and Williams. Economics of Transportation.Harperand Brothers, Publishers, New York, 1959.
2. Button, Kenneth. Transport Economics. Edward Elgar Publishing, 3rd Edition, 2010.
3. McCarthy, Patrick. Transportation Economics.Wiley-Blackwell, 1st Edition, 2001.

Course Code: CEL525
Course Title: TRAFFIC ENGINEERING DESIGN AND MANAGEMENT
Structure (L-T-P): 3-0-0
Pre-requisite: CEL460
Contents:
Traffic Engineering: Definition, Elements of traffic engineering, traffic engineering problems, Issues for traffic engineer, Components of traffic system – Road User and vehicle characteristics, travel demand and patterns. Traffic Stream Characteristics: Lane and directional systems, Traffic flow characteristics - Speed, Flow and Density, Other flow characteristics – Headways, Occupancy, Flow rate, Capacity, traffic demand v/s volume v/s capacity, Relationships of flow characteristics- Greenshield's, Greenburg, Underwood, Edie, multi-regime relationships. Traffic speed study and volume study. Capacity Analysis: HCM 2010 and IRC guidelines, two-lane highway, multilane highway, basic freeway sections, Service volumes of urban and rural roads, Design of Intersections, Parking Areas and Terminals: Design of at-grade

intersection, roundabout, grade-separated intersection, on-street parking, off-street parking, parking for disabled, truck terminal, container terminal. Road Safety Engineering: Statistical analysis of accidents, accident modelling, remedial measures, road safety audit, transportation system management (TSM) techniques, traffic sign, road marking, signal control, traffic calming techniques, achievable speed reductions, estimate of accident reductions and benefits. Traffic Forecasting: Forecast based on past trends and extrapolation, forecasts and mathematical models, period for forecasting, time series approach. Traffic Forecasting: Forecast based on past trends and extrapolation, forecasts and mathematical models, period for forecasting, time series approach. Planning for Public Transport: Selection of public transport technology, MRTS, LRTS, BRTS, ITS Modules, driver information and guidance, public transport travel information and ticketing, freight and fleet management, system integration.

Text Book:

1. Kadiyali, L.R., Traffic Engineering and Transport Planning, 6th ed., Khanna Publishers, 2012
2. McShane, W.R. and Roess, R.P., Traffic Engineering, Prentice Hall, 2010.
3. Pignataro, L. J. Traffic Engineering: Theory and Practice. Prentice hall, Inc, 1973.

Reference Books:

1. Papacostas, C. S. and Prevedouros, P.D., Fundamentals of Transportation Engineering, Prentice Hall, 2001
2. Kerner, Boris S. Introduction to Modern Traffic Flow Theory and Control. Springer, 1st Edition.Edition, 2009.
3. Drew, D.R. Traffic flow theory and control. McGraw Hill Book Company, 1976.
4. Highway Capacity Manual, Transportation Research Board, Washington, D.C., 2010.
5. Currin. Introduction to Traffic Engineering: Manual F/data Collect & Analysis, CL Engineering, 2nd Edition, 2012.

Course Code: CEL526
Course Title: TRAFFIC SAFETY
Structure (L-T-P): 3-0-0
Pre-requisite: CEL460
Contents:

Introduction: Road traffic accidents scenario in India, characteristics of accidents, accident vs. crash, effect of human factors, planning for road network, land use and road environment for safety, designing for road safety – links and junctions, road safety engineering, road safety improvement strategies, elements of a road safety plan. Crash investigation and analysis: Steps in treatment of crash locations, diagnosing crash problem and solutions, accident report form, storing of data, using and interpreting crash data, identifying and prioritizing hazardous locations, condition and collision diagrams; Vulnerable road users: crashes related to pedestrian and bicyclists, their safety, provision for disabled; Crash reconstruction: understanding basic physics, calculation of speed for various skid, friction, drag, and acceleration scenarios. Statistical analysis of accidents: Descriptive statistics, confidence interval, hypothesis testing, models related to accident frequency, accident severity, accident duration, various methodological issues – over/under dispersion, time-varying explanatory variables, unobserved heterogeneity, endogeneity, under-reporting, spatial and temporal correlation, etc; Accident prediction model. Before -after methods in crash analysis: Before and after study, before and after study with control sites, comparative parallel study, before, during and after study, Empirical Bayes method. Economic analysis of accidents: Accident costing-economic appraisal, EUAC, PWOC, B/C ratio, IRR, NPV. Traffic management system: Traffic flow improvements, expressway patrol, public transit, ridesharing, mobility rest areas, park-and-ride lots, bus bays, signage, markings; ITS applications - vehicular navigation, crash avoidance system, incident management, traffic management centre, highway side communication. Road safety audits: Procedure, aims and objectives, roles and responsibility, history of road safety audit, design standards, tasks, various stages of safety audits; common identifiable problems, structuring of report, identifying common problems. Vehicle-animals conflicts- causes and preventive measures.

Text Book:

1. American Association of State Highway and Transportation Officials (AASHTO), "Highway Safety Manual", 1st Edition, AASHTO.
2. Simon P. Washington, Matthew G. Karlaftis, Fred L. Mannering, "Statistical and Econometric Methods for Transportation Data Analysis", 2nd Edition, Chapman &Hall/CRC Press.

Reference Books:

1. Ezra Hauer, "Observational Before -After Studies in Road Safety", Pergamon Press.
2. Limpert, Rudolf. "Motor Vehicle Accident Reconstruction and Cause Analysis", 5th Edition, Lexas Publishing, Charlottesville, VA.
3. Indian Roads Congress, "Highway Safety Code", IRC: SP-44:1996.
4. Indian Roads Congress, "Road Safety Audit Manual", IRC:SP-88-2010.

Course Code: CEL527
Course Title: GROUND IMPROVEMENT TECHNIQUES
Structure (L-T-P): 3-0-0
Pre-requisite: CEL351, CEL354
Contents:

Introduction to ground improvement, overview of various techniques; Shallow compaction, soil stabilization: principle, method, stabilization with chemicals, cement, lime, ash, bitumen; In-situ densification of cohesionless and consolidation of cohesive soils: Dynamic compaction and consolidation, Vibrofloation, Sand pile compaction, Preloading with sand drains and fabric drains, Stone columns, Lime piles, relative merits of various methods and their limitations; Drainage techniques: Well points, Vaccum and electro-osmotic methods; Grouting: principles, types of grouts, grouting equipments and machinery, injection methods, grout operation and monitoring, applications; Concept of reinforcement: Types of reinforcement material and specification, design method, effect of water and dynamic loading, Applications of reinforced earth; Geosynthetics: types, use of Geotextiles for filtration, drainage and separation in road and other works; Ground anchors and soil nails process: principles, construction process, structural elements, pull-out capacity estimates, application criteria, design of anchored walls and nailed soil-retaining structures.

Text Books:

1. Moseley, M.P., Ground Improvement Blockie Academic and Professional, Chapman and Hall, Glassgow, 1993.
2. Jones J.E.P., Earth Reinforcement and Soil Structure, Butterworths, 1995.
3. Raj P.P., Ground improvement techniques, Laxmi Publications, .

Reference Books:

1. Koerner, R.M., Design with Geosynthetics, 3rd ed. Prentice Hall, NewJersey, 2002.
2. Jewell, R.A., Soil Reinforcement with Geotextiles, CIRIA special publication, London, 1996.
3. Jones J.E.P., Earth Reinforcement and Soil Structure, Butterworths, 1995.

Course Code: CEL528
Course Title: ADVANCED SOIL MECHANICS
Structure (L-T-P): 3-0-0
Pre-requisite: CEL351
Contents:

Clay mineralogy; Soil-air-water interaction; Consistency; Soil compaction; Concept of effective stress. Elastic theories of stress distributions in soils: Boussinesq's equation, Wester-gaard, Burmister Theories, Different conditions of loads, Constitutive relationship for soils; Shear strength: stresses in soils, failure criterions, Mohr's circle, stress paths, UU, CU, CD tests, drained and undrained stress-strain relationships, Stress- Strain relationship, Skempton's Pore pressure coefficients, Critical state theory, normal consolidation line, critical state line, Roscoe surface, Hvorslev surface, no tension line, effect of over consolidation on shear parameters; Time-Dependent Behaviour of Clays: Introduction - quasi-reconsolidation, rate effects, clay minerals, Creep and stress relaxation, Rheological models, Singh-Mitchell model; Introduction to partially saturated soil.

Text Books:

1. Das, B. M. Advanced Soil Mechanics. CRC Press, 2013.
2. Lambe, T. W. and Whitman, R.V., "Soil Mechanics", John Wiley.

Reference Books:

1. Taylor, D.W. Fundamental of soil Mechanics. John Wiley and Sons.
2. Holtz, R.D., Kovacs, W.D., and Sheahan, T.C. An Introduction to Geotechnical Engineering. 2nd edition, Pearson, 2011.
3. Mitchell, J.K. and Soga, K. Fundamentals of Soil Behaviour. 3rd edition, John Wiley & Sons, 2005.
4. Kurian, N. P. Modern Foundations – Introduction to Advanced Techniques. Tata McGraw-Hill Publishing Company Limited, New Delhi, 1984.

Course Code: CEL529
Course Title: HILL ROADS CONSTRUCTION
Structure (L-T-P): 3-0-0
Pre-requisite: CEL255
Contents:

Hill road definition, systematic approach for hill roads, standards and geo metrics, alignment and planning of hill roads, hill roads drainage works, detailed survey, design, estimation, of hill road works, rocks blasting, explosives, quarries, hill cutting techniques and tunnels, stabilization of soils, slopes and land slide control. Geometric design standards in hill areas: design issues in hill roads, special consideration in hill road design, route selection, engineering data for design, geometric design standards, design of hair-pin bends, climbing lane. Construction of bituminous and cement concrete roads at high altitudes, construction and maintenance problems and remedial measures. Safety requirement & labor law enforcement, typical problems in hill roads, works and contract management, execution of road works, master plan of hill roads.

Text Book:

1. Treatise on hill roads by R.S. Gahlowt and V.P. Gupta, Standard book house, 2nd edition, 2018

Reference Book:

1. Hill Road Manual (IRC: SP-48), Indian Roads Congress (IRC), Ministry of Road Transport & Highways (MORTH).

M. Tech. (Computer Science and Engineering) specialization in Artificial Intelligence
OVERALL CREDIT STRUCTURE

S. No	Category	Symbol	M. Tech (Credits)
1	**PG Core**	**PC**	**30**
1.1	Departmental Core	DC	13
1.2	Project Phase-I	P1	05
1.3	Project Phase-II	P2	10
1.4	Seminar	SM	02
2	**PG Elective**	**PE**	**25**
2.1	Specialization Electives	SE	19
2.2	Open Courses	OC	06
	TOTAL REQUIREMENT		**55 (Minimum)**

Postgraduate Core (PC)		**L-T-P**	**Credit**
CSD501	Project phase-I	-	05
CSD502	Project phase-II	-	10
CSD503	Seminar	-	02
CSL501	Advanced Data Structures and Algorithms	3-0-0	03
CSL502	Optimization Techniques	3-0-0	03
CSL503	Statistical Models for Computer Science	3-0-0	03
CSP501	Software Lab I	0-0-8	04
Specialization Elective (SE)			
CSP502	Software Lab II	0-0-2	01
CSP503	Software Lab III	0-0-2	01
CSL504	Advanced Neural Networks	3-0-0	03
CSL505	Pattern Recognition and Machine Learning	3-0-0	03
CSL506	Computer Vision	3-0-0	03
CSL507	Cryptography	3-0-0	03
CSL508	Data Analytics	3-0-0	03
CSL509	Web Semantics	3-0-0	03
CSL514	Advanced Cryptography	3-0-0	03
ECL545	Human and Machine Speech Communication	3-0-0	03
ECL521	Internet of Things	3-0-0	03

M. Tech (Computer Science and Engineering) specialization in Computing Systems
OVERALL CREDIT STRUCTURE

S. No	Category	Symbol	M. Tech (Credits)
1	**PG Core**	**PC**	**30**
1.1	Departmental Core	DC	13
1.2	Project Phase-I	P1	05
1.3	Project Phase-II	P2	10
1.4	Seminar	SM	02
2	**PG Elective**	**PE**	**25**
2.1	Specialization Electives	SE	19
2.2	Open Courses	OC	06
	TOTAL REQUIREMENT		**55 (Minimum)**

Postgraduate Core (PC)		**L-T-P**	**Credit**
CSD501	Project phase-I	-	05
CSD502	Project phase-II	-	10
CSD503	Seminar	-	02
CSL501	Advanced Data Structures and Algorithms	3-0-0	03
CSL502	Optimization Techniques	3-0-0	03
CSL503	Statistical Models for Computer Science	3-0-0	03
CSP501	Software Lab I	0-0-8	04
Specialization Elective (SE)			
CSP502	Software Lab II	0-0-2	01
CSP503	Software Lab III	0-0-2	01
CSL507	Cryptography	3-0-0	03
CSL510	Cloud Enabled Technologies	3-0-0	03
CSL511	Wireless and Mobile Communication	3-0-0	03
CSL512	Distributed Systems	3-0-0	03
CSL513	Advanced Computer Architecture	3-0-0	03
CSL514	Advanced Cryptography	3-0-0	03
CSL515	Open Source Software	3-0-0	03
ECL545	Human and Machine Speech Communication	3-0-0	03
ECL521	Internet of Things	3-0-0	03

Course Syllabi (Post Graduate)
Department of Computer Science and Engineering

Course Code: CSL501
Course Title: Advanced Data Structures and Algorithms
Structure (L-T-P): 3-0-0
Pre-requisite: NIL
Contents:

Heaps: Binary Heap, Binomial Heaps, Fibonacci Heaps. Trees: Red-Black, M-Way Tree, K-d, Interval Tree, Splay Tree. Overview of Divide and Conquer, Greedy and Dynamic Programming strategies. Basic Search and Traversal Techniques for Graphs, Backtracking, Branch and Bound. Point location Convex hulls. Advanced Algorithms for Graph and Combinatorial Optimization Problems, Shortest Path Problems: Single Source Shortest Path (SP) Problems, Assembly Line Scheduling. Efficient Scanning Orders – Topological Order for Acyclic Networks, Shortest First Search for Nonnegative Networks (Dijkstra), Flows in Networks: Basic Concepts, Maxflow-Mincut Theorem, Ford and Fulkerson Augmenting Path Method, Integral Flow Theorem, Maximum Capacity Augmentation, Edmond-Karp Method, String Processing: String Searching and Pattern Matching. Approximation and Randomized Algorithms. NP completeness: Informal Concepts of Deterministic and Nondeterministic algorithms, P and NP, NP-Completeness, Statement of Cook's Theorem, Some Standard NP-Complete Problems.

Text Book:

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein. Introduction to Algorithms. 3rd ed.,MIT Press, 2009
2. Sahni Sartaj and Horrowitz Ellis, Fundamentals of Computer Algorithms.

Reference Books:

1. Robert Sedgewick and Kevin Wayne. Algorithms, 4th ed., Addison Wesley, 2011.

Course Code: CSL502
Course Title: Optimization Techniques
Structure (L-T-P): 3-0-0
Pre-requisite: NIL
Contents:

Linear Programming Problems (LPP): Basic LPP and Applications; Components of LP Problem Formulation, Simplex Duality Theory; Duality in linear programming, Charnes' Big – M Method. Network Models: Shortest Path Problems, Maximum Flow Problems, CPM and PERT, Minimum Cost Network Flow Problems, Minimum Spanning Tree Problems, local and global optima. Integer Programming: Formulating Integer Programming Problems, Branch-and-Bound Method: Solving Pure and mixed Integer Programming Problems and Knapsack problems, unconstrained optimization techniques, constrained optimization. Queuing Network Models: Poisson distributions, wait time, server utilization, SRPT, Pure Birth and Death Models; M/M/1 queue, ∞ /FIFO, N/ FIFO. Game Theory: 2- person Zero – sum Game; Saddle Point; Mini-Max and Maxi-Min Theorems, Inventory Control: EOQ Models ; Deterministic and probabilistic Models ; Optimization and Performance in Web Computing, Internet Application, Curse of dimensionality.

Text Books:

1. Taha, H.A. Operations Research, 5th ed., Macmillan Publishing Company, 1992.

Reference Books:

1. Mustafi, C. K. Operations Research, 4th ed., New Age International, 2009
2. Hadley G. Linear Programming, Narosa Publishers, 1997
3. Hillier F. and G. J. Liebermann. Operations Research, Holder Day Inc, 1974.
4. Mohapatra, P.K.J. Introduction to System Dynamics Modelling, 1st ed., Universities Press, 1994.
5. Schaum Outline Series. Operations Research, 2nd ed., Tata McGraw Hill, 2003.
6. Smith, David K. Network Optimization in Practice. Ellis Harwood Publications, 1982.
7. Kanth, K. Introduction to Computer System Performance Evaluation, McGraw Hill, 1992.

Course Code: CSL503
Course Title: STATISTICAL MODELS FOR COMPUTER SCIENCE
Structure (L-T-P): 3-0-0
Pre-requisites: NIL
Contents:

Introduction: Probability Models, Sample Space, Events, their algebra, graphical methods of representing events, Probability Axioms and their applications, Conditional probability, Independence of Events, Bayes' Rule and Bernoulli Trials. Random Variables: Random variables, and their event spaces, Probability mass function, Distribution functions, Some discrete distributions (Bernoulli, Binomial, Geometric, Negative Binomial, Poisson, Hyper geometric and Uniform), Probability Generating Function, Discrete random vectors, Continuous random variables: some continuous distributions (Exponential, Hyper exponential, Erlang, Gamma, Normal), Functions of random variables, jointly distributed random variables. Expectation: Introduction, Moments, Expectation of functions of more than one random variable, Brief introduction to Conditional pmf, pdf and expectation, Moments and transforms of some distributions (Uniform, Bernoulli, Binomial, Geometric, Poisson, Exponential, Gamma, Normal), Computation of mean time to failure. Stochastic Processes: Classification of stochastic processes, The Bernoulli process, The Poisson process, renewal process, renewal model of program behavior. Markov Chains: Computation of n-step transition probabilities, State classification and limiting distributions, Distribution of times between state changes, Irreducible finite chains with aperiodic states, M/G/1 queuing system, Discrete parameter Birth-Death processes, Analysis of program execution time. Continuous parameter Markov Chains, Birth-Death process with special cases, Non-Birth-Death Processes.

Text Book:

1. Trivedi, Kishor S. Probability, Statistics with Reliability, Queuing and Computer Science Applications. Wiley-India, 2008.

Reference Books:

1. Hayes, J.F. Modeling of Computer Communication Networks. Khanna Publishing, Delhi.
2. Ross, Sheldon M. Introduction to Probability Models. 11th ed. Academic Press Inc, 2014.
3. Feller, W. An Introduction to Probability Theory and its applications, 2 vols., Wiley Eastern, 1975.
4. Kleinrock, L. Queuing Systems, 2 vols, John Wiley, 1976.

Course Code: CSL504
Course Title: ADVANCED NEURAL NETWORKS (3-0-0-3)
Structure (L-T-P): 3-0-0
Pre-requisite: NIL
Contents:

Biological Neuron, Idea of computational units, McCulloch–Pitts unit and Thresholding logic, Linear Perceptron, Perceptron Learning Algorithm, Linear separability. Convergence theorem for Perceptron Learning Algorithm.Feedforward Networks: Multilayer Perceptron, Gradient Descent, Backpropagation, Empirical Risk Minimization, regularization, auto encoders. Deep Neural Networks: Difficulty of training deep neural networks, Greedy layerwise training. Better Training of Neural Networks: Newer optimization methods for neural networks (Adagrad, adadelta, rmsprop, adam, NAG), second order methods for training, Saddle point problem in neural networks, Regularization methods (dropout, drop connect, batch normalization). Recurrent Neural Networks: Back propagation through time, Long Short Term Memory, Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs. Convolutional Neural Networks: LeNet, AlexNet. Generative models: Restrictive Boltzmann Machines (RBMs), Introduction to MCMC and Gibbs Sampling, gradient computations in RBMs, Deep Boltzmann Machines. Recent trends: Variational Autoencoders, Generative Adversarial Networks, Multi-task Deep Learning, Multi-view Deep Learning. Applications: Vision, NLP, Speech (just an overview of different applications in 2-3 lectures).

Text Book:

1. Deep Learning, Ian Goodfellow and Yoshua Bengio and Aaron Courville, MIT Press, 2016.

Reference Books:

1. Neural Networks: A Systematic Introduction, Raúl Rojas, 1996
2. Pattern Recognition and Machine Learning, Christopher Bishop, 2007

Course Code: CSL505
Course Title: PATTERN RECOGNITION AND MACHINE LEARNING
Structure (L-T-P): 3-0-0
Pre-requisite: NIL
Contents:
Data Mining: Introduction, Basic data mining tasks, Data mining issues, Data mining metrics, Data mining from a database perspective, Comparison of Database, Data warehouse and Data mining. Attributes: Nominal, Ordinal and Numeric. Similarity and Dissimilarity measures. Data pre-processing: Need, data summarization, data cleaning, data integration and transformation, data reduction techniques. Classification: Statistical based algorithms, Distance based algorithms, Decision Tree based algorithms, Neural Network based algorithms, Rule based algorithms, Combining techniques. Association Rules: Introduction, mining various kinds of association rules, Apriori algorithms, FP tree, Parallel and Distributed algorithms, Rule generation, Advanced association rule techniques, Measuring the quality of rules. Clustering: Similarity and distance measures, Hierarchical algorithms, Partitioned algorithms, Density based clustering; Grid based clustering, clustering large databases. Advanced Techniques: Introduction to Web mining, spatial mining and Temporal mining.
Data Warehouse: Introduction to Data warehousing: Application of Data warehousing and mining, Data warehouse development life cycle, analysis, Data ware house Architecture, OLAP, ROLAP and MOLAP, Concepts of Fact and Dimension table. Efficient methods for data cube computation, discovery driven exploration of data cubes, complex aggregation, attribute oriented induction for data generalization.
Text Books:
1. Data Mining concepts and techniques by Jiawei Han, Micheline Kamber, Jian Pei
2. Introduction to data mining by Pang-Ning Tan, Vipin Kumar, Michael Steinbach

Additional Book
1. Advanced Data Mining Techniques by David L. Olson, Dursun Delen.

Course Code: CSL506
Course Title: COMPUTER VISION (3-0-0-3)
Structure (L-T-P): 3-0-0
Pre-requisite: NIL
Contents:
Image Processing – Basics, Image Sensing and Acquisition, Image Sampling and Quantization, Some Basic Relationships between Pixels, Intensity Transformations and Spatial Filtering, Convolution, Filtering in the Frequency Domain – Fourier Transform and Wavelets, Image Restoration and Reconstruction, Morphological Image Processing, Image Segmentation and Grouping, Corner and Blob Detection, Descriptor.
Computer Vision - Motion Estimation - Regularization theory, Optical computation, Stereo Vision, Structure from motion, Shape Representation and Segmentation - Deformable curves and surfaces, Snakes and active contours. Gaussian Pyramids. Object recognition - Hough transforms and other simple object recognition methods, Scale Invariant Feature Transform (SIFT), Shape correspondence and shape matching, Principal component analysis. Segmentation using clustering methods, Mixture model. Applications – Salient Object Detection, Face Recognition, Optical Character Recognition.
Text Books:
1. Rafael C. Gonzalez and Richard E. Woods. Digital Image Processing, 2nd ed., Prentice Hall, 2002
2. Forsyth A. David and Ponce Jean, Computer Vision, A Modern Approach. 2nd ed., 2011

Additional Book:
1. Richard Szeliski. Computer Vision: Algorithms and Applications. Springer, London 2011

Course Code: CSL507
Course Title: Cryptography
Structure (L-T-P): 3-0-0
Pre-requisite: NIL
Contents:
Mathematics of Cryptography: Integer and Modular arithmetic, Linear and Quadratic congruence, Euclidean and Extended Euclidean algorithm, Algebraic structure: Group, Ring, Field. Factorization, Discrete logarithm, Fermat and Euler's theorem. Overview of cryptography, cryptanalysis, cryptology. Security goals and services, types of security attacks. Monoalphabetic, polyalphabetic and Transposition ciphers, Stream ciphers: RC4, A5. Block ciphers: Feistel, S-DES, DES, S-AES, AES, Blowfish, IDEA, Security analysis of block ciphers. Modern block ciphers: ECB, CBC, CFB, OFB, CTR. Asymmetric key cryptography: Introduction, RSA cryptosystem, Attacks on RSA cryptosystem. Random Oracle Model (ROM), Message authentication, Hash functions. Digital signature: Introduction, Services, Digital signature using RSA, Attacks on digital signature. Symmetric key distribution, Public key distribution, PKI, X.509 certificate. Key agreement protocols: Diffie-Hellman and station-to-station.
Text Books:
1. Forouzan, Behrouz A., and Debdeep Mukhopadhyay. Cryptography and Network Security (Sie). McGraw-Hill Education, 2011.
2. Stallings, William. Cryptography and network security: Principles and practice. Pearson, 2016.

Course Code: CSL 508
Course Title: DATA ANALYTICS
Structure (L-T-P): 3-0-0
Pre-requisite: NIL
Contents:
Descriptive and Inferential Statistics: Introduction, Descriptive Statistics, Probability Distributions, Inferential Statistics through hypothesis tests, Permutation & Randomization Test
Regression & ANOVA: Regression, ANOVA (Analysis of Variance)
Machine Learning: Introduction and Concepts, Differentiating algorithmic and model based frameworks Regression: Ordinary Least Squares, Ridge Regression, Lasso Regression, K Nearest Neighbors Regression & Classification
Supervised Learning with Regression and Classification techniques -1: Bias-Variance Dichotomy Model Validation Approaches, Logistic Regression, Linear Discriminant Analysis, Quadratic Discriminant Analysis, Regression and Classification Trees, Support Vector Machines, Ensemble Methods: Random Forest, Neural Networks, Deep learning
Unsupervised Learning and Challenges for Big Data Analytics: Clustering
Associative Rule Mining, Challenges for big data analytics
Prescriptive analytics: Creating data for analytics through designed experiments, Creating data for analytics through Active learning, Creating data for analytics through Reinforcement learning
Text Books:
1. Hastie, Trevor, et al. The elements of statistical learning. Vol. 2. New York: springer, 2009.
2. Montgomery, Douglas C., and George C. Runger. Applied statistics and probability for engineers. John Wiley & Sons, 2010.

Course Code: CSL 509
Course Title: WEB SEMANTICS
Structure (L-T-P): 3-0-0
Pre-requisite: NIL
Contents:
Brief history of the web and the foundation of the "semantic web" ontology, the Semantic Web stack technologies:URIs & namespaces, XML & XMLS datatypes, RDF, RDF/XML, RDFS, & Individuals, OWL 2. Application development using Semantic Web technologies. SPARQL—an RDF query language for heterogeneous data stores. Jena—a Semantic Web API for Java—Semantic Frameworks. The OWL dialects Full and DL with a concentration on OWL DL. OWL 2 features and its profiles EL, QL, and RL with a review of Lite. D2RQ and Federation concepts. Semantic Web design patterns. Semantic web and Web 2.0, Applications of Semantic Web.
Text Books:
1. Grigoris Antoniou, Frank Van Harmelen,A Semantic Web Primer,MIT Press, 2008.
2. Pascal Hitzler, Markus Krotzsch, Sebastian Rudolph,Foundations of Semantic Web Technologies,CRCPress, 2009.

3. Dean Allemang, James Hendler,Semantic Web for the Working Ontologist: Effective Modeling in RDFS andOWL,Morgan Kauffmann, ISBN-10: 0-12-373556-4.
4. Geroimenko, Vladimir; Chen, Chaomei (Eds.) 2nd ed., 2006, XIV, 248 p. 108 illus., Hardcover ISBN: 978-1-85233-976-0,Visualizing the Semantic Web XML-based Internet and Information Visualization,Springer-Verlag London Ltd; 2Rev Ed edition (Oct 2005).
5. Michael C. Daconta, Leo J. Obrst, Kevin T. Smith,The Semantic Web: A Guide to the Future of XML,Web Services, and Knowledge Management: A Guide to the Future of XML, Web Services and KnowledgeManagement,John Wiley & Sons (20 Jun 2003).[B] S Powers,Practical RDF (Paperback) ,OReilly (1 Aug 2003).
6. Thomas B. Passin,Explorer's Guide to the Semantic Web (Paperback),Manning Publications (8 Jul 2004).

Course Code: CSL510
Course Title: CLOUD ENABLED TECHNOLOGIES
Structure (L-T-P): 3-0-0
Pre-requisite: NIL
Contents:
Introduction to Cloud Computing: virtualization basics, Hypervisor, Types and services of Cloud. Storage and Management: clustering, Harnessing RAM, Scalable transactional systems. Datacenter: Virtualized datacenters, Datacenter Networking. Securing Cloud Storage: cloud security; CryptDB, privacy. Cloud Enabled Technologies: Big data concepts, Hadoop; Scalable data storage – NOSQL antecedents, MongoDB, Encryption techniques, SSL, Docker Containers. Programming frameworks: MapReduce recap & MRvDB , Dryad/DryadLINQ, Django. Case Study: Implementation examples of Cloud services.
Text Book:
1. Smith, James and Ravi Nair. Virtual Machines: Versatile Platforms for Systems and Processes, 1st ed., Elsevier, 2005.
2. Chandrasekaran, K. Essentials of Cloud Computing, 1st ed., Chapman and Hall/CRC, 2014.

Reference Books:
1. White, Tom. Hadoop: The Definitive Guide, 4th ed., O`Really, 2015
2. Bernard Golden, Amazon Web Services for Dummies, 2015.
3. Kavis, Michael J., Architecting the Cloud: Design Decisions for Cloud Computing Service Models, Wiley, 2014

Course Code: CSL511
Course Title: WIRELESS AND MOBILE COMMUNICATION
Structure (L-T-P): 3-0-0
Pre-requisite: NIL
Contents:
Introduction to wireless networks. IEEE 802.11 (Wireless LAN), Bluetooth, IEEE 802.15. Mobile Network layer. Mobile transport layer. Recent trends in wireless network and telecommunication systems like 3G, LTE, LTE-advanced, 4G and 5G. Cellular concepts: Cell structure, frequency reuse, cell splitting, channel assignment, handoff, interference, capacity, power control; MAC--SDMA, FDMA, TDMA, CDMA, Cellular Wireless Networks. Modulation schemes: BPSK, QPSK and variants, QAM, MSK and GMSK, multicarrier modulation, OFDM. GSM and GPRS. Mobile IP – Dynamic Host Configuration Protocol, Mobile adhoc networks - Routing Protocols– Multicast routing-TCP over Wireless Networks – Indirect TCP – Snooping TCP – Mobile TCP – Fast Retransmit / Fast Recovery – Transmission.
Text Book:
1. Schiller, Jochen. Mobile Communications, 2nd ed., Pearson Education, 2003.

Reference Books:
1. Rappaport, Theodore S. Wireless Communications: Principles and Practice. 2nd ed. Pearson, 2010.
2. Stallings, William. Wireless Communications & Networks. 2nd ed. Pearson, 2009.

Course Code: CSL512
Course Title: DISTRIBUTED SYSTEMS
Structure (L-T-P): 3-0-0
Pre-requisite: NIL
Contents:
Motivation and goals, broad overview and advantages of distributed systems, main characteristics absence of global clock and state and possibility of large network delays Issues in distributed systems such as transparency, scalability, security etc. Middlewares such as sockets, RPC, RMI etc. Distributed file systems- design issues- case studies with emphasis on NFS- distributed shared memory-coherence and coherence protocols- design issues and case studies, clock synchronization. Theoretical foundations- Lamport's clocks-Chandy-Lamport Global State recording algorithm- termination detection, leader election. Distributed mutual exclusion- Lamport, Ricart - Agrawal non-token based algorithm - token based algorithms- comparative performance analysis. Distributed deadlock detection issues- central and distributed detection algorithm-agreement protocols- model of processor failures- Byzantine agreement and other problems- solutions and applications. Distributed scheduling- issues, load distributing algorithms- load sharing policies and case studies- task migration and issues Recovery: introduction and basic concepts - backward and forward error recovery, Checkpointing: synchronous and asynchronous-atomic actions and commit protocols- voting protocols- reliable communication.
Text Books:
1. Singhal, M. and Shivaratri, N.G., Advanced Concepts in Operating Systems, Tata McGraw Hill, 2013.
2. Coulouris, G.F., Dollimore, J. and Kindberg, T., Distributed Systems: Concepts and Design, 4th ed., Pearson Education, 2012.

Additional Book:
1. Tanenbaum, A.S., Modern Operating Systems, 3rd ed., Prentice Hall, 2014.

Course Code: CSL513
Course Title: ADVANCED COMPUTER ARCHITECTURE
Structure (L-T-P): 3-0-0
Pre-requisites: NIL
Contents:
Review of Computer Organization and Architecture, RISC-CISC architecture, Instruction Set Principles and Examples, Memory addressing modes, Amdahl's Law, Introduction to computing models. Pipeline: schedule optimization, design of instruction, arithmetic, super and super scalar pipeline. Advance Pipelining: Hardware and Software technique for ILP, Dynamic Instruction Scheduling. Principles of scalable performance, performance metrics and measures, speedup performance laws, advanced processor technology, superscalar and VLIW processors. Elementary theory about dependence analysis, techniques for extraction of parallelism, branch prediction, dynamic scheduling, multiple issue and speculation, limits on instruction level parallelism. Memory hierarchy, cache performance, protection and examples of virtual memory. Cache Optimizations. Multiprocessors and multi-computers, Brief overview of SIMD, MIMD, vector architectures and multi-core architectures. Verified memory, cache memory organizations, shared memory organizations. Cache coherence. Thread level parallelism.
Text Book:
1. Hennessy, J.L.,Patterson, D.A. and Asanovi , K., Computer Architecture: A Quantitative Approach, 5th ed., Elsevier, 2013.

Reference Books:
1. Hwang, K.,Ramachandran, A. and Purushothaman, R., Advanced Computer Architecture: Parallelism, Scalability, Programmability,Tata McGraw Hill,2004.
2. Sima, D., Fountain, T.J. and Kacsuk, P. Advanced Computer Architectures: ADesign Space Approach, Pearson Education, 2005.

Course Code: CSL514
Course Title: Advanced Cryptography
Structure (L-T-P): 3-0-0
Pre-requisite: CSL507
Contents:
Number theory, Probability and information theory, Probable security, Shannon's theory, Computational complexity, CRT. Symmetric key cryptography: Introduction, Classical ciphers, Linear and Differential

cryptanalysis, S-box design and analysis. Asymmetric key cryptography: Introduction, RSA algorithm, Rabin cryptosystem, ElGamal cryptography, Elliptic curve cryptography. Key management: Key establishment and Group key agreement protocols. Hash Functions and Digital Signature: MD-4, MD-5, SHA-256, SHA-512, Whirlpool. Digital signature using RSA, ElGamal and Elliptic curve cryptography, DSS. Other advanced topics: Identity based cryptosystem, Attribute based cryptography, Secure multiparty computation, Visual cryptography, Threshold cryptography, Quantum cryptography, Zero- knowledge proofs, Secret sharing schemes, Steganography: image, video, audio, text. Watermarking: invisible, visible.

Text Books:

1. Forouzan, Behrouz A., and Debdeep Mukhopadhyay. Cryptography and Network Security (Sie). McGraw-Hill Education, 2011.
2. Douglas R. Stinson. Cryptography: Theory and Practice, CRC press.
3. Cimato, Stelvio, and Ching-Nung Yang, eds. Visual cryptography and secret image sharing. CRC press, 2017.
4. Cox, Ingemar, et al. Digital watermarking and steganography. Morgan Kaufmann, 2007.

Research papers:

1. Beimel, Amos. "Secret-sharing schemes: a survey." International Conference on Coding and Cryptology. Springer, Berlin, Heidelberg, 2011.
2. Bruss, Dagmar, et al. "Quantum cryptography: A survey." ACM Computing Surveys (CSUR) 39.2 (2007): 6.
3. Dutta, Ratna, and Rana Barua. "Overview of Key Agreement Protocols." IACR Cryptology ePrint Archive 2005 (2005): 289.
4. Pérez-Freire, Luis, et al. "Watermarking security: a survey." Transactions on Data Hiding and Multimedia Security I. Springer, Berlin, Heidelberg, 2006. 41-72.
5. Petitcolas, Fabien AP, Ross J. Anderson, and Markus G. Kuhn. "Information hiding-a survey." Proceedings of the IEEE87.7 (1999): 1062-1078.
6. Goyal, Vipul, et al. "Attribute-based encryption for fine-grained access control of encrypted data." Proceedings of the 13th ACM conference on Computer and communications security. Acm, 2006.

Course Code: CSL515
Course Title: OPEN SOURCE SOFTWARE
Structure (L-T-P): 3-0-0
Pre-requisites: NIL
Contents:

PHILOSOPHY: Notion of Community–Guidelines for effectively working with FOSS community–, Benefits of Community based Software Development –Requirements for being open, free software, open source software –Four degrees of freedom – FOSS Licensing Models – FOSS Licenses – GPL- AGPL- LGPL – FDL – Implications – FOSS examples. LINUX: Linux Installation and Hardware Configuration – Boot Process-The Linux Loader (LILO) – The Grand Unified Bootloader (GRUB) – Dual-Booting Linux and other Operating System – Boot-Time Kernel Options- X Windows System Configuration-System Administration – Backup and Restore Procedures- Strategies for keeping a Secure Server. PROGRAMMING LANGUAGES: Programming using languages like Python or Perl or Ruby. PROGRAMMING TOOLS AND TECHNIQUES: Usage of design Tools like Argo UML or equivalent, Version Control Systems like Git or equivalent, – Bug Tracking Systems- Package Management Systems. FOSS CASE STUDIES: Open Source Software Development – Case Study – Libreoffice –Samba. The Global Scope of Open Source and Free Software Licensing, Major developments related to open source moment, Open source the Indian scenario, Negative Effects of Open Source and Free Software Licensing, Legal Impacts of Open Source and Free Software Licensing, Software Development Using Open Source and Free Software Licenses.

Text Book:

1. Ellen Siever, Stephen Figgins, Robert Love, Arnold Robbins, “Linux in a Nutshell”, Sixth Edition, OReilly Media, 2009.

Reference Books:

1. Philosophy of GNU URL: http://www.gnu.org/philosophy/.
2. Linux Administration URL: http://www.tldp.org/LDP/lame/LAME/linux-admin-made-easy/.
3. The Python Tutorial available at http://docs.python.org/2/tutorial/.
4. Perl Programming book at http://www.perl.org/books/beginning-perl/.
5. Ruby programming book at http://ruby-doc.com/docs/ProgrammingRuby/.
6. Version control system URL: http://git-scm.com/.
7. Samba: URL: http://www.samba.org/.
8. Libre office: http://www.libreoffice.org/.

M. Tech (Electrical Engineering) specialization in Power System & Control
OVERALL CREDIT STRUCTURE

S. No	Category	Symbol	M. Tech (Credits)
1	**PG Core**	**PC**	**30**
1.1	Departmental Core	DC	13
1.2	Project Phase-I	P1	05
1.3	Project Phase-II	P2	10
1.4	Seminar	SM	02
2	**PG Elective**	**PE**	**25**
2.1	Specialization Electives	SE	19
2.2	Open Courses	OC	06
	TOTAL REQUIREMENT		**55 (Minimum)**

Postgraduate Core (PC)		**L-T-P**	**Credit**
EED501	Project Phase-I	-	05
EED502	Project Phase-II	-	05
EED503	Seminar	-	02
EEL501	Non Linear Control System	3-0-0	03
EEL502	Power Electronics Circuit Design and Analysis	3-0-0	03
EEL503	Grid Connected Renewable Energy System	3-0-0	03
EEL504	FACTS	3-0-0	03
EEP501	Advance Power and Drives Lab	0-0-2	01
Specialization Elective (SE)		**L-T-P**	**Credit**
EEL505	Optimal Control Theory	3-2-0	04
EEL508	Wind Energy	3-0-0	03
EEL506	Process Control & Instrumentation	3-0-0	03
EEL513	EHVAC Transmission	3-0-0	03
EEL516	Distribution System Modeling And Analysis	3-0-0	03
EEL517	Power System Planning	3-0-0	03
EEL512	Power System Dynamics And Stability	3-0-0	03
EEL507	Computer Aided Power System Analysis	3-0-0	03
EEL511	Digital Protection & Power System	3-0-0	03
EEP511	Digital Protection & Power System	0-0-2	01
EEL519	Smart Grid Technology	3-0-0	03
EEL521	Power System Deregulation	3-0-0	03
EEL522	Robust and Adaptive Control	3-0-0	03
EEL523	Sliding Mode Control	3-0-0	03
EEP502	Power System Lab	0-0-2	01

M. Tech (Electrical Engineering) specialization Power Electronics & Drives
OVERALL CREDIT STRUCTURE

S. No	Category	Symbol	M. Tech (Credits)
1	**PG Core**	**PC**	**30**
1.1	Departmental Core	DC	13
1.2	Project Phase-I	P1	05
1.3	Project Phase-II	P2	10
1.4	Seminar	SM	02
2	**PG Elective**	**PE**	**25**
2.1	Specialization Electives	SE	19
2.2	Open Courses	OC	06
	TOTAL REQUIREMENT		**55 (Minimum)**

Postgraduate Core (PC)		**L-T-P**	**Credit**
EED501	Project Phase-I	-	05
EED502	Project Phase-II	-	05
EED503	Seminar	-	02
EEL501	Non Linear Control System	3-0-0	03
EEL502	Power Electronics Circuit Design and Analysis	3-0-0	03
EEL503	Grid Connected Renewable Energy System	3-0-0	03
EEL504	FACTS	3-0-0	03
EEP501	Advance Power and Drives Lab	0-0-2	01
Specialization Elective (SE)		**L-T-P**	**Credit**
EEL505	Optimal Control Theory	3-2-0	04
EEL508	Wind Energy	3-0-0	03
EEL510	Advanced AC Electric Drives	3-0-0	03
EEL509	Power Quality Mitigation Techniques	3-0-0	03
EEL514	Modeling and Analysis of Electrical Machines	3-0-0	03
EEL515	Computer Aided Special Machine Design	2-0-0	02
EEP515	Computer Aided Special Machine Design Lab	0-0-2	01
EEL518	Advanced Electric Machines	3-0-0	03
EEL520	Switch Mode Power Converter and Its Applications	3-2-0	04
EEL506	Process Control & Instrumentation	3-0-0	03
EEP503	Power Electronics and Drives Lab	0-0-2	01
EEL522	Robust and Adaptive Control	3-0-0	03
EEL523	Sliding Mode Control	3-0-0	03

Course Syllabi (Post Graduate)
Department of Electrical Engineering

Course Code: EEL501
Course Title: NONLINEAR CONTROL SYSTEM
Structure (L-T-P): 3-0-0
Prerequisite: EEL251, EEL254
Contents:
State variable analysis & design: Concept of state and state variables, Diagonalisation, Eigen values and eigenvector, Determination of state transition matrix, Solution of state equations-properties of the state transition matrix, Computation of state transition matrix, Computation by techniques based on the cayley-hamilton theorem, Sylvester's expansion theorem. Concepts of controllability and observability, Effect of pole-zero cancellation in transfer function. Pole placement by state feedback, State observer systems. Introduction to design of control systems, Design of phase lag and phase lead controllers in time domain as well as frequency domain.
Nonlinear systems: Behavior of nonlinear systems, Investigation of nonlinear systems. Study of common physical nonlinearities-saturation, Friction, Backlash, Relay, Multivariable etc.
The phase plane method- basic concepts; Singular points: Nodal point, Saddle point, Focus point, Centre or vortex point; Stability of non-linear systems: Limit cycles; Construction of phase trajectories: Construction by analytical method, Construction by graphical methods.
The Describing function method: Basic concepts, Derivation of describing functions- dead zone and saturation, Relay with dead-zone, Hysteresis, Backlash.
Stability analysis by describing function method: Relay with dead zone, Relay with hysteresis, and Stability analysis by gain-phase plots. Jump resonance.
Liapunov's stability analysis: Introduction, Liapunov's stability criterion, Basic stability theorems, Liapunov functions, Instability. Direct method of liapunov for the linear systems, Methods of constructing liapunov functions for nonlinear systems.
Text Book:
1. Control Systems (Principles & Design) by M.Gopal, Tata Mc.Graw Hill Publishing Company Ltd, 3rd Edition (2008).

Reference Books:
1. Systems and Control by Stanislaw H.Zak, Oxford University Press (2003).
2. Non Linear Systems, by Hassan K. Khallil, Prentice Hall, Inc. (Pearson Education), Publications, 3rd edition (2002).
3. Ogata K., Modem Control Engineering, 2nd Edition, PHI.
4. Doyle, J.C., Francis, B.A. and Tannenbaum, A.R., Feedback Control Theory, Dover Publications (2009).

Course Code: EEL502
Course Title: POWER ELECTRONIC CIRCUIT DESIGN AND ANALYSIS
Structure (L-T-P): 3-0-0
Prerequisite: EEL255
Contents:
Switched mode converters: Non-isolated and isolated topologies (flyback, forward, Cuk, SEPIC, Zeta, Half bridge, Push-pull and Bridge converter), Continuous and discontinuous modes of operations, Steady state & dynamic analysis, Modeling and control, EMI issues.
Classification of resonant converters, Basic resonant circuit concepts, Load resonant converters, Resonant switch converters, Zero voltage switching.
Multilevel converters: H- Bridge, Diode clamped, Cascaded and modular, Multilevel converter, Principles, Control and applications.
Other advanced converters: Multi pulse converters, High power factor converter, Matrix converter.
Reactive elements in power electronic systems, Design of inductor, Design of transformer, Capacitors for power electronic applications.
Heat sink calculations.
Text Book:
1. N. Mohan, T. Undeland, and W. Robbins, "Power Electronics Converters, Applications, and Design," Third edition, 2003, John Wiley and Sons Inc.

Reference Books:
1. Rashid M.H. "Power Electronics, circuit, Devices and applications", Prentice Hall of India.
2. Ericksson, R., and Maksimovic D., Fundamentals of Power Electronics, 2nd ed., Springer, 2013.

Course Code: EEL503
Course Title: GRID CONNECTED RENEWABLE ENERGY SYSTEM
Structure (L-T-P): 3-0-0
Prerequisite: EEL255, EEL256
Contents:
Characteristic of Converters: Functional characteristics of power converters, Converter designs ,Indirect converter Electromagnetic compatibility (EMC) Protective measures during power conditioning, Grid Protection , Grid Effects 247 General compatibility and interference Output behavior of wind power plants, Voltage response in grid supply Harmonics and subharmonics ,Voltage faults and the fault-ride-through (FRT) , Remedial Measures against Grid Effects and Grid Resonances ,Filters design , Function of harmonic absorber filters and compensation units, Grid Control and Protection ,Grid Connection Rules. power system economics and management
Power conditioning and maximum power point tracking (MPPT) algorithms MPPT algorithms based on based on buck- and boost-converter topologies, Maximum power point tracking (MPPT) algorithms,
Inverter control topologies for stand-alone and grid-connected operation. Analysis of inverter at fundamental frequency and at switching frequency. Feasible operating region of inverter at different power factor values for grid-connected systems, Stand-alone PV systems. Consumer applications, residential systems, PV water pumping, PV powered lighting, rural electrification, etc., Grid-connected (utility interactive) PV systems. Active power filtering with real power injection, Modeling and simulation of stand-alone and grid-connected PV systems.
Hybrid wind–photovoltaic energy systems
Design and configuration of a wind–photovoltaic (PV); hybrid energy system Modelling and simulation of a wind–photovoltaic (PV); hybrid energy system Sizing and optimization of a wind–photovoltaic (PV); hybrid energy system
Text Book:
1. R. Messenger, J. Ventre, Photovoltaic Systems Engineering, 2nd ed., CRC Press, 2004.
2. S. Heier, "Grid Integration of wind energy conversion systems", Wiley, New York (USA).

Reference Books:
1. A. Goetzberger, V. U. Hoffmann, Photovoltaic Solar Energy Generation, Springer-Verlag, 2005.
2. L. Castaner, S. Silvestre, Modeling Photovoltaic Systems Using PSpice, John Wiley & Sons, 2002.
3. R. J. Komp, Practical photovoltaics: electricity from solar cells, 3rd ed., Aatec Publications, 2001.
4. M. R. Patel, Wind and Solar Power Systems, CRC Press, 1999.
5. R. H. Bube, Photovoltaic Materials, Imperial College Press, 1998.
6. T. Markvart, Solar Electricity, John Wiley & Sons, 1994.

Course Code: EEL504

Course Title: FACTS
Structure (L-T-P): 3-0-0
Prerequisite: EEL256, EEL255
Contents:
Introduction of semiconductor devices, Need of FACTS, Steady state and dynamic problems in AC systems, Power flow, types of conductors in transmission line.
Flexible AC transmission systems (FACTS) : Basic realities & roles, types of facts controller, principles of series and shunt compensation. Thermal ratings.
Description of static VAR compensators (SVC), Thyristor controlled series compensators (TCSC), Static phase shifters (SPS), Static condenser (STATCON), Static synchronous series compensator (SSSC) and Unified power flow controller (UPFC). IEEE standards. DVR: circuit operation and control.
modelling and analysis of FACTS controllers. Control strategies to improve system stability. Harmonics, harmonics creating loads, modeling, harmonic power flow, mitigation of harmonics, filters, passive filters.
location of FACTS devices, real life examples, BEP.
Text Books:
1. Hingorani, N. G. and Gyugi, L., Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, IEEE Press, Delhi, 2001.
2. Padiyar, K.R., FACTS Controllers in Power Transmission and Distribution, New Age International Publisher, 2013.

Reference Book:
Ghosh, A. and Ledwich, G., Power Quality Enhancement Using CustomPower Devices, Springer Verlag, 2012.

Course Code: EEL505
Course Title: OPTIMAL CONTROL THEORY
Structure (L-T-P): 3-2-0
Prerequisite: EEL254
Conents:
Basic mathematical concepts, conditions for optimality, Parameter optimization. Calculus of variations : problems of Lagrange. Mayer and Bolza. Euler-Language equation and transversality conditions, Lagrange's multipiliers. Pontryagin's manimum principle: theory, application to minimum time, energy and control effort problems, and terminal control problem. Dynamic programming : Belaman's principle of optimality, multistage decision processes. Application to optimal control. Linear regulator problem : matrix Riccati equation and its solution, tracking problem. Brief introduction to H-2 and H-infinity optimal control problem.
Text Books:
1. Kirk, D. E., Optimal Control Theory: An Introduction, Dover Publications 2004.
2. Kwakernaak, H. and Sivan, R., Linear Optimal Control Systems, Wiley- Interscience, 1972
3. KEMIN ZHOU with JOHN C. DOYLE and KEITH GLOVER ROBUST AND OPTIMAL CONTROL PRENTICE HALL, Englewood Clis, New Jersey 07632
4. D. subbaram naidu, optimal control systems, CRC Press LLC, 2003

Reference Books:
1. Anderson, B.D.O. and Moore, J.B., Optimal Control: Linear Quadratic Methods, Dover Publications, 2007.
2. Sage, A.P. and White, C.C., Optimum Systems Control, 2nd ed., PrenticeHall, 1977.
3. Tabak, D. and Kuo, B.C., Optimal Control by Mathematical Programming,Prentice Hall, 1971.
4. Athans, M. and Falb, P.L., Optimal Control: An Introduction to the Theory and its Applications, Dover Publications, 2007

Course Code: EEL506
Course Title: PROCESS CONTROL & INSTRUMENTATION
Structure (L-T-P): 3-0-2
Prerequisite: EEL252, EEL254
Contents:
An introduction to automatic process control, basic concepts and techniques, selection of controlled variables & manipulated variables, controller selection and tuning procedures, dynamic behavior of process model, special feedback techniques, direct synthesis and adaptive control, decoupling and feed-forward methods, various multiple loop feedback control strategies widely used in industries, such as cascade, ratio, split-range, selective, feed-forward compensation, sensors, transmitters, transducers and actuators, final control elements, selection of a controller's action and direction, basics of industrial automation systems: PLCs and Distributed Control Systems (DCS), their features and applications.
Types of processes: Dead time signal and multi-capacity, self and non-self-regulating , interaction and non-interaction, linear and non-linear, process gain , process reaction curve, process time constant and constant step analysis method for finding time constant, dead time, dynamic element in control loop, PID control of processes, tuning of PID controllers, basic idea of MPC.
Text Books:
1. Shinskey, F.G., Process Control Systems: Application, Design and Tuning, 4^{th} ed., McGraw Hill, 1996.
2. Chaudhuri, U.R. and Chaudhuri, U.R., Fundamentals of Automatic Process Control, CRC Press/Taylor and Francis, 2013.

Reference Books:
1. Rao, A.R., Process Control Engineering, Gordon and Breach Science Publishers, 1993.
2. Bequette, B.W., Process Control: Modeling, Design and Simulation, Prentice Hall, 2010.

Course Code: EEL507
Course Title: COMPUTER AIDED POWER SYSTEM ANALYSIS
Structure (L-T-P): 3-0-0
Prerequisite: EEL251, EEL353
Contents:
Review of matrix operations, Graph theory, and Various circuit incidence matrices, Primitive network and matrix, Formation of various network matrices by singular transformation interrelations.
Building algorithm for bus impedance matrix, Modification of bus impedance matrix for change of reference bus for network changes, Formation of bus admittance matrix and modification, Gauss elimination, Node elimination (Kron reduction), LU factorization, Schemes of ordering, Sparsity, Calculation of z bus elements for y bus.
Representation of three phase network elements, Treatment under balanced and unbalanced excitation, Transformation matrices, Unbalanced elements.
Network short circuit studies using Z bus, Short circuit calculations for various types of faults.
Load flow studies, its importance. Classification of buses, Load flow techniques, Iterative solutions and computer flow charts using gauss-seidel and newton-raphson methods, Decoupled and fast decoupled load flow solution, Representation of regulating and off nominal ratio transformers, Comparison of methods.
Introduction to AC-DC load flow problems: Formation and solutions.
Optimal power flow: Solution methods of OPF, Steepest gradient method, OPF using newton's method, Successive quadratic programming, Successive linear programming, Interior point methods and variants, Security and environmental constraint OPF.
Power system security, Contingency analysis using z bus sensitivity factors.
Introduction to state estimation, maximum likelihood weighted least square error estimation, State estimate of an AC network.
Text Book:

1. G.W. Stagg & A.H EI-Abaid, “Computer methods in Power system analysis”, McGraw Hill, New York.
2. M A Pai, Dheeman Chatterjee, “Computer Techniques in Power System Analysis”, McGraw Hill Education
3. Computer Methods In Power System Analysis, G.W. Stagg & A.H. El-Abiad, Mc-Graw Hills

Reference Books:

1. Arrillaga, C.P Arnold &Harker, “Computer Modeling of Electrical Power Systems”, John Wiley & Sons
2. John J.Grainger and W.D.Stevenson, “Power System Analysis”, McGraw Hill, New York, 1994.
3. A.J. Wood & W.F. Wollenberg, “Power Generation, Operation, and Control”, 2nd Edn, John Wiley & Sons, New York, 1996.
4. O.I. Elgerd, “Electric Energy Systems Theory: An Introduction”, McGraw Hill, New York, 1982.

Course Code: EEL508
Course Title: WIND ENERGY
Structure (L-T-P): 3-0-0
Prerequisite: EEL255
Contents:

Wind turbine, Wind turbine architecture, Turbine aerodynamic model (Cp-λ characteristics), Wind generators compared with conventional power plant, Grid code regulation for integration of wind generation, MPPT

Synchronous generator modelling, Steady state operation, Excitation control, Prime mover control.

Induction machine construction, Steady state characteristics, Fixed speed induction generator (FSIG) for wind generation, FSIG model as a voltage behind a transient reactance. Dynamic performance of FSIG wind turbines.

Doubly fed induction generator (DFIG) construction, Steady state characteristics, Control strategies for a DFIG, Dynamic performance assessment, Fully rated converter based (FRC) wind turbines, Synchronous generator based (FRC-SG), Induction generator based(FRC-IG).

Influence of rotor dynamics on wind turbine operation: Blade bending dynamics, Derivation of three mass models, two mass models.

Power system stabilizers for a synchronous generator, DFIG, FRC wind farms. Integration of wind farms into the power systems. Wind turbine control for system contingencies: Frequency regulation, Fault ride through (FRT) capability.

Text Book:

1. S.N. Bhadra, D. Kastha, S. Banerjee, "Wind Electrical Systems, Oxford University Press, 2013.
2. D. P. Kothari, Wind Energy Systems and Applications, Narosa, 2013.

Reference Books:

1. Olimpo Anaya-Lara, Nick Jenkins, J. Ekanayake, P. Cartwright, Mike Hughes, “Wind Energy Generation: Modelling and Control”, Wiley Publication,2009.
2. S. Heier, “Grid Integration of wind energy conversion systems”, Wiley, New York (USA).
3. Johnson Gary L. “Wind Energy System”, Prentice Hall Inc. Englewood Cliffs N. J. (USA).
4. L. L. Freris, “Wind Energy Conversion System”, Prentice Hall (U.K.).

Course Code: EEL509
Course Title: POWER QUALITY MITIGATION TECHNIQUES
Structure (L-T-P): 3-0-0
Prerequisite: EEL256, EEL353
Contents:

Power quality standards and monitoring: Introduction, State of the art on power quality standards and monitoring, Power quality terminologies, Power quality definitions, Power quality standards, Power quality monitoring.

Passive shunt and series compensation, Active shunt compensation: DSTATCOMs,

Active series compensation, Unified power quality compensators, Loads that cause power quality problems: Introduction, State of art on nonlinear loads, Classification of nonlinear loads, Principle operation and control of nonlinear loads, Analysis and design of nonlinear loads, Modeling simulation and performance of nonlinear loads, Passive power filters, Shunt active power filters, Series active power filters, Hybrid power filters.

Text Book:

1. Bhim Singh, Ambrish Chandra and Kamal Al-Haddad , Power Quality Mitigation Techniques, Wiley, 2015

Reference Books:

1. Arindam Gosh, Gerard Ledwich, Power Quality Enhancement using custom Power devices, Kluwer Academic Publishers, 2002
2. A. Moreno- Munoz (Ed.), Power Quality Mitigation Technologies in a Distributed Systems, Springer, 2007

Course Code: EEL510
Course Title: ADVANCED AC ELECTRIC DRIVES
Structure (L-T-P): 3-0-2
Prerequisite: EEL254, EEL255
Contents:

Power electronics converter for ac drive control, Voltage source inverter, Current source inverter. Multilevel converter, Different PWM techniques for two level and multi-level converter. Space vector modulation techniques, Selective harmonic elimination techniques.

Inverter fed AC drives : Constant v/f controlled induction motors, Slip power controlled induction motor drives, Vector controlled induction motor drives : Direct vector control, Indirect vector control, Sensor less vector control, Tuning of the vector controller, Parameter sensitivity of the indirect vector controlled induction motor drives, Flux weakening operation , Adaptive control techniques.

Permanent magnet synchronous motor drive: Synchronous machine permanent magnet, Vector control of PM synchronous motor and different control strategies; Flux weakening operation; Speed controller design; Sensorless control, Parameter sensitivity.

Principle of soft switching in inverters and converters.

Text Book:

1. Krishnan R., “Electric Motor Drives – Modeling, Analysis and Control”, Prentice Hall of India Private Limited. 2007.

Reference Books:

1. Holmes D.G., Lipo T.A., “Pulse Width Modulator For Power Converters – Principles and Practice”, IEEE Press, John Wiley & Sons, Inc. 2003.
2. Murphy J. M. D. and Turnbull F. G., “Power Electronics Control of AC Motors”, Peragmon Press. 1990.
3. Bose B. K., "Power Electronics and Variable Frequency Drives", IEEE Press, Standard Publisher Distributors. 2001.
4. Bose B. K., “Modern Power Electronics and AC Drives”, Pearson Education. 2008.
5. Dubey G. K., "Power Semiconductor Controlled Drives", Prentice-Hall International Editions. 1989.

Course Code: EEL511
Course Title: DIGITAL PROTECTION OF POWER SYSTEM
Structure (L-T-P): 3-0-2

Prerequisite: EEL256, EEL353, EEL355

Contents:

Review on power system protection schemes: Over current relay, Differential, and Distance.

Introduction to Numerical Relay- Numerical protection schemes of power system equipments, Different methods to compute the phasor, Phasor based protection, Detection of fault

Distance relaying: Algorithms for different types of fault, Classification of fault, Problems with distance relay in the presence of series compensation and three terminal line, Performance of distance relay during power swing and load encroachment, Time domain algorithms, Travelling wave based protection, Fault location algorithms.

Directional relay: Phasor based algorithms, sequence component based algorithms, Problems with directional relay with the presence of series compensation.

Differential protection: Phasor based differential protection of transmission line, Transformer, Bus bar, Performance during CT saturation.

Adaptive relaying:- Over current, Distance, Differential relaying.

WAMS: - Wide area measurement System, Phasor measurement unit based system protection schemes.

Switchgear – ACBs, SF6 CB, VCBs and short circuit testing. Problems in relaying due to CTs and transient in CCVTs

Text Book:

1. A.G.phadke, S.H. Horowitz, Power system relaying, 3rd ed, willeyPublisers, 2010,

Reference Books:

1. A. G. Phadke, J. S.Thorp, Computer Relaying for Power Sytem, John willey and Sons, 2009
2. P. M.Anderson, Power System protection, Mac Graw Hill 1999
3. G. Zeigler, Numerical Distance Protection, Willey Publisher

Course Code: EEL512

Course Title: POWER SYSTEM DYNAMICS & STABILITY

Structure (L-T-P): 3-0-0

Prerequisite: EEL256, EEL353

Contents:

Definitions and classification of power system stability synchronous machine modeling for stability studies: Basic equations of a synchronous machine, The dq0 transformation, Per unit representation, Equivalent circuits for direct and quadrature axes, Steady state analysis, Transient performance, Magnetic saturation, Equations of motion, Swing equation, Simplified model with ammortisseurs neglected, Constant flux linkage model.

Excitation and **governing system**: Elements of excitation systems, Types of excitation system, dc, ac and static excitation systems, System representation by block diagram and state equations, Prime mover control system.

Small signal stability of power systems: Fundamental concepts of stability of dynamic systems, Eigen properties of the state matrix, Small signal stability of a single machine infinite bus system, Effects of excitation system, Power system stabilizers, System state matrix with ammortisseurs, Small signal stability of multi machine systems. Use of PSS to improve small signal stability.

Transient stability: Equal area criterion, Numerical integration methods, Simulation of power system dynamic response, Direct methods of transient stability analysis – description of transient energy function approach, Limitations of the direct methods. Methods of improving transient stability.

Voltage stability: Basic concepts related to voltage stability, Voltage collapse, Voltage stability analysis – static and dynamic analysis, The continuation power flow analysis, Bifurcation methods prevention of voltage collapse.

Text Book:

1. P. Kundur, 'Power System Stability and Control', 1st ed., McGraw Hill Education, 2006.

2. K.R. Padiyar, 'Power System Dynamics', 2nd ed., BS Publications, 2002.

Reference Books:.

1. P.M Anderson and A.A Fouad 'Power System Control and Stability', 2nd ed., Wiley India Pvt. Ltd., 2008.
2. P. W. Sauer and M. A. Pai, "Power system dynamics and stability", Prentice-Hall, 1997.

Course Code: EEL513

Course Title: EHV AC TRANSMISSION

Structure (L-T-P): 3-0-0

Prerequisite: EEL256, EEL353

Contents:

Role of EHV AC Transmission, Standard transmission voltages, Average value of line parameters, Power handling capacity.

Line parameters, Properties of bundled conductors, Resistance, Inductance and capacitance of bundled conductor lines, Temperature rise of conductors and current carrying capacity. Voltage gradients on conductors: Charge potential relations for multi-conductor lines, Surface voltage gradient on conductors, Distribution of voltage gradient on sub conductors of bundle.

Corona Effects: Corona loss, Attenuation of traveling waves, Audible noise, Limits for audible noise, AN measurement and meters, Day night equivalent noise level, Limits for radio interference fields, RI excitation function, Measurements of RI, RIV, Excitation function.

Switching Over voltages: Origin of over voltages and their types, Over voltages due to interruption of low inductive current and interruption of capacitive currents, Reduction of switching surges on EHV systems.

Power frequency over voltages: Problems at power frequency, No-load voltage conditions and charging current, Voltage control using synchronous condensers, Sub synchronous resonance in series-capacitor compensated lines, State reactive compensating schemes.

Operational aspects of Power flow: Line loadability, Effects of over load, reactive power limitations and over voltage problem.

Text Book:

1. Begamudre, "EHV AC Transmission engineering", Wiley Easter Ltd. 2nd Ed.

Reference Books:

1. EPRI, Palo Alto, "Transmission line reference book 345 KV".
2. Rao S., "EHV AC & HVDC Transmission Systems" - Khanna Pub
3. Edison Electric Institute, "EHV transmission reference book", GE Co.
4. Rudenberg, "Transient performance of electric power systems" McGraw Hill.

Course Code: EEL514

Course Title: MODELING AND ANALYSIS OF ELECTRICAL MACHINES

Structure (L-T-P): 3-0-0

Prerequisite: EEL253

Contents:

Energy state functions, Modeling of electromechanical systems Matrix method and use of generalized circuit theory of machines. Different methods of transformation, Phase variable instantaneous symmetrical component techniques, Development of basic performance equation and analysis of different rotating machines such as D.C., Synchronous and induction machines, Dynamics and transients in electric machines. Switching transients and surges, Transient and short circuit studies on alternators run-up switching and other transients in induction machines relevant computer techniques for machine analysis. Modelling of special electrical machines.

Text Book:

1. P.C. Krause, "Analysis of Electric Machinery and Drive Systems, 3rd Edition," IEEE Press 2013, ISBN: 978-1-118-02429-4

Reference Books:

1. P. C. Krause, O. Wasynczuk, and S. D. Sudhoff, Analysis of electric machinery and drive systems, 2nd ed., New York: Wiley-IEEE, 2002.
2. Chee-MunOng, "Dynamic Simulation of Electric Machinery: Using MATLAB/SIMULINK," Prentice Hall 1997, ISBN: 0137237855
3. Lyshevski, Sergey Edward, "Electromechanical systems, electric machines and applied mechatronics, CRC Press, 2000.
4. D. W. Novotny and T. A. Lipo, 1996, Vector Control and Dynamics of AC Drives, Clarendon Press, New York.
5. B. K. Bose, 2002, Modern Power Electronics and AC Drives, Prentice Hall, New Jersey.
6. R. Krishnan, 2001, Electric Motor Drives Modeling, Analysis and Control, Prentice Hall, New Jersey.

Course Code: EEL515
Course Title: COMPUTER AIDED SPECIAL MACHINE DESIGN
Structure (L-T-P): 2-0-2
Prerequisite: EEL253, EEL351
Contents:

Synchronous Reluctance Motors:
Constructional features – Types – Axial and Radial flux motors – Operating principles – Variable Reluctance and Hybrid Motors – SYNREL Motors – Voltage and Torque Equations - Phasor diagram - Characteristics.

Stepping Motors:
Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi stack configurations – Torque equations – Modes of excitations – Characteristics – Drive circuits – Microprocessor control of stepping motors – Closed loop control.

Switched Reluctance Motors:
Constructional features – Rotary and Linear SRMs - Principle of operation – Torque production Steady state performance prediction-Analytical method -Power Converters and their controllers Methods of Rotor position sensing – Sensorless operation – Closed loop control of SRM - Characteristics.

Permanent Magnet Brushless D.C. Motors:
Permanent Magnet materials – Magnetic Characteristics – Permeance coefficient -Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations –Commutation – Power controllers – Motor characteristics and control.

Permanent Magnet Synchronous Machines:
Principle of operation – Ideal PMSM – EMF and Torque equations – Armature reaction MMF –Synchronous Reactance – Sinewave motor with practical windings - Phasor diagram – Torque/speed characteristics - Power controllers - Converter Volt-ampere requirements.

Text Books:

1. K.Venkataratnam, 'Special Electrical Machines', Universities Press (India) Private Limited, 2008.

Reference Books:

1. T.J.E. Miller, 'Brushless Permanent Magnet and Reluctance Motor Drives', Clarendon Press, Oxford, 1989.
2. R.Krishnan, 'Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application', CRC Press, New York, 2001.
3. P.P. Aearnley, 'Stepping Motors – A Guide to Motor Theory and Practice', Peter Perengrinus London, 1982.
4. T. Kenjo and S. Nagamori, 'Permanent Magnet and Brushless DC Motors', Clarendon Press, London, 1988.
5. T. Kenjo, 'Stepping Motors and Their Microprocessor Controls', Clarendon Press London, 1984.

Course Code: EEL516
Course Title: DISTRIBUTION SYSTEM MODELING AND ANALYSIS
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Introduction to distribution system, Nature of loads: Individual customer load, Distribution transformer loading, Feeder load, Voltage drop calculations using allocated loads. Approximate methods of analysis: K factors, Uniformly distributed loads, Lumping loads in geometric configurations, Series impedance of overhead lines, Series impedance of underground lines, Shunt admittance of overhead and underground lines. Distribution system line models, Voltage regulation, Three phase transformer model, Load model.

Distribution system load flow for balanced and unbalanced system radial and weekly meshed systems, Short circuit analysis of distribution systems, Basic of distribution system reliability, Voltage regulation in distribution systems, Distribution system protection issues, Distributed generation integration issues in distribution system**,** optimal placement of capacitor banks in distribution network.

Text Book:

1. Kersting W. H., Distribution system modeling and analysis, CRC press, New York, 2002.

Reference Books:

1. Brown R. E., Electric power distribution reliability, CRC press, New York, 2009.
2. Nothcote-Green J. and Willson R., Control and automation of electric power distribution systems, CRC press, New York, 2007.
3. Chowdhury A. A. and Koval D. O., Power distribution system reliability practical methods and applications, Wiley IEEE press, 2009.

Course Code: EEL517
Course Title: POWER SYSTEM PLANNING
Structure (L-T-P): 3-0-0
Prerequisite: EEL256, EEL353
Contents:

Basic Planning Issues: Introduction, Power system elements and structure, Static and dynamic planning, Transmission and distribution planning; Long-term and short-term planning, Basic issues in transmission planning; Optimization Techniques: Introduction; Problem definition and modelling, Mathematical and heuristic solution algorithms;

Economic Principles: Introduction, Definition of various terms, Cash flow concept: Time value of money and economic terms, Economic analysis: Present worth method, Annual cost method, Rate of return method;

Load Forecasting: Introduction, Load characteristics and driving parameters, Spatial load forecasting, Long-term forecasting methods: Trend analysis, Econometric modelling, end-use analysis, Combined analysis, load forecasting of small and large scale utility;

Single and multi-bus generation expansion planning: Problem description and mathematical formulation, Objective functions and constraints, Solution approaches; **Reliability indices**

Substation Expansion Planning: Problem definition and formulation, Mathematical view: Objection function and constraints, Required data; Solution methodologies, Case studies; Network Expansion Planning: Problem definition and formulation: Objective function and constraints, Solution methodologies: Enumeration and heuristic methods, Case study; Reactive Power Planning: Introduction, Voltage profile and stability, Performance control parameters, Static and dynamic reactive power sources, Static reactive resource allocation and sizing, Dynamic

reactive resource allocation and sizing, Solution methods, Case study; Planning with System Uncertainties: Introduction, Deregulation, Uncertainties in regulated and deregulated environment, Practical planning issues in deregulated environment, Dealing with uncertainties in planning: Expected cost criterion, Min-max regret criterion, Laplace criterion, and VNM criterion.

Text Book:

1. H. Seifi and M. S. Sepasian, "Electric Power System Planning: Issues, Algorithms and Solutions", 2011, Springer.

Reference Books:

1. R. L. Sullivan, "Power System Planning", 1987, McGraw Hill.
2. J. Schlabbach and K-H. Rofalsk, "Power System Engineering: Planning, Design, and Operation of Power Systems and Equipment", 2008, Wiley.

Course Code: EEL518
Course Title: ADVANCED ELECTRIC MACHINES
Structure (L-T-P): 3-0-0
Prerequisite: EEL253
Contents:

Single phase induction motors and special machines: Constructional details of single phase induction motor – Double revolving field theory and operation – Equivalent circuit – No load and blocked rotor test – Performance analysis – Starting methods of single-phase induction motors - Shaded pole induction motor - Linear reluctance motor - Repulsion motor - Hysteresis motor - AC series motor; Synchronous reluctance motors: Constructional features – Types – Axial and radial air gap motors – Operating principle – Reluctance – Phasor diagram - Characteristics – Vernier motor; Stepping motors: Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi-stack configurations – Theory of torque predictions – Linear and non-linear analysis – Characteristics – Drive circuits.

Switched reluctance motors: Constructional features – Principle of operation – Torque prediction – Power controllers – Non-linear analysis – Microprocessor based control - Characteristics – Computer control; Permanent magnet brushless d.c. Motors: Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations – Power controllers – Motor characteristics and control; Permanent magnet synchronous motors: Principle of operation – EMF and torque equations – Reactance – Phasor diagram – Power controllers - Converter - Volt-ampere requirements – Torque speed characteristics - Microprocessor based control.

Text Book:

1. T.J.E. Miller, "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1989.

Reference Books:

1. P.P. Aearnley, "Stepping Motors – A Guide to Motor Theory and Practice", Peter Perengrinus, London, 1982.
2. D.P. Kothari and I.J. Nagrath, 'Electric Machines', Tata McGraw Hill Publishing Company Ltd, 2002.
3. P.S. Bhimbhra, 'Electrical Machinery', Khanna Publishers, 2003.
4. T. Kenjo, "Stepping Motors and Their Microprocessor Controls", Clarendon Press London, 1984.
5. T. Kenjo and S. Nagamori, "Permanent Magnet and Brushless DC Motors", Clarendon Press, London, 1988.
6. A.E. Fitzgerald, Charles Kingsley, Stephen.D.Umans, 'Electric Machinery', Tata McGraw Hill publishing Company Ltd, 2003.

Course Code: EEL519
Course Title: SMART GRID TECHNOLOGY
Structure (L-T-P): 3-0-0
Prerequisite: EEL256, EEL255, EEL353
Contents:

Review of basic elements of electrical power systems, Desirable traits of a modern grid, Principal characteristics of the smart grid, Key technology areas; Smart grid communication: Two way digital communication paradigm, network architectures, IP-based systems, Power line communications, Advanced metering infrastructure; Renewable generation: Renewable resources: Wind and solar, Microgrid architecture, Tackling intermittency, Distributed storage and reserves; Wide area measurement: Sensor networks, Phasor measurement units, Communications infrastructure, Fault detection and Self-healing systems, Application and challenges; Security and privacy: Cyber security challenges in smart grid, Defense mechanism, Privacy challenges.

Text Book:

1. J. Momoh 'Smart Grid: Fundamentals of Design and Analysis' Wiley-IEEE Press, 2012.

Reference Books:

1. P. F. Schewe 'The Grid: A Journey through the Heart of our Electrified World' Joseph Henry Press, 2006.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama 'Smart Grid: Technology and Applications' Wiley press, 2012.
3. Ali Keyhani, 'Design of smart power grid Renewable Energy Systems' 2nd Edition Wiley-IEEE Press.

Course Code: EEL520
Course Title: SWITCHED MODE POWER CONVERTERS AND ITS APPLICATION
Structure (L-T-P): 3-2-0
Prerequisite:EEL255
Contents:
Contents:

The ideal switch; basic switch cell; basic topology rules; possible basic converter topologies: buck, boost, buck-boost; steady-state analysis; dc transformer equivalent.

Switch characteristics of common switches: Power Diodes, SCRs, Power BJTs, GTOs, Power MOSFETs, IGBTs; conduction and switching loss; V-I plane representation of switches; switch realization from basic switch cell; drive requirements for switches; drive circuits; switching aid networks; designing with real switches: switch selection, loss calculation, basics of thermal design.

Effect of non-idealities on converter performance, efficiency, steady-state voltage gain; state space averaging; basics of small signal analysis; ac equivalent circuit.

Control of converters; voltage mode control; review of bode plots; design of converter controls.

Resonant Converters; Parallel loaded and series loaded resonant converters; transfer characteristics; design.

Inverters; basic two-level inverters: topology derivation and switching schemes; PWM methods: sine-triangle and space-phasor methods.

Multi-level inverters: basic topology derivation and introduction to PWM schemes for multi-level inverters. Applications of converters: Computer power supply, LED lighting, Flood light, Telecommunication, Welding machine.

Text Book:

1. Mohan N., Undeland T.M., Robbins W. P.; Power Electronics: Converters, Applications and Design; John Wiley & Sons, 1995.

Reference Books:

1. Joseph Vithayathil; Power Electronics- Principles & Applications; Tata Mc-Graw Hill.
2. Robbert Ericksson, Dragan Maksimovic; Fundamentals of Power Electronics; Khuwer Academic Publishers.

Course Code: EEL521
Course Title: POWER SYSTEM DEREGULATION
Structure (L-T-P): 3-0-0
Prerequisite:EEL256, EEL353
Contents:
Competitive market for generation, role of the existing power industry, electricity demand operation and reliability, renewable generation technologies, energy policy and cost, distributed generation, market regulation, connection and use of system charges, traditional central utility model, independent system operator (ISO), retail electric providers. Wholesale electricity markets, characteristics, bidding, market clearing and pricing, ISO models, market power evaluation, demand side management, distribution planning. Role of the transmission provider, multilateral transaction model, power exchange and ISO - functions and responsibilities, classification of ISO types, trading arrangements, power pool, pool and bilateral contracts, multilateral trades. Transmission pricing in open access system, rolled in pricing methods, marginal pricing methods, zonal pricing, embedded cost recovery, open transmission system operation, and congestion management in open access transmission systems in normal operation. Predicting electricity costs, electricity cost derivation, electricity pricing of inter provincial power market, transmission pricing.
Text Book :
1. Loi L. L., "Power System Restructuring and Deregulation – Trading, Performance and Information Technology", John Wiley and Sons.2003.
2. Fred C. S., Michael C. C., Richard D. T. and Roger E. B., "Spot Pricing of Electricity", Kluwer Academic Publishers.1988

Reference Book:
1. Marija I., Francisco G. and Lester F., "Power Systems Restructuring: Engineering and Economics", kluwer

Course Code: EEL522
Course Title: ROBUST AND ADAPTIVE CONTROL
Structure (L-T-P): 3-0-0
Prerequisite: EEL254
Contents:
System Identification: Introduction, Off-line parameter estimation, on-line parameter estimation.
Adaptive Control: Introduction, Adaptive control with gradient method (MIT rule), Model reference adaptive control – Hyperstability design, Self-tuning regulators.
Robust Control: Introduction, Model uncertainity and its representation, robust stability in the H_∞-context, robust performance in the H_∞-context, Kharitonov's theorm and related results.
Fuzzy Control: Introduction to intelligent control, general remarks on fuzzy control, fuzzy sets, fuzzy controllers, elements of a fuzzy controller, fuzzification, the rule base, the inference engine, defuzzification, applications.
Text Book:
1. Petros A. Ioannou, Jing Sun, "Robust adaptive control", Prentice-Hall, Inc., 1995.

Reference Books:
1. P. N. Paraskevopoulos, Modern Control Engineering, Marcel Dekker, 2002
2. Boutalis Y., Theodoridis D., Kottas T., Christodoulou M.A., "System Identification and Adaptive Control", Springer, 2014

Course Code: EEL523
Course Title: SLIDING MODE CONTROL
Structure (L-T-P): 3-0-0
Prerequisite: EEL254, EEL505, EEL 501
Contents: Simple Variable Structure Systems, Sliding Mode Definition, A Simple Sliding Mode Controller,Sliding in Multi-Input Systems, Sliding Mode and System Zeros, Nonideal Sliding Mode, Sliding Surface Design, State Estimation of Uncertain Systems , Discontinuous Estimators , Boundary Layer Estimators , Sliding Modes in Solving Optimization Problems , Optimization Problem Statement , Penalty Function Method , Dynamical Gradient Circuit Analysis , Control of the Boost Converter , Direct Control , Indirect Control , Simulations. , Experimental Implementation , Control of the Buck-Boost Converter , Direct Control ,Indirect Control , Simulations, Control of the Zeta Converter , Direct Control , Indirect Control , Simulations. , Multi-variable Case, Sliding Surface, Equivalent Control and Ideal Sliding Dynamics, Invariance with Respect to Matched Perturbations , Accessibility of the Sliding Surfaces, Control of the Boost-Boost Converter , Direct Control , Indirect Control , Simulations., Experimental Sliding Mode Control Implementation, Control of Double Buck-Boost Converter, Direct Control , Indirect Control. Simulations

Course Code: EEL524
Course Title: MICROGRID OPERATION AND CONTROL
Structure (L-T-P): 3-0-0
Prerequisite: EEL256, EEL353
Contents:
Introduction: The microgrid concept, different type of microgrid AC/DC, Integration with different distributed generation, demand side integration, operation strategy of microgrid, market models for microgrid, external market and regulatory setting for microgrid, different microgrid applications**.**
Analysis of microgrid: Load flow techniques for operation od microgrid with AC and DC.
Microgrid Control: Different control techniques of microgrid, voltage or frequency control, load consumption/sharing, black **state**, role pf information and communication technology, microgrid control architechture, centeralised and decentralized control, forecasting application in control, participation in energy market, mathematical formulation of economic operation, multiagent system based microgrid operation, coordination algorithms for microgrid control, microgrid atate estimation, intelligent local controllers, Droop control of microgrid, transition between islanded and grid connected mode.
Microgrid Protection: Challenges of microgrid protection, over current and directional over current protection, distance protection, differential protection, adaptive protection for microgrid, fault analysis for microgrid, fault current limitation in microgrid.
Hybrid Microgrid: Basic concept, control and protection, techniques or hybrid microgrid.
Overview of Microgrid Projects: PV based microgrid, wind based microgrid, microgrid with combination of energy sources. Hybrid microgrid – Dcand AC both. **Islanding detection methods**

Text Books:
1. Nikos Hatziargyriou, Microgrids: Architectures and control, Wiley-IEEE series publication, March 2014.
2. Hassan Bevrani, Bruno Francois, Toshifumi Ise, Microgrid Dynamics and Control by, Wiley, 1st edition , July 2017.

Reference Books:
1. Magdi S. Mahmoud, Microgrid: Advanced Control Methods and Renewable Energy System integration, Butterworth-Heinemann; 1st edition, November 3, 2016.

M. Tech (Electronics Engineering) specialization in Microelectronics and VLSI
OVERALL CREDIT STRUCTURE

S.No.	Category	Symbol	M.Tech (2-Year) (Credits)
1	**PG Core**	PC	30
1.1	Departmental Core	DC	13
1.2	Project Phase-I	P1	05
1.3	Project Phase-II	P2	10
1.4	Seminar	SM	02
2	**PG Elective**	PE	25
2.1	Specialization Electives	SE	19
2.2	Open Course	OC	06
Total Requirement		**55 (Minimum)**	

Departmental Core (DC)		**L-T-P**	**Credits**
ECD501	Project Phase-I	-	05
ECD502	Project Phase-II	-	10
ECD503	Seminar	-	02
ECL502	MOS Device Physics	3-0-0	03
ECL534	Advanced Digital Signal Processing	3-0-0	03
ECL504	CMOS Analog VLSI Design	3-0-0	03
ECP504	CMOS Analog VLSI Design Lab	0-0-2	01
ECL554	Probability, Stochastic Process and Numerical Methods	3-0-0	03
Specialization Elective (SE)		**L-T-P**	**Credits**
ECL503	CMOS Digital VLSI Design	3-0-0	03
ECP503	CMOS Digital VLSI Design Lab	0-0-2	01
ECL505	VLSI Physical Design	3-0-0	03
ECL511	VLSI System Design	3-0-0	03
ECP511	System Design Lab	0-0-2	01
ECL512	MOS Device Modeling	3-0-0	03
ECL513	Low-power VLSI Design	3-0-0	03
ECL514	VLSI Testing	3-0-0	03
ECL515	Nano-scale Devices	3-0-0	03
ECL516	CAD for VLSI	3-0-0	03
ECP516	VLSI CAD Lab	0-0-2	01
ECL517	VLSI Interconnects	3-0-0	03
ECL518	Optoelectronics Devices	3-0-0	03
ECL519	VLSI/ULSI Technology	3-0-0	03
ECL520	Micro Electromechanical Systems	3-0-0	03
ECL521	Internet of Things	3-0-0	03
ECL522	Mechatronics	3-0-0	03
ECL523	Organic Electronics	3-0-0	03
ECL524	Mixed-Signal VLSI Design	3-0-0	03
ECP524	Mixed-Signal VLSI Design Lab	0-0-2	01
ECL525	Thermal effects in Nanoscale Devices and Circuits	3-0-0	03
ECL526	CFOA and its linear and nonlinear applications	3-0-0	03
ECP526	Analog Signal Processing Lab	0-0-2	01
ECL527	VLSI Signal Processing Systems	3-0-0	03
ECL541	Radio Frequency Circuit Design	3-2-0	04
ECL542	Image Processing	3-0-0	03
ECP542	Image Processing Lab	0-0-2	01
SCL457	Semiconductor Materials and Optoelectronics	3-0-0	03
CSL513	Advanced Computer Architecture	3-0-0	03

M. Tech (Electronics Engineering) specialization in Communication Systems
OVERALL CREDIT STRUCTURE

S.No.	Category	Symbol	M.Tech (2-Year) (Credits)
1	**PG Core**	PC	30
1.1	Departmental Core	DC	13
1.2	Project Phase-I	P1	05
1.3	Project Phase-II	P2	10
1.4	Seminar	SM	02
2	**PG Elective**	PE	25
2.1	Specialization Electives	SE	19
2.2	Open Course	OC	06
Total Requirement		**55 (Minimum)**	

Departmental Core (DC)		**L-T-P**	**Credits**
ECD501	Project Phase-I	-	05
ECD502	Project Phase-II	-	10
ECD503	Seminar	-	02
ECL502	MOS Device Physics	3-0-0	03
ECL534	Advanced Digital Signal Processing	3-0-0	03
ECL504	CMOS Analog VLSI Design	3-0-0	03
ECP504	CMOS Analog VLSI Design Lab	0-0-2	01
ECL554	Probability, Stochastic Process and Numerical Methods	3-0-0	03
Specialization Elective (SE)		**L-T-P**	**Credits**
ECL531	Advanced Microwave Engineering	3-0-0	03
ECL532	Advanced Antenna Theory and Design	3-0-0	03
ECL533	Advanced Digital Communication Systems	3-0-0	03
ECL541	Radio Frequency Circuit Design	3-2-0	04
ECL542	Image Processing	3-0-0	03
ECP542	Image Processing Lab	0-0-2	01
ECL543	RF Receiver Design for Wireless Applications	3-0-0	03
ECL544	CAD of RF and Microwave Circuits	3-0-0	03
ECP544	RF and Microwave Circuits Lab	0-0-2	01
ECL545	Human and Machine Speech Communications	3-0-0	03
ECP545	Machine Communications Lab	0-0-2	01
ECL546	Advanced Wireless Mobile Communications	3-0-0	03
ECL547	Theory of Estimation and Detection	3-0-0	03
ECL548	MIMO System	3-0-0	03
ECL549	Microwave and Millimeter Wave Engineering	3-0-0	03
ECL550	2D Signals and Image processing	3-0-0	03
ECP550	Signals and Image processing Lab	0-0-2	01
ECL551	Adaptive Signal Processing	3-0-0	03
ECL552	Introduction to Machine Learning	3-0-0	03
ECP552	Machine Learning Lab	0-0-2	01
ECL555	Fiber Optic Communication Systems	3-0-0	03
ECP555	Optic Communication Systems Lab	0-0-2	01
ECL556	Radar Signal Processing	3-0-0	03
ECL557	RF MEMS	3-0-0	03
ECL558	Computational Electromagnetics	3-0-0	03
ECL559	Evolutionary Optimization Algorithms	3-0-0	03
ECP559	Optimization Algorithms Lab	0-0-2	01
ECL560	Biomedical Image Processing	3-0-0	03
ECP560	Biomedical Image Processing Lab	0-0-2	01
ECL561	Biomedical Signal Processing	3-0-0	03
ECP561	Biomedical Signal Processing Lab	0-0-2	01
ECL562	Principles of Biomedical Instrumentation Design	3-0-0	03
CSL505	Pattern Recognition and Machine Learning	3-0-0	03
CSL506	Computer Vision	3-0-0	03
CSL511	Wireless and Mobile Communications	3-0-0	03

Course Code: ECL502
Course Title: MOS DEVICE PHYSICS
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

MOS Capacitor: Energy band diagram of Metal-Oxide-Semiconductor contacts, Mode of Operations: Accumulation, Depletion, Midgap, and Inversion, 1D Electrostatics of MOS, Depletion Approximation, Accurate Solution of Poisson's Equation, CV characteristics of MOS, LFCV and HFCV, Non-idealities in MOS, oxide fixed charges, interfacial charges, Midgap gate Electrode, Poly-Silicon contact, Electrostatics of non-uniform substrate doping, ultrathin gate-oxide and inversion layer quantization, quantum capacitance, MOS parameter extraction.

Physics of MOSFET: Drift-Diffusion Approach for IV, Gradual Channel Approximation, Sub-threshold current and slope, Body effect, Pao & Sah Model, Detail 2D effects in MOSFET, High field and doping dependent mobility models, High field effects and MOSFET reliability issues (SILC, TDDB, & NBTI), Leakage mechanisms in thin gate oxide, High-K-Metal Gate MOSFET devices and technology issues, Intrinsic MOSFET capacitances and resistances, Meyer model.

SOI MOSFET: FDSOI and PDSOI, 1D Electrostatics of FDSOI MOS, VT definitions, Back gate coupling and body effect parameter, IV characteristics of FDSOI-FET, FDSOI-sub-threshold slope, Floating body effect, single transistor latch, ZRAM device, Bulk and SOI FET: discussions referring to the ITRS.

Nanoscale Transistors: Diffusive, Quasi Ballistic & Ballistic Transports, Ballistic planer and nanowire-FET modeling: semi-classical and quantum treatments.

Advanced MOSFETs: Strain Engineered Channel materials, Mobility in strained materials, Electrostatics of double gate, and Fin-FET devices

Text Books:

1. Yannis Tsividis, *Operation and Modeling of the MOS Transistor*, 2nd ed., Oxford University Press, 2016.
2. Arora, N. *MOSFET Modeling for VLSI Circuit Simulation*. World Scientific, 2007.

Reference Books:

1. Yuan Taur & Tak H. Ning, *Fundamentals of Modern VLSI Devices*, Cambridge, 1998.
2. S.M. Sze & Kwok K. Ng, *Physics of Semiconductor Devices*, Wiley, 2007.
3. Mark Lundstrom & Jing Guo, *Nanoscale Transistors: Device Physics, Modeling & Simulation*, Springer, 2005.

Course Code: ECL503
Course Title: CMOS DIGITAL VLSI DESIGN
Structure (L-T-P): 3-0-0
Prerequisite: ECL256
Contents:

Digital ICs design flow, Issues in Digital Integrated Circuit Design, MOS Transistor basics –Static and Dynamic Behavior, Secondary effects.

CMOS Inverter Static and Dynamic Behavior, Noise Margin, Power Consumption and Power Delay Product, Latch up, Technology Scaling.

Logic gates- Static CMOS Design: Complementary CMOS, Ratioed Logic, Pass Transistor Logic. Dynamic CMOS Design: basic principles, performance of dynamic logic, Noise consideration, Power consumption in CMOS gates – switching activity, Glitches, Logical Efforts, Layout.

Sequential Circuits: Bistability, CMOS static flip-flop, Pseudo static latch, Dynamic two-phase flip-flop, C^2MOS latch, NORA (no race)-CMOS logic design style, Schmitt Trigger, Astable and monostable circuits.

Arithmetic Building blocks: Adder, Multiplier and Shifters, ALU Timing Issues in synchronous design Interconnect Parasitics.

Memories and array structures: ROM and RAM cells design, SRAM cell and arrays, memory peripheral circuits.

BiCMOS Logic Circuits: Introduction, Basic BiCMOS Circuit behavior, Switching delay in BiCMOS logic circuits.

Text Books:

1. Rabaey, J. M. *Digital Integrated Circuits - A Design perspective*. 2nd ed. Pearson Education, 2003.

Reference Books:

1. Martin, K. *Digital integrated circuit design*. Oxford University Press, 2000.
2. Kuo, J., and Lou, J. *Low voltage CMOS VLSI circuits*. John Wiley, 1999.
3. Weste, N., and Eshraghian, K. *Principles of CMOS VLSI Design - A Systems perspective*. 2nd ed. Addison-Wesley, 1993.

Course Code: ECL504
Course Title: CMOS ANALOG VLSI DESIGN
Structure (L-T-P): 3-0-0
Prerequisite: ECL252
Contents:

Introduction: Motivation for analog VLSI and mixed signal circuits in CMOS technologies and issues thereof. CMOS device fundamentals: Basic MOS models, device capacitances, parasitic resistances, substrate models, transconductance, output resistance, fT, frequency dependence of device parameters.

Single stage amplifiers: Common source amplifier, source degeneration, source follower, common gate amplifier, cascade stage. Differential Amplifiers: Basic differential pair, common mode response, differential pair with MOS loads, Gilbert Cell, device mismatch effects, input offset voltage.

Current Mirrors, Current and Voltage Reference: Basic current mirrors, cascode current mirrors, active current mirrors, low current biasing, supply insensitive biasing, temperature insensitive biasing, impact of device mismatch.

Frequency Response of Amplifiers: Miller effect, CS amplifier, source follower, CG amplifier, cascade stage, differential amplifier, Multistage amplifier. Feedback: Feedback topologies, effect of load, modeling input and output ports in feedback circuits

Operational Amplifiers: Performance parameters, One-stage and two-stage Op Amps, gain boosting, comparison, common mode feedback, input range, slew rate, power supply rejection, noise in Op Amps Stability and Frequency Compensation: Multi pole systems, phase margin, frequency compensation

Text Books:

1. Razavi, Behzad. *Design of Analog CMOS Integrated Circuits*. 2nd ed. Tata McGraw Hill, 2002.

Reference Books:

1. Allen, Phillip E., and Holberg, Douglas R. *CMOS Analog Circuit Design*. Oxford University Press, 2002.
2. Carusone, Tony C., Johns, David A., and Martin, Kenneth W. *Analog Integrated Circuit Design*. 2nd ed. John Wiley and Sons, 1997.
3. Gray, Paul, and Meyer, Robert. *Analysis and Design of Analog Integrated Circuits*. John Wiley and Sons, 1993.
4. R. Jacob Baker. *CMOS Circuit Design, Layout, and Simulation*. 3rd ed. IEEE press Wiley, 2010.
5. Gray, P.R., Hodges, D.A., R.W. Brodersen, Eds. *Analog MOS integrated Circuits*. IEEE press Wiley, 1980

Course Code: ECL505
Course Title: VLSI PHYSICAL DESIGN
Structure (L-T-P):3-0-0
Prerequisite: NIL

Contents:

Introduction: Layout and design rules, materials for VLSI fabrication, basic algorithmic concepts for physical design, physical design processes and complexities.

Partition: Kernigham-Lin's algorithm, Fiduccia Mattheyes algorithm, Krishnamurty extension, hMETIS algorithm, multilevel partition techniques.

Floor-Planning: Hierarchical design, wirelength estimation, slicing and non-slicing floorplan, polar graph representation, operator concept, Stockmeyer algorithm for floorplanning, mixed integer linear program.

Placement: Design types: ASICs, SoC, microprocessor RLM; Placement techniques: Simulated annealing, partition-based, analytical, and Hall's quadratic; Timing and congestion considerations.

Routing: Detailed, global and specialized routing, channel ordering, channel routing problems and constraint graphs, routing algorithms, Yoshimura and Kuh's method, zone scanning and net merging, boundary terminal problem, minimum density spanning forest problem, topological routing, cluster graph representation.

Sequential Logic Optimization and Cell Binding: State based optimization, state minimization, algorithms; Library binding and its algorithms, concurrent binding. Static Timing Analysis.

Text Books:

1. Sarrafzadeh, M. and Wong, C.K. *An Introduction to VLSI Physical Design*. 4th ed. McGraw-Hill, 1996.

Reference Books:

1. Sherwani, N.A. *Algorithm for VLSI Physical Design Automation*. 2nd ed. Kluwer, 1999.
2. Wolf, W. *Modern VLSI Design System on Silicon*. 2nd ed. Pearson Education, 2000.
3. Sait, S.M. and Youssef, H. *VLSI Physical Design Automation: Theory and Practice*. World Scientific, 1999.
4. Dreschler, R. *Evolutionary Algorithms for VLSI CAD*. 3rd ed. Springer, 2002.
5. Lim, S.K. *Practical Problems in VLSI Physical Design Automation*. Springer, 2008.

Course Code: ECL511

Course Title: VLSI SYSTEM DESIGN

Structure (L-T-P):3-0-0

Prerequisite: ECL256

Contents:

Introduction to Digital and Embedded systems design: Digital Design Using ROMs, PLAs and PLAs, BCD Adder, 32 – bit adder, A shift and add multiplier, Array multiplier, and Binary divider. Introduction to Embedded system, Design cycle in the development

phase for an embedded system, Use of target system or its emulator nd In-circuit emulator, Use of software tools for development of an ES.

Hardware Description Languages (HDL): Digital system Design Process, Hardware Description Languages, Hardware Simulation, Hardware Synthesis, Levels of Abstraction, Characterizing Hardware Languages, Objects and Classes, Signal Assignments, Concurrent and Sequential Assignments.

Design Organization and Parameterization: Definition and usage of Subprograms, Packaging Parts and Utilities, Design Parameterization, Design Configuration, Design Libraries. Type Declarations and Usage, Operators, Subprogram Parameter Types and Overloading, Other Types and Types Related Issues, Predefined Attributes, User Defined Attributes.

Dataflow Description: Multiplexing and Data Selection, State Machine Description, Three State Bussing.

Behavioral Description of Hardware: Process Statement, Assertion Statement, Sequential Wait Statements, Formatted ASCII I/O Operations, IC Design Flow. Practical Designs

EPGA Architecture: Designing and Implementation of Finite State Machines for FPGA; Synthesis Techniques nd Timinig Analysis; Placement and Routing; Embedded Hardware and Software Design with FPGA.

DSP Processor Architecture: Architecture; Functional Units; Fetch and Execute Packets; Pipelining; Registers; Linear and circular Addressing Modes; Instruction Set Assembler Directives for TMS320C6x or ADSP21xx; Linear Assembly; ASM statement within C; C-Callable Assembly Function; Timers; interrupts; Multichannel Buffered Serial Ports; Direct Memory Access; Memory Considerations; Fixed and Floating Point Format Code Improvement ; Constraints Programming Examples Using : C, Assembly, and Linear Assembly.

ARM Architecture and Organization: ARM Assembly Programming; THUMB Assembly Programming; ARMTHUMB Interworking; Assembly and C Mixed Programming; Exception Handling; ARM Tool chain (Assemblers, Compilers, Linkers & Debuggers); Firmware Programming; Cache & MMU; Peripheral Programming; ARM Cortex family of Processors and architecture; Operating modes, Registers and Memory Map of Cortex-M3; Embedded OS; Porting of Embedded OS on ARM.

Text Books:

1. Embedded System Design: Embedded System Foundations of Cyber- Physical Systems by Peter Marwedel, Springer,2010
2. Reference Books: Embedded System Design: A Unified Hardware/Software introduction by Frank Vahid, Tony Givargis, John Wiley & Sons, Inc.,2001
3. Fundamental of Logic Design - Charles H. Roth, and Larry L. Kinney, Brooks/Cole Inc.,2014
4. Digital Logic and Microprocessor Design with VHDL, Enoch O.Hwang, Publisher- Thomson/Nelson,2006
5. Digital Design and Computer Architecture, David Money Harris andSarah L. Harris, Elsevier.2012
6. VHDL for Programming Logic, Kevin Skahill, Person Education,2004
7. ARM System-on-Chip Architecture, Furber, S., 2nd ed. Pearson Education.2000
8. DSP Applications Using C and the TMS320C6x DSK, Rulph Chassaing, John Wiley & Sons, Inc.,2002

Course Code: ECL512

Course Title: MOS DEVICE MODELING

Structure (L-T-P): 3-0-0

Prerequisite: ECL502

Contents:

MOS Capacitor: Energy band diagram of Metal-Oxide-Semiconductor contacts, Mode of Operations: Accumulation, Depletion, Midgap, and Inversion, 1D Electrostatics of MOS, Depletion Approximation, Accurate Solution of Poisson's Equation, CV characteristics of MOS, LFCV and HFCV, Non-idealities in MOS, oxide fixed charges, interfacial charges, Midgap gate Electrode, Poly-Silicon contact, Electrostatics of non-uniform substrate doping, ultrathin gate-oxide and inversion layer quantization, quantum capacitance, MOS parameter extraction

Review of MOS basics, Modeling Techniques, Numerical, analytical and empirical approaches.

MOSFET DC models: Pao-Sah model, charge sheet model, piece-wise linear model, models for depletion devices, carrier mobility models in deep-submicron and nanoscale dimensions, short geometry models, source/drain resistance evaluation. Dynamic models: Intrinsic charges and capacitance, Meyer's model, quasi-static and non-quasi-static model, low frequency modeling of MOS transistors, high frequency modeling of MOS transistors. SPICE MOSFET models: Level 1, 2, 3 and 4 models and their comparison. Statistical modeling: Model sensitivity, principal factor method, principal component analysis, regression models

Text Books:

1. Arora, N. *MOSFET Modeling for VLSI Circuit Simulation*. World Scientific, 2007.

Reference Books:

1. Tsividis, Y. *Operation and Modeling of the MOS Transistor*. Oxford University Press, 1999.

Course Code: ECL513
Course Title: LOW-POWER VLSI DESIGN
Structure (L-T-P): 3-0-0
Prerequisite: ECL502, ECL503
Contents:

Introduction: Need for low power VLSI chips, Sources of power dissipation in Digital Integrated circuits. Emerging low power approaches. Physics of power dissipation in CMOS devices.

Device and Technology Impact on Low Power, Review of Power basics, Transistor sizing and gate oxide thickness,.

Power Estimation: Simulation Power analysis- SPICE circuit simulators, Gate level logic simulation, Capacitive power estimation, Static state power, Gate level capacitance estimation, Architecture level analysis, Data correlation analysis. Monte Carlo simulation.

Low Power Design: Circuit level- Power consumption in circuits, Flip Flops and Latches design, High capacitance nodes, Low power digital cells library Logic level- Gate reorganization. Low Power Clock Distribution.

Low Power Architecture and Systems: Power and performance management, Switching activity reduction, Parallel architecture with voltage reduction, Flow graph transformation, Low power arithmetic components, Low power memory design.

Algorithm and Architectural Level Methodologies: Introduction, design flow, algorithmic level analysis and optimization, architectural level estimation & synthesis. Adder, Multiplier and Shifters.

Text Books:

1. Roy, K., Prasad, S. *Low-Power CMOS VLSI Circuit Design*. Wiley, 2000.

Reference Books:

1. Yeap, Gary K. *Practical Low Power Digital VLSI Design*. Springer, 2002.
2. Rabaey, Jan M., and Pedram, M. *Low power design methodologies*. Kluwer Academic, 1997.

Course Code: ECL514
Course Title: VLSI TESTING
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Motivation for Testing: Design for testability, the problems of digital and analog testing, Design for test, Software testing.

Faults in Digital Circuits: General introduction, Controllability and Observability, Fault models – stuck-at faults, Bridging faults, Intermittent faults.

Digital Test Pattern Generation: Test pattern generation for combinational logic circuits, Manual test pattern generation, Automatic test pattern generation – Roth's D-algorithm, Developments following Roth's Dalgorithm, Pseudorandom test pattern generation, Test pattern generation for sequential circuits, Exhaustive, Delay fault testing .

Signatures and Self-Test: Input compression output compression arithmetic, Reed-Muller and spectral coefficients, Arithmetic and Reed-Muller coefficients, Spectral coefficients, Coefficient test signatures, Signature analysis and online self-test .

Testability Techniques: Partitioning and ad-hoc methods and scan-path testing, Boundary scan, Offline built in Self-Test (BIST), Hardware description languages and test .

Testing of Analog and Digital circuits: Testing techniques for Filters, A/D Converters, RAM, Programmable logic devices and DSP, Test generation algorithms for combinational logic circuits – fault table, Boolean difference, Path sensitilization, D-algorithm, Podem, Fault simulation techniques – serial single fault propagation, Deductive, Parallel and concurrent simulation, Test generation for a sequential logic, Design for testability – adhoc and structured methods, Scan design, Partial scan, Boundary scan, Pseudo-random techniques for test vector generation and response compression, Built–in-Self test, PLA test and DFT.

Text Books:

1. Bushnell, M.L., and Agrawal, V. D. *Essentials of Electronics Testing: for Digital Memory and mixed signal VLSI circuits*. Kluwer Academic Publishers, 2002.

Reference Books:

1. Abramovici, M., Breuer, M. A., and Friendman, A.D. *Digital systems and Testing and Testable Design*. Wiley, 1994.
2. Hurst, Stanley L. *VLSI Testing: digital and mixed analogue digital techniques*. IET, 1998.

Course Code: ECL515
Course Title: NANO-SCALE DEVICES
Structure (L-T-P): 3-0-0
Prerequisite: ECL502
Contents:

CMOS scaling challenges in nanoscale regimes: Moore and Koomey's law, Leakage current mechanisms in nanoscale CMOS, leakage control and reduction techniques, process variations in devices and interconnects.

Device and technologies for sub 100nm CMOS: Silicidation and Cu-low k interconnects, strain silicon – biaxial stain and process induced strain; Metal-high k gate; Emerging CMOS technologies at 32nm scale and beyond – FINFETs, surround gate nanowire MOSFETs, heterostructure (III-V) and Si-Ge MOSFETs.

Device scaling and ballistic MOSFET: Two dimensional scaling theory of single and multigate MOSFETs, generalized scale length, quantum confinement and tunnelling in MOSFTEs, velocity saturation, carrier back scattering and injection velocity effects, scattering theory of MOSFETs. Density of States (1D, 2D, 3D), Virtual Source Model, Ballistic MOSFET, Landauer's Theory, Transmission Theory.

SOI MOSFET: FDSOI and PDSOI, 1D Electrostatics of FDSOI MOS, VT definitions, Back gate coupling and body effect parameter, IV characteristics of FDSOI-FET, FDSOI-sub-threshold slope, Floating body effect.

Emerging nanoscale devices: Si and hetero-structure nanowire MOSFETs, carbon nanotube MOSFETs, Tunnel FET, quantum wells, quantum wires and quantum dots; Single electron transistors, resonant tunnelling devices.

Non-classical CMOS: CMOS circuit design using non-classical devices – FINFETs, nanowire, carbon nanotubes and tunnel devices.

Text Books:

1. Lundstrom, M. *Nanoscale Transport: Device Physics, Modeling, and Simulation*. Springer, 2005.

Reference Books:

1. Maiti, C.K., Chattopadhyay, S. and Bera, L.K. *Strained-Si and Hetrostructure Field Effect Devices*. Milton Park, Taylor and Francis 2007.
2. Hanson, G.W. *Fundamentals of Nanoelectronics*. Pearson India, 2008.
3. Wong, B.P., Mittal, A., Cao, Y., and Starr, G. *Nano-CMOS Circuit and Physical Design*. Wiley, 2004
4. Kundu, S. and Sreedhar, A. *Nanoscale CMOS VLSI Circuits: Design for Manufacturability*. McGraw Hill, 2010.

Course Code: ECL516
Course Title: CAD FOR VLSI
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Introduction: Evolution of design automation; CMOS realizations of basic gates. Circuit and system representation: Behavioral, structural and physical models, design flow.

Modeling techniques: Types of CAD tools, introduction to logic simulation and synthesis.

HDL: Syntax, hierarchical modeling, Verilog/VHDL construct, simulator directives, instantiating modules, gate level modeling.

Delay modeling: Event based and level sensitive timing control, memory initialization, conditional compilation, time scales for simulation.

Advanced modeling techniques: Static timing analysis, delay, switch level modeling, user defined primitive (UDP), memory modeling.

Logic synthesis: Logic synthesis of HDL construct, technology cell library, design constraints, synthesis of Verilog/VHDL construct.

Model optimization: Various optimization techniques, design size.

FPGAs based system design: Commercial FPGA architecture, LUT and routing architecture, FPGA CAD flow; Typical case studies.

Text Books:

1. Weste, N. and Eshraghian, K., *Principles of CMOS VLSI Design – A Systems Perspective*, 2nd Ed., Addison Wesley.
2. Wolf, W., *Modern VLSI Design: System on Chip*, 2nd Ed., Prentice Hall of India
3. Massobrio. *Semiconductor Device Modeling with Spice*. 2nd ed. New Delhi: Tata McGraw-Hill, 2010.

Reference Books:

1. Williams, Spencer E. *A New TCAD-based Statistical Methodology for the Optimization and Sensitivity Analysis of Semiconductor Technologies*. Louisiana Tech University, 1999.

Course Code: ECL517
Course Title: VLSI INTERCONNECTS
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Interconnects: Interconnect Parameters: Resistance, Inductance, and Capacitance, Interconnect RC Delays: Elmore Delay Calculation. Interconnect Models: The lumped RC Model, the distributed RC

Model, the transmission line model. SPICE Wire Models, Scaling issues in interconnects, Gate and Interconnect Delay

Parasitic extraction: Parasitic resistance, effect of surface/interface scattering and diffusion barrier on resistance, Capacitance: parallel-plate capacitance, fringing capacitance, coupling capacitance, methods of capacitance extraction, self-inductance, mutual inductance, methods of inductance extraction, high frequency losses, frequency dependent parasitic, skin effect, dispersion effect.

CMOS Repeater: The Static Behavior- Switching Threshold, Noise Margins, The Dynamic Behavior- Computing the capacitances, Propagation Delay: First order Analysis, Propagation Delay from a Design perspective, Power, energy and Energy-Delay- Dynamic Power Consumption, Static Consumption, Analyzing Power Consumption using SPICE

Repeater Design, Transient Analysis of an RC loaded CMOS repeater, Delay Analysis, Analytical power expressions: Dynamic power, Short circuit Power, Resistive Power Dissipation, CMOS Repeater insertion.

Crosstalk, Contribution of driver and interconnect to dissipated energy, Crosstalk effects in logic VLSI circuits. Introduction to Future VLSI Interconnects.

Text Books:

1. Moll, F., Roca, M. *Interconnection Noise in VLSI Circuits*. Springer Science & Business Media, 2007.

Reference Books:

1. Rabaey, Jan M. *Analysis and Design of Digital Integrated Circuits– A design Perspective*. 2nd ed. TMH, 2003.
2. Uymera, John P. *Introduction to VLSI Circuits and Systems*. Wiley, 2002.
3. Goel, Ashok K. *High-Speed VLSI Interconnects*. 2nd ed. New Jersey, John Wiley & Sons, 2007.
4. Diamand, Y.S. *Advanced Nanoscale ULSI Interconnects: Fundamentals and Applications*. Springer, 2009.
5. Wong, Philip H. S., and Akinwande, D. *Carbon nanotube and Graphene Device Physics*. Cambridge University Press, 2011.

Course Code: ECL518
Course Title: OPTOELECTRONICS DEVICES
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Optical processes in semiconductors, EHP formation and recombination, absorption and radiation in semiconductor, deep level transitions, Auger recombination, luminescence and time resolved photoluminescence, optical properties of photonic band-gap materials

Junction photodiode: PIN, heterojunction and avalanche photodiode; Comparisons of various photodetectors, measurement techniques for output pulse.

Photovoltaic effect, V-I characteristics and spectral response of solar cells, heterojunction and cascaded solar cells, Schottky barrier and thin film solar cells, design of solar cell, Modulated barrier, MS and MSM photodiodes; Wavelength selective detection, coherent detection; Microcavity photodiode.

Dynamic effects of MOS capacitor, basic structure and frequency response of charge coupled devices, buried channel charge coupled devices. Electroluminescent process, choice of light emitting diode (LED) material, device configuration and efficiency; LED: Principle of operation, LED structure, frequency response, defects, and reliability.

Semiconductor laser diode, Einstein relations and population inversion, lasing condition and gain, junction lasers, heterojunction laser, multi quantum well lasers, beam quantization and modulation.

Text Books:

1. Bhattacharya, P. *Semiconductor Optoelectronic Devices*. 2nd ed. Pearson Education Inc., 1994.

Reference Books:

1. Yariv, A., and Yeh, P. *Photonics – Optical Electronics in Modern Communications*. Oxford University Press, 2007.
2. Deen, M. J., and Basu, P.K. *Silicon Photonics – Fundamentals and Devices*. John Wiley & Sons Ltd., 2012.

Course Code: ECL519
Course Title: VLSI/ULSI TECHNOLOGY
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Environment for VLSI Technology: Clean room and safety requirements. Wafer cleaning processes and wet chemical etching techniques. Impurity incorporation: Solid State diffusion modeling and technology, Ion Implantation modeling, technology and damage annealing; characterization of impurity profiles.

Wafer preparation and Crystal growth of Si and GaAs (Bridgeman, CZ and Liquid encapsulation method), Process flow of Novel MOS based devices.

Oxidation: kinetics of silicon dioxide growth both for thick, thin and ultrathin films. Oxidation technologies in VLSI and ULSI. Characterization of oxide films, high k and low k dielectrics for ULSI.

Lithography: Photolithography, E-beam lithography and newer lithography techniques for VLSI/ULSI, mask generation. Chemical Vapour Deposition techniques: 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 interconnects; 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 and Bipolar circuits; Advanced MOS technologies.

Text Books:

1. Sze, S.M. *VLSI Technology*. 2nd ed. Tata McGraw-Hill, 2011.

Reference Books:

1. Ghandhi, S.K. *VLSI Fabrication Principles*. 2nd ed. Wiley India, 2010.
2. Plummer, James D. *Silicon VLSI Technology Fundamentals: Practice and Modeling*. Pearson Education, 2009.
3. Campbell, Stephen A. *The Science & Engineering of Microelectronics Fabrication*. 2nd ed. Oxford University Press, 2001.

Course Code: ECL520
Course Title: MICRO ELECTROMECHANICAL SYSTEMS
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Introduction to MEMS, MEMs devices overview. Fabrication, Mechanical Properties.

Surface micromachining, Oxide anchored Cantilever beam, poly anchored beams, LPCVD poly silicon deposition, doping, oxidation, Transport in Poly Si, 2 and 3 terminal beams.

Bulk micromachining; Wet etching –isotropic and anisotropic; Etch stop – Electrochemical etching; Dry etching; Bonding, Comparison of bulk and Surface micromachining: LIGA; SU-8; Moulding processes; Stiction: process, in-use, Measuring stiction, Pull-in parallel plate capacitor, Pressure Sensor: piezo-resisitivity, Diffused Si, Poly, porous Si.

Beams: Structure; force, moments, equation, spring constant; Stress, pull-in, pull-out; resonance freq, etc, Accelerometer. Quasistatic, capacitive, equivalent circuit; Analog; Tunnel; Thermal accelerometer, Rate Gyroscope ,Biosensor and BioMEMS; Microfluidics; Digital Microfluidics; Ink jet printer.

Optical MEMS: Displays -DMDs, LGVs, active and passive components, RF MEMS: switches, active and passive components, Packaging; Reliability, Scaling.

Text Books:

1. Ananthasuresh, G. K. *Micro and Smart Systems*. Wiley India, 2014.

Reference Books:

1. Bao, M.-H. *Micro Mechanical Transducers: Pressure Sensors, Accelerometers and Gyroscopes*. 1st ed., Elsevier, 2004.
2. Kovacs, G.T.A. *Micromachined Transducers Source book*. Tata McGraw Hill, 1998.
3. Senturia, S.D. *Microsystem Design*. Kluwer Academic Publishers, 2005.

Course Code: ECL521
Course Title: INTERNET OF THING
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Introduction: Overview of IoT systems, Components of an IoT system, Sensor Node: Wearable Electronics Sensors, Calibration, Batteries, Power supply, Microprocessors, Data communication Sensor Node: Firmware design, Basic firmware design concepts – Digital arithmetic, Data format, H/w resources utilization, Power optimization, Modularization, Data/command interfaces, Clock budgeting.

Connectivity API development using Python and Android, Networking, IoT Data Processing, IoT data management, Python libraries for data analysis (Pandas, scikit), Cloud computing

Text Books:

1. Arshdeep Bahga and Vijay Madisetti. *Internet of Things: A Hands-on Approach*, Universities Press, 2015.

Reference Books:

1. Edward Ashford Lee and Sanjit Arun kumar Seshia. *Introduction to Embedded Systems: A Cyber-Physical Systems Approach*, 2013.
2. John Guttag. *Introduction to Computation and Programming using Python*, MIT Press, 2013.

Course Code: ECL522
Course Title: MECHATRONICS
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Systems And Design: Mechatronic systems – Integrated design issue in mechatronic – mechatronic key element, mechatronic approach – control program control – adaptive control and distributed system – Design process – Type of design – Integrated product design Mechanism, load condition, design and flexibility – structures – man machine interface, industrial design and ergonomics, information transfer, safety.

Control And Drives: Control devices – Electro hydraulic control devices, electro pneumatic proportional controls – Rotational drives– Pneumatic motors: continuous and limited rotation – Hydraulic motor: continuous and limited rotation – Motion convertors, fixed ratio, invariant motion profile, variators.

Real Time Interfacing: Real time interface – Introduction, Elements of a data acquisition and Control system, overview of I/O process, installation of I/O card and software – Installation of the application software – over framing.

Case Studies: Case studies on data acquisition – Testing of transportation bridge surface materials – Transducer calibration system for Automotive application – strain gauge weighing system – solenoid force – Displacement calibration system – Rotary optical encoder – controlling temperature of a hot/cold reservoir – sensors for condition monitoring – mechatronic control in automated manufacturing

Text Books:

1. Bolton, *Mechatronics – Electronic Control Systems in Mechanical and Electrical Engineering*, 2nd Edition, Addison Wesly Longman Ltd., 1999.

Reference Books:

1. Devdas shetty, Richard A. Kolkm, *Mechatronics System Design*, PWS Publishing Company, 1997.
2. Bradley, D. Dawson, N.C. Burd and A.J. Loader, *Mechatronics: Electronics in products and Processes*, Chapman and Hall, London, 1991.
3. Brian Morriss, *Automated Manufacturing Systems – Actuators Controls, Sensors and Robotics*, McGraw Hill International Edition, 1995.

Course Code: ECL523
Course Title: ORGANIC ELECTRONICS
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Organic and Inorganic Materials & Charge Transport: Introduction; Organic Materials: Conducting Polymers and Small Molecules, Organic Semiconductors: p-type, n-type, Ambipolar Semiconductors, Charge Transport in Organic Semiconductors, Charge Transport Models, Energy Band Diagram, Organic and inorganic materials for: Source, Drain and Gate electrodes , Insulators, Substrates; Comparison between Organic and Inorganic Semiconductors.

Device Physics and Structures: Organic Thin Film Transistors: Overview of Organic Field Effect Transistor (OFET); Operating Principle; Classification of Various Structures of OFETs; Output and Transfer Characteristics; OFETs Performance Parameters: Impact of Structural Parameters on OFET; Extraction of Various Performance Parameters, Advantages, Disadvantages and Limitations.

Organic Device Modeling and Fabrication Techniques: Modeling of OTFT Different Structures, Origin of Contact Resistance, Contact Resistance Extraction, Analysis of OFET Electrical Characteristics, Validation and Comparison of OFETs. Organic Devices and Circuits Fabrication Techniques.

Organic Light Emitting Diodes (OLEDs): Introduction; Different Organic Materials for OLEDs; Classification of OLEDs, Output and Transfer Characteristics; Various Optical, Electrical and Thermal properties, Advantages, Disadvantages and Limitations.

Organic Solar Cells: Introduction, Materials, various properties, Characteristics, Advantages, Disadvantages and Limitations and Applications; OTFT Applications based on Recent Technology Development.

Text Books:

1. Hagen Klauk, *Organic Electronics: Materials, Manufacturing and Applications*, Wiley-VCH Verlag Gmbh & Co. KGaA, 2006.
2. Klaus Mullen, Ullrich Scherf, *Organic Light Emitting Devices*: *Synthesis, Properties and Applications*, Wiley-VCH Verlag Gmbh & Co. KGaA, 2005

Reference Books:

1. Hagen Klauk, *Organic Electronics II: More Materials and Applications*, Wiley-VCH Verlag Gmbh & Co. KGaA, 2012
2. Flora Li, Arokia Nathan, Yiliang Wu, Beng S. Ong, *Organic Thin Film Transistor Integration: A Hybrid Approach*, Wiley-VCH, 1st Ed., 2011
3. Wolfgang Brutting, *Physics of Organic Semiconductors*, Wiley VCH Verlag Gmbh & Co. KGaA, 2005.

Course Code: ECL524
Course Title: MIXED-SIGNAL VLSI DESIGN
Structure (L-T-P): 3-0-0
Prerequisite: ECL503, ECL504
Contents:

Signals, Filters and Tools: Sinusoidal signal, Comb filters and representation of signals Sampling and Aliasing: Impulse Sampling, Decimation, K-Path Sampling Sample-and-Hold, Track-and-Hold, Implementation of S/H, Discrete Analog Integrator Analog Filters: Integrator building blocks, MOSFET-C Integrator gm-C Integrators, Discrete time Integrators, Filtering topologies, Bilinear and Bi quadratic Transfer function Digital Filters: SPICE Models for DACs and ADCs, Sinc Shaped digital filters, Band-pass and High pass Filters, Filtering topologies, FIR Filter, Concept of stability and Overflow Data Convertor SNR: Quantization noise, Signal-to-Noise Ratio (SNR), Concept of Spectral Density, Clock Jitter reduction techniques, Improving SNR using Averaging and Feedback, Basics of Data Convertor Design: (ADC and DAC), Mix signal layout, Voltage mode signaling and data transmission, current mode signaling and data transmission Passive mixed signal layout Noise shaping, Improving SNR and Linearity, Improving Linearity using Active circuits, Noise Shaping Data Converters: First Order Noise Shaping, Second order noise shaping, noise shaping topologies, Cascaded Modulators, Bandpass Data Converters: Continuous Time bandpass noise shaping, Active and Passive component bandpass modulators, switched capacitor bandpass modulator, Digital I/Q Extraction to bandpass High Speed Data Converters: Topologies, path settling time, implementation, generation of clock signals and comparators, Clocked comparators, ADC.

Text Books:

1. Baker, Jacob R. CMOS Mixed signal Circuit Design. 2nd ed. Wiley IEEE Press, 2009.

Reference Books:

1. Baker, Jacob R. *CMOS circuit design, layout and simulation*. 2nd ed. IEEE press, 2008.
2. Razavi, Behzad. *Design of analog CMOS integrated circuits*. Tata McGraw-Hill, 2003.

Course Code: ECL525
Course Title: THERMAL EFFECTS IN NANOSCALE DEVICES AND CIRCUITS
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Content:

Lattice Structure, Phonons, and Electrons: Introduction and Atomic Bonding, Mathematical Description of the Lattice, Lattice Vibrations and Phonons, Free Electrons.

Carrier Statistics: Statistical Ensembles, Phonon Density of States, Electron Density of States.

Basic Thermal Properties: Introduction to Specific Heat, Acoustic Phonon Specific Heat, Optical Phonon Specific Heat, Electron Specific Heat, Thermal Conductivity from Kinetic Theory, Basics of Joule Heating.

Some general aspects of heat conduction, Scaling effect, Self-Heating Effect in Nanoscale Devices(SOI MOSFET, Multi Gate Transistor), Thermal Resistance & Thermal Capacitance in Electronic Devices, Calculation of Thermal Resistance of Electronic Devices, Solution of the self-heating problem.

Thermal modeling for Nanoscale Devices, Current state of the art in modeling heating effects in nanoscale devices: Some general considerations about the solution of the heat transport problem in devices, Solving lattice heating problem in nanoscale devices, Thermal degradation in high-k devices.

Effect of Self heating on Performance & Reliability, Self-Heating Effect in Circuit, Thermal constraints and Thermal management in electronic system.

Text Books:

1. Raleva K., Shaik A.R. , Vasileska D. & Goodnick S.M. Modeling Self-Heating Effects in Nanoscale Devices, A Morgan & Claypool publication, 2017.
2. Zhang Zhuomin, Nano/Microscale Heat Transfer, 5th Edition, McGraw-Hill Education, 2007.

Course Code: ECL526
Course Title: CFOA AND ITS LINEAR AND NONLINEAR APPLICATIONS
Structure (L-T-P): 3-0-0
Prerequisite: ECL151, ECL351
Contents

Introduction to CFOA: Merits, Demerits, Basic circuits and available varieties. Design of different applications of analog VLSI employing CFOA such as grounded and floating synthetic inductor realisation, active filter realisation, synthesis of sinusoidal oscillators, linear and non-linear applications. Realisation of other active building blocks using CFOA. Implementation of CFOA using Bipolar/CMOS.

Current conveyors and their variants , linear and non-linear applications of CC in analog VLSI.

Practical: Practicals as per course contents including simulation as well as hardware experimentation using commercially available Integrated circuits.

Text Books:

1. R. Senani, D. R. Bhaskar, V. K. Singh and A. K. Singh, `Current Feedback Operational Amplifiers and Their Applications', Springer Science, Business Media, New York, 2013.

Reference Books:

1. T. Deliyannis, Yichuang Sun and J. K.Fidler *Continuous-time active filter design*. CRC press, 1998.
2. R. Senani, D. R. Bhaskar and A. K. Singh, `Current Conveyors: Variants, Applications and Hardware Implementations', Springer International Publishing, Switzerland.

Course Code: ECL527

Course Title: VLSI SIGNAL PROCESSING SYSTEMS

Structure (L-T-P): 3-0-0

Prerequisites: ECL352

Contents

Introduction to DSP systems – Typical DSP algorithms, Data flow and Dependence graphs - critical path, Loop bound, iteration bound, longest path matrix algorithm, Pipelining and Parallel processing of FIR filters, Pipelining and Parallel processing for low power.

Retiming – definitions and properties, Unfolding – an algorithm for unfolding, properties of unfolding, sample period reduction and parallel processing application, Algorithmic strength reduction in filters and transforms – 2-parallel FIR filter, 2-parallel fast FIR filter, DCT architecture, rank-order filters, Odd-Even merge-sort architecture, parallel rank-order filters.

Fast convolution – Cook-Toom algorithm, modified Cook-Toom algorithm, Pipelined and parallel recursive filters – Look-Ahead pipelining in first-order IIR filters, Look-Ahead pipelining with power-of2 decomposition, Clustered look-ahead pipelining, Parallel processing of IIR filters, combined pipelining and parallel processing of IIR filters.

Bit-level arithmetic architectures – parallel multipliers with sign extension, parallel carry-ripple and carry-save multipliers, Design of Lyon's bit-serial multipliers using Horner's rule, bit-serial FIR filter. CSD representation, CSD multiplication using Horner's rule for precision improvement, Distributed Arithmetic fundamentals and FIR filters.

Numerical strength reduction – sub-expression elimination, multiple constant multiplication, iterative matching, synchronous pipelining and clocking styles, clock skew in edge-triggered single phase clocking, two-phase clocking, wave pipelining, Asynchronous pipelining, bundled data versus dual rail protocol.

Text Book:

1. Keshab K. Parhi, "VLSI Digital Signal Processing Systems, Design and implementation ", Wiley, Interscience, 2007.

Reference Books:

1. U. Meyer – Baese, "Digital Signal Processing with Field Programmable Gate Arrays", Springer, Second Edition, 2004.
2. Kung S. Y, H. J. While House, T. Kailath,"VLSI and Modern Signal Processing", Prentice Hall,1985.
3. Jose E. France, Yannis Tsividis, "Design of Analog – Digital VLSI Circuits for Telecommunications and Signal Processing", Prentice Hall, 1994.
4. Medisetti V. K, "VLSI Digital Signal Processing", IEEE Press (NY), USA,1995

Course Code: **ECL531**

Course Title: ADVANCED MICROWAVE ENGINEERING

Structure (L-T-P): 3-0-0

Prerequisite: ECL254

Contents:

Overview of basic Microwave theory: Transmission lines, single & double stub matching, S-parameters.

Microwave Filters: Periodic structures, Filter design by Image parameter method, insertion loss method, filter transformations, filter implementations, stepped impedance low pass filters, coupled line filters, filters using coupled resonators,

Theory and design of ferromagnetic components: plane wave propagation in ferrite medium, Propagation in ferrite loaded rectangular waveguide, ferrite isolators, phase shitters, circulators.

Noise in Microwave circuits, noise figure of passive two port network, mismatched lossy line

Active RF and microwave devices: Diode & circuits, BJT's, FET's, Microwave Integrated circuits, Microwave tubes

Two port power gains, stability circles, tests for unconditional stability

System aspects of antenna: gain, aperture efficiency, power radiated, background and brightness temperature, antenna noise temperature,

Wireless communication: Friis formula, link budget and margin, radio receiver architecture, Microwave propagation, introduction to radar systems, radiometer systems.

Introduction to Recent trends in microwave: UWB Systems, Microwave Imaging, Microwave sources: Reletron, gyrotron, remote sensing.

Text Books:

1. Pozar, D.M. *Microwave and RF Design of Wireless Systems*. Wiley, 2000.

Reference Books:

1. Bahl, I., and Bhartia, P. *Microwave Solid State Circuit Design*. 2nd ed. John Wiley & Sons, 2003.
2. Chang, K., Bahl, I., and Nair, V. *RF and Microwave Circuit and Component Design for Wireless Systems*. Wiley Inter Science, 2002
3. Rohde, U.L., and Newkirk, D.P. *RF/Microwave Circuit Design for Wireless Applications*. John Wiley & Sons, 2000
4. Gonzalez, G. *Microwave Transistor Amplifiers: Analysis and Design*. 2nd ed. Prentice-Hall, 1997.
5. Skolnik, Merrill I. *Introduction to Radar Systems*. Tata McGraw-Hill Education; 2007.

Course Code: **ECL532**

Course Title: ADVANCED ANTENNA THEORY AND DESIGN

Structure (L-T-P): 3-0-0

Prerequisite: ECL354

Contents:

Fundamental Concepts: Radiation pattern, near- and far-field regions, reciprocity, directivity and gain, effective aperture, polarization, input impedance, efficiency, Friis transmission equation, radiation integrals and auxiliary potential functions.

Radiation from Wires and Loops: Infinitesimal dipole, finite-length dipole, linear elements near conductors, dipoles for mobile communication, small circular loop.

Aperture Antennas: Huygens' principle, radiation from rectangular and circular apertures, design considerations, Babinet's principle, Fourier transform method in aperture antenna theory.

Horn and Reflector Antennas: Radiation from sectoral and pyramidal horns, design concepts, prime-focus parabolic reflector and cassegrain antennas.

Microstrip Antennas: Basic characteristics, feeding methods, methods of analysis, design of rectangular and circular patch antennas.

Antenna Arrays: Analysis of uniformly spaced arrays with uniform and non-uniform excitation amplitudes, extension to planar arrays.

Introduction to recent trends: Leaky wave antenna, SIW structures, Vivaldi Antenna, Optical antennas, Fractal Antennas, reconfigurable antennas.

Text Books:

1. Balanis, C.A., *Antenna Theory and Design*, 3rd Ed., John Wiley & Sons. 2005

2. Kraus, J.D. and Fleisch, D.A., *Electromagnetics with Applications*, McGraw-Hill. 1999.
3. Jordan, E.C. and Balmain, K.G., *Electromagnetic Waves and Radiating Systems*, 2nd Ed., Prentice-Hall of India. 1993.

Reference Books:

1. Stutzman, W.L. and Thiele, H.A., *Antenna Theory and Design*, 2nd Ed., John Wiley & Sons. 1998
2. Elliot, R.S., *Antenna Theory and Design*, Revised edition, Wiley IEEE Press. 2003
3. Garg, R., Bhartia, P., Bahl, I. and Ittipiboon, A., *Microstrip Antenna Design Handbook*, Artech House. 2001.

Course Code: **ECL533**

Course Title: ADVANCED DIGITAL COMMUNICATION SYSTEMS

Structure (L-T-P): 3-0-0

Prerequisite: ECL355

Contents:

Introduction: Elements of digital communication system – Communication channels and their characteristics– Mathematical models for channels. Representation of digitally modulated signals – Performance of memory less modulation methods – signaling schemes with memory – CPFSK – CPM. Optimum Receivers for AWGN Channels: Waveform and vector channel models. Detection of signals in Gaussian noise. Optimum detection and error probability for band limited signaling and power limited signaling – Non coherent detection – Comparison of digital signaling methods – Lattices and constellations based on lattices –Detection of signaling schemes with memory – Optimum receiver for CPM – Performance analysis for wireline and radio communication systems. Introduction to partially coherent, double differentially coherent communication systems. Channel Coding: Introduction to linear block codes, Convolution coding –Tree, Trellis and State diagrams – Systematic, Non-recursive and recursive convolutional codes – The inverse of a convolutional Encoder and Catastrophic codes – Decoding of convolutional codes - Maximum likelihood decoding, Viterbi algorithm and other decoding algorithms – Distance properties – Punctured convolutional codes, Dual-k codes, Concatenated codes – MAP and BCJR algorithms – Turbo coding and Iterative decoding – Factor graphs and sum-product algorithms – LDPC codes – Trellis coded modulation - Performance comparison.

Pulse Shaping and Equalization: Pulse shaping: Characterization of Band limited channels – ISI – Nyquist criterion – Controlled ISI – Channels with ISI and AWGN – Pulse shaping for optimum transmissions and reception. Equalization: MLSE – Linear equalization – Decision feedback equalization – ML detectors – Iterative equalization – Turbo equalization. Adaptive linear equalizer – Adaptive decision feedback equalization – Blind equalization. Synchronization: Signal parameter Estimation-Carrier phase Estimation–Symbol timing Estimation – Joint estimation of carrier phase and symbol timing − Performance characteristics of ML Estimators.

Text Books:

1. Proakis, John G., and Salehi, Masoud. *Digital Communications*. 5th ed. Tata McGraw Hill, 2008.

Reference Books:

1. Glover, Ian A., and Grant, Peter M. *Digital Communications*. 2nd edition, Pearson education, 2008.
2. Goldsmith, Andrea. *Wireless Communications*. Cambridge University Press, 2005.
3. Simon, Marvin, K., Hinedi, Sami, M., and Lindsey, William C. *Digital Communication Techniques: Signal Design and Detection*. Prentice Hall of India, 2009.
4. Sklar, Bernard. *Digital Communications: Fundamentals and Applications.* 2nd ed. Pearson Education, 2002.
5. Theodoridis, S., and Koutroumbas, K. *Pattern Recognition*. 4th ed. Academic Press, 2009.

Course Code: **ECL534**

Course Title: ADVANCED DIGITAL SIGNAL PROCESSING

Structure (L-T-P): 3-0-0

Prerequisite: ECL352

Contents:

Introduction to multi-resolution/multiscale analysis with some practical situations. Time-frequency analysis and wavelets.

Haar wavelet, Multiresolution Analysis (MRA), Relating dyadic MRA to filter banks. Elements of multirate systems and two-band filter bank design for dyadic wavelets.

Families of wavelets: Orthogonal and biorthogonal wavelets, Daubechies' family of wavelets, Conjugate Quadrature Filter Banks (CQF) and their design. Data compression - fingerprint compression standards, JPEG-2000 standards.

The Continuous Wavelet Transform (CWT). Journey from the CWT to the DWT. The class of spline wavelets. The wavepacket transform. Applications.

Text Books:

1. Howard L. Resnikoff, Raymond O. Wells, *Wavelet Analysis: The Scalable Structure of Information*, Springer, 1998.
2. P. Vaidyanathan, *Multirate Systems and Filter Banks*, Pearson Education.

Reference Books:

1. K. P. Soman, K. I. Ramachandran, *Insight Into Wavelets - From Theory to Practice*, Prentice Hall of India, 2004.
2. Michael W. Frazier, *An Introduction to Wavelets Through Linear Algebra*, Springer, 1999.

Course Code: ECL541

Course Title: RADIO FREQUENCY CIRCUIT DESIGN

Structure (L-T-P): 3-2-0

Pre-requisite: ECL254

Contents:

Review of Passive RLC networks. Transmission lines. Two-port network modeling. S-parameter model. Challenges in RF transceiver design.

Transceiver architectures. Translation of communication specifications to circuit specifications. Active devices for RF circuits: HBT and MESFET, SiGe HBT and MOSFET, GaAs pHEMT,. PIN diode.

Device parameters and their impact on circuit performance, intrinsic and extrinsic models. RF Amplifier design issues: noise types and their characterization, two port network noise analysis, noise figure and its applications, noise models of passive and active devices, large scale and linearity issues, voltage references and biasing.

Low Noise Amplifier design: LNA topologies, power match vs noise match. Linearity and large-signal performance. LNA design case studies.

RF Power amplifiers: General properties. Class A, AB and C PAs. Class D, E and F amplifiers. Mixers, oscillators.

Design and performance characterization. Spurious frequencies, phase noise.

Text Books:

1. Lee, T.H., *The Design of CMOS Radio Frequency Integrated Circuits*, 2nd ed., New York: Cambridge University Press, 2004.
2. Ludwig, R. and Bogdanov, G., *RF Circuit Design: Theory and Applications*, 2nd ed. ed., Pearson Education, 2009.

Reference Books:

1. Radmanesh, M.M., *Radio Frequency and Microwave Electronics Illustrated*, Prentice-Hall, 2001.
2. Leung, B., *VLSI for Wireless Communication*, 2nd ed. Springer, 2011.

Course Code: ECL542

Course Title: IMAGE PROCESSING

Structure (L-T-P): 3-0-0

Prerequisite: NIL

Contents:

Image representation, gray scale and colour images, image sampling and quantization. Two dimensional orthogonal transforms-DFT, FFT, WHT, Haar trans-form, KLT, DCT. Image enhancement-filters in spatial and frequency domains, histogram-based processing, homomorphic filtering. Edge detection-non parametric and model based approaches, LOG filters, localisation problem. Image Restoration-PSF, circulant and block circulant matrices, deconvolution, restoration using inverse filtering, Wiener filtering and maximum entropy-based methods. Mathematical morphology, binary morphology, dilation, erosion, opening and closing, duality relations, gray scale morphology, applications such as hit-and-miss transform, thinning and shape decomposition. Computer tomography parallel beam projection, Radon transform, and its inverse, Back-projection operator, Fourier-slice theorem, CBP and FBP methods, ART, Fan beam projection. Image communication, JPEG, MPEGs and H.26x standards, packet video, error concealment.

Image texture analysis, co-occurrence matrix, measures of textures, statistical models for textures. Hough Transform, boundary detection, chain coding, and segmentation, thresholding methods.

Text Books:

1. Jain, A. K., *Fundamentals of Digital Image Processing*, Prentice Hall of India, 2012.
2. Gonzalez, R.C. and Woods, R.E., *Digital Image Processing*, 3rd ed., Pearson Education, 2013.

Reference Books:

1. Haralick, R.M. and Shapiro, L.G., *Computer and Robot Vision*, Addison Wesley, 1993.
2. Jain, R., Kasturi, R. and Schunck, B.G., *Machine Vision*, McGraw-Hill, 1995.
3. Pratt, W. K., Digital Image Processing, 4th ed., Wiley India, 2012.

Course Code: ECL543

Course Title: RF RECEIVER DESIGN FOR WIRELESS APPLICATIONS

Structure (L-T-P): 3-0-0

Prerequisite: NIL

Contents:

Introduction to Wireless Systems: Classification of wireless systems; Design and performance issues: Choice of operating frequency.

Noise and Distortion in Microwave Systems: Basic threshold detection, noise temperature and noise figure, noise figure of a lossy transmission line; Noise figure of cascade systems: Noise figure of passive networks, two-port networks, mismatched transmission lines and Wilkinson power dividers; Dynamic range and inter-modulation distortion.

Microwave Amplifier Design: Two-port power gains; Stability of transistor amplifier circuits; Amplifier design using S-parameters: Design for maximum gain, maximum stable gain, design for specified gain.

Low-noise amplifier design, and design of class-A power amplifiers.

Mixers: Mixer characteristics: Image frequency, conversion loss, noise figure.

Devices for microwave switches; Device models; Types of switches; Switch configurations; Multi-port, broad-band and isolation switches.

Oscillators and Frequency Synthesizers: General analysis of RF oscillators, transistor oscillators, dielectric resonator oscillators, oscillator noise and its effect on receiver performance.

Text Books:

1. Pozar, D.M. *Microwave and RF Design of Wireless Systems*. Wiley, 2000.

Reference Books:

1. Bahl, I., and Bhartia, P. *Microwave Solid State Circuit Design*. 2nd ed. John Wiley & Sons, 2003.
2. Chang, K., Bahl, I., and Nair, V. *RF and Microwave Circuit and Component Design for Wireless Systems*. Wiley Inter Science, 2002
3. Rohde, U.L., and Newkirk, D.P. *RF/Microwave Circuit Design for Wireless Applications.* John Wiley & Sons, 2000
4. Larson, L.E. *RF and Microwave Circuit Design for Wireless Applications*. Artech House, 1996.
5. Egan, W. F. *Practical RF Circuit Design*. John Wiley & Sons, 1998.
6. Gonzalez, G. *Microwave Transistor Amplifiers: Analysis and Design*. 2nd ed. Prentice-Hall, 1997.

Course Code: ECL544

Course Title: CAD OF RF AND MICROWAVE CIRCUITS

Structure (L-T-P): 3-0-0

Prerequisite: NIL

Contents:

Review of basic microwave theory: Transmission Lines - Concepts of characteristic impedance, reflection coefficient, standing and propagating waves, Equivalent Circuits.

Network analysis: S, Z, ABCD, Y, T multi-port parameters, impedance matching Techniques.

Planar transmission lines: Stripline, Microstrip line and suspended stripline,

Filters: Low pass, band pass, high pass, band stop filters using lumped element as well as distributed element realization.

Direction Couplers: Hybrid Branch line, rat race and parallel coupled type, even and odd mode analysis.

Power divider, Power combiner.

Practical's: Design of filters, direction coupler, power divider using simulator.

Text Books:

1. Pozar, D. M. *Microwave Engineering*. 3rd ed. John Wiley.

Reference Books:

1. Collin, R.E. *Foundation for Microwave Engineering*. 2nd ed. John Wiley and Sons, 2007.
2. Edwards, T., and Steer, M.B. *Foundations for Microstrip Circuits Design*. 4th ed. John Wiley, 2009.
3. Bhat, B., and Koul, S. K. *Stripline like transmission lines for Microwave Integrated Circuits.* New Age Publishers, 1989.

Course Code: ECL545

Course Title: HUMAN AND MACHINE SPEECH COMMUNICATIONS

Structure (L-T-P):3-0-0

Prerequisite: ECL251

Contents:

Introduction: Human-machine speech communications aspects; digital representations of speech; intensity level of sound.

Speech production: Anatomy and physiology of speech organs; articulatory phonetics; acoustic phonetics; phonetics transcription, Physiological and Mathematical Model.

Speech signal analysis: Time domain methods; Frequency domain methods; Pitch estimation spectrogram analysis; Spectrum analysis, MFCC.

Linear prediction coding: Least squares autocorrelation and covariance methods; Line spectral frequencies.

Psychoacoustics and auditory perception: Hearing; critical bands; phenomena of masking; Mel scale.

Speech signal coding: Speech coder attributes; Coding rates; PCM; ADPCM; CELP; Coding standards.

Assessment of speech quality: Objective and subjective quality evaluation measures.

Automatic Speech recognition: Pattern recognition approach; Dynamic time warping; Feature extraction; HMM; Language models.

Text Books:

1. Rabiner, L. R., and Schafer, R. W. *Digital Processing of Speech Signals*. 4th ed. Pearson Education, 2009.

Reference Books:

1. Quatieri, Thomas F., Cloth. *Discrete-Time Speech Signal Processing: Principles and Practice.* Pearson Education, 2008.
2. Young, S., and Bloothooft, G. *Corpus-Based Methods in Language and Speech Processing*. Springer Science and Business Media, 2013.
3. Deller, J, R., Proakis, J. G., and Hansen J. H. *Discrete Time Processing of Speech Signals*. John Wiley and Sons, 2000
4. Gold, B., and Morgan, N. *Speech and Audio Signal Processing: Processing and perception of speech and music*. 2nd ed. John Wiley and sons 2011.
5. Huang, X. D., Ariki, Y., and Jack, M. A. *Hidden Markov Models for Speech Recognition*. Edinburgh University Press, 1990.

Course Code: ECL546

Course Title: ADVANCED WIRELESS MOBILE COMMUNICATIONS

Structure (L-T-P): 3-0-0

Prerequisite: ECL355

Contents:

Wireless Communications and Diversity: Fast Fading Wireless Channel Modelling Rayleigh/Ricean Fading Channels, BER Performance in Fading Channels, Diversity modelling for Wireless Communications, BER Performance Improvement with diversity, Types of Diversity – Frequency, Time, Space.

Broadband Wireless Channel Modelling: WSSUS Channel Modelling, RMS Delay Spread, Doppler Fading, Jakes Model, Autocorrelation, Jakes Spectrum, Impact of Doppler Fading

OFDM and MIMO: Introduction to OFDM, Multicarrier Modulation and Cyclic Prefix Channel model and SNR performance, OFDM Issues – PAPR, Frequency and Timing Offset Issues, Introduction to MIMO, MIMO Channel Capacity, SVD and Eigen-modes of the MIMO Channel, MIMO Spatial Multiplexing & Diversity MIMO - OFDM

UWB (Ultra-Wide Band): UWB Definition and Features, UWB Wireless Channels, UWB Data Modulation, Uniform Pulse Train, Bit-Error Rate Performance of UWB

3G and 4G Wireless Standards: GSM, GPRS, WCDMA, UMTS, LTE, WiMAX, 5G technology.

Text Books:

1. Tse, D., and Viswanath, P. *Fundamentals of Wireless Communications*. Cambridge University Press, 2005

Reference Books:

1. Rappaport, Theodore S. *Wireless Communications: Principles and Practice*. 2nd Edition. Pearson Education India, 2010.
2. Biglieri, Ezio. *MIMO Wireless Communications*. Cambridge University Press, 2007.
3. Haykin, S., and Moher, M. *Modern Wireless Communications*. Pearson Education, 2011.
4. Goldsmith, A. *Wireless Communications*. Cambridge University Press, 2005.

Course Code: ECL547

Course Title: THEORY OF ESTIMATION AND DETECTION

Structure (L-T-P): 3-0-0

Prerequisite: SCL253, ECL352

Contents:

Introduction: Classification of Estimation Approaches, Formulation of the Detection Problems, Hierarchy of Detection Problems.

Classical Unbiased Estimation and Bounds: Minimum variance unbiased estimator (MVUE), Cramer-Rao lower bound (CRLB) on unbiased estimators, Fisher information and its relation to CRLB, Computation of CRLB in general cases Linear model of data and its generalization.

General MVU Estimation: Sufficient statistics, Determination of MVUE using a sufficient statistics, Best linear unbiased estimation (BLUE).

Maximum Likelihood Estimation (MLE): Basic Procedure of MLE, MLE for Transformed Parameters, MLE for General Linear Model, Asymptotic Property of MLE.

Least Squares Estimator: Basic Procedure of LSE, Linear Least Squares, Geometrical Interpretations of LS Approach, Constrained Least Squares.

Estimation of Signals: Linear Minimum Mean Square Error (LMMSE) Estimator, Bayesian Gauss-Markov Theorem, Wiener Filtering and Prediction.

Detection Theory: Simple hypothesis testing, Neyman-Pearson criterion, Bayes criterion, Minimax criterion, Composite hypothesis testing, Bayesian criterion Generalized likelihood ratio tests.

Text Books:

1. Kay, S. M. *Fundamentals of Statistical Signal Processing: Estimation Theory*. Vol I, Prentice-Hall, 1995.

Reference Books:

1. Poor, H. V. *An Introduction to Signal Detection and Estimation*.2nd ed. Springer, 1998.
2. Helstrom, Carl W. *Elements of Signal Detection & Estimation*. Prentice Hall, 1994.
3. Srinath, M. D., Rajasekaran, P. K., and Visawanath, R. *Introduction to Statistical Signal Processing with Applications*. Prentice Hall, 1995.

Course Code: ECL548

Course Title: MIMO SYSTEM

Structure (L-T-P): 3-0-0

Prerequisite: ECL355

Contents:

Spatio-Temporal Propagation Modeling: Introduction, Directional Channel Modeling, Gaussian Wide Sense Stationary Uncorrelated Scattering, Gaussian Scatter Density Model.

Theory of MIMO Wireless Communication: Shannon's Capacity Formula, Extended Capacity Formula for MIMO Channels, Remarks on the Extended Shannon Capacity Formula, Capacity of SIMO — MISO Channels, Stochastic Channels, MIMO Capacity with Rice and Rayleigh Channels.

Information Theory and Electromagnetism: The Laws of Electromagnetism, Spatial Capacity and Correlation, Spatial Sampling and MIMO Capacity, MIMO Capacity of Waveguide Channels, Spatial Capacity of Waveguide Channels.

Introduction to Space–Time Coding: MIMO System and Space–Time Coding, Alamouti's Transmit Technique, Space–Time Block Codes, Orthogonal Space–Time Block Codes, Space–Time Trellis Codes.

Feedback Techniques for MIMO Channels: Limited Feedback MIMO, Quantized Signal Adaptation Algorithms.

Antenna Selection in MIMO Systems: Spatial Multiplexing, Implementing Antenna Selection: Criteria and Algorithms.

Performance of Multi-User Spatial Multiplexing: Multiple-User MIMO Channel, Multi-User MIMO Transmission Schemes.

Text Books:

1. Tsoulos, G. *MIMO System Technology for Wireless Communications.* Taylor and Francis Group, 2006.

Reference Books:

1. Tse, D., and Viswanath, P. *Fundamentals of Wireless Communication*. Cambridge University Press, 2005.
2. Paulraj, Nabar, R., and Gore, D. *Introduction to Space-time Communications*. Cambridge University Press, 2003.

Course Code: ECL549
Course Title: MICROWAVE AND MILLIMETER WAVE ENGINEERING
Structure (L-T-P): 3-0-0
Pre-requisite: NIL
Contents:

Fundamental Concepts: Elements of microwave/millimeter wave integrated circuits; Classification of transmission lines: Planar, quasiplanar and 3-D structures, their basic properties, field distribution and range of applications; Substrate materials and technology used for fabrication.

Analysis of Planar Transmission Lines: Variational approach for the determination of capacitance of planar structures; Transverse transmission line techniques for multi-dielectric planar structures; Rigorous analysis of dielectric integrated guides; Use of effective dielectric constant in the approximate analysis of dielectric guide.

Meta-materials: Theory of Composite Right/Left Handed (CRLH) transmission line meta-materials; Representation of CRLH meta-material by an equivalent homogeneous CRLH TL; L-C network implementation and its physical realization.

Discontinuities: Analysis of discontinuities in planar and non-planar transmission lines and their equivalent circuit representation.

Passive Circuits: Design and circuit realization of filters, couplers, phase shifters, and switches using planar and non-planar transmission lines.

Active Circuits: Design and circuit realization of amplifiers and oscillators using planar and non-planar transmission lines.

Text Books:

1. Edwards, Terry C., and Michael B. Steer. *Foundations for microstrip circuit design*. John Wiley & Sons, 2016.
2. Bhat, Bharathi, and Shiban K. Koul. *Stripline-like transmission lines for microwave integrated circuits*. New Age International, 1989.
3. Koul, Shiban K. *Millimeter wave and optical dielectric integrated guides and circuits*. Wiley, 1997.

Reference Books:

1. Caloz, Christophe, and Tatsuo Itoh. *Electromagnetic metamaterials: transmission line theory and microwave applications*. John Wiley & Sons, 2005.
2. Ludwig, Reinhold. *RF Circuit Design: Theory & Applications*, 2/e. Pearson Education India, 2000.
3. Wolff, Ingo. *Coplanar microwave integrated circuits*. John Wiley & Sons, 2006.
4. Bhat, Bharathi, and Shiban K. Koul. *Analysis, design, and applications of fin lines*. Artech House Publishers, 1987.

Course Code: ECL550
Course Title: 2D SIGNALS AND IMAGE PROCESSING
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

2D Signals and system: 2D filtering, FIR, IIR.

Digital Image fundamentals: image representation, image sampling and quantization.

Spatial filtering and Filtering in frequency domain: Histogram processing, smoothening and sharpening filters, Edge detection-non parametric and model based approaches, LOG filters, localization problem.

Two dimensional orthogonal transforms: DFT, FFT, WHT, Haar transform, KLT, DCT.

Image Restoration: PSF, circulant and block-circulant matrices, deconvolution, restoration using inverse filtering, Wiener filtering and maximum entropy-based methods.

Morphological processing: Mathematical morphology, binary morphology, dilation, erosion, opening and closing, duality relations. Gray scale morphology, applications such as hit-and-miss transform, thinning and shape decomposition.

Image compression: JPEG, H.26x standards.

Image texture analysis: co-occurrence matrix, measures of textures, statistical models for textures. Hough Transform, boundary detection, chain coding, and segmentation, thresholding methods.

Pattern Recognition and its introduction.

Text Books:

1. Gonzalez, R. C., and Woods, R. E. *Digital image processing*. 3rd ed. Pearson, 2008.

Reference Books:

1. Lim, J. S. *Two Dimensional Signal and Image Processing*. Prentice Hall, 1990.
2. Pratt, W. K. *Digital Image Processing*. 3rd ed. Vol I. Wiley, 2001.
3. Jain, A. K. *Fundamentals of Digital Image Processing*. 4th ed. Prentice Hall India, 1989.

Course Code: ECL551
Course Title: ADAPTIVE SIGNAL PROCESSING
Structure (L-T-P): 3-0-0
Prerequisite: ECL352
Contents:

Vectors, Matrices and Eigen Analysis. Application to adaptive signal processing. Stochastic Processes, Ensemble average, mean, average power, auto and cross correlation functions, stationarity and white noise, Auto-regressive process. Optimal FIR (Wiener) filter, Method of steepest descent, extension to complex valued signals.

Least Squares and LMS algorithms, Normal equations, properties. Eigen System decomposition. Gradient search technique, convergence properties of LMS. Normalized LMS algorithm. Recursive solution techniques, RLS algorithm. Application to noise cancellation, modeling of physical processes, communications.

Text Books:

1. Haykin, S., *Adaptive Filter Theory*, 4th ed., Pearson Education, 2012.

Reference Books:

1. Treichler, J.R., *Theory and Design of Adaptive Filters*, Prentice Hall of India, 2010.
2. Widrow B., Stearns S.D., *Adaptive Signal processing*, Prentice Hall, 1985.

Course Code: **ECL552**
Course Title: INTRODUCTION TO MACHINE LEARNING
Structure (L-T-P): 3-0-0
Prerequisite: SCL253
Contents:

Introduction: Basic definitions, types of learning, Clustering vs. Classification; Supervised vs. unsupervised, Relevant basics of Linear Algebra, vector spaces, hypothesis space and inductive bias, evaluation, cross-validation.

Linear regression, Decision trees, Over fitting.

Instance based learning, Feature reduction, Collaborative filtering based recommendation.

Probability and Bayes learning.

Logistic Regression, Support Vector Machine, Kernel function and Kernel SVM.

Neural network: Perceptron, Multilayer network, Back propagation, Introduction to Deep Neural Network.

Clustering: introduction, k-means, Gaussian Mixture Model.

Text Books:

1. Tom Mitchell *Machine Learning*, 1st Ed., McGraw- Hill, 1997.
2. Ethem Alpaydin, *Introduction to Machine Learning*, 2nd ed.
3. R. O. Duda, P. E. Hart and D. G. Stork, *Pattern Classification*, 2nd edition, Wiley-Interscience, 2001.

Reference Books:

1. Bishop, Christopher M., *Pattern Recognition and Machine Learning*, Springer, 2007.
2. Koller, D., and Friedman, N. *Probabilistic Graphical Models: Principles and Techniques*. MIT Press, 2009.
3. Theodoridis, S. and Konstantinos Koutroumbas, *Pattern recognition*, 4th Ed., Academic Press, 2008.

Course Code: ECL554
Course Title: PROBABILITY, STOCHASTIC PROCESS AND NUMERICAL METHODS
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Probability spaces. Random variables and random vectors. Distributions and densities-Conditional distributions and densities. Independent random variables. Transformation of random variables.

Expectations. Indicator. Moment generating function. Characteristic function. Multiple random variable. Gaussian random vector. Co-variance matrix. Complex random variables. Sequence of random variable-Central limit theorem.

Strictly stationary random process. Wide sense stationary random process. Complex random process. Jointly strictly and wide sense stationary of two random processes. Correlation matrix obtained from random process. Ergodic process. Independent random process. Uncorrelated random process. Random process as the input and output of the system. Power spectral density.

Application to communication systems, White random process. Gaussian random process. Cyclo-stationary

random process. Wide sense cyclo stationary random process. Sampling and reconstruction of random process. Band pass random process.

Solution of Ordinary differential equations – One-step and multistep methods – Boundary value and Eigen value Problems. Partial Differential Equation, Introduction to Finite Element Methods and Finite Difference Methods.

Text Books:

1. Papoulis, A., Pillai, S. U. *Probability, Random variables and Stochastic Processes*. 4th ed. Tata-Mcgraw Hill, 2001.
2. Chapra, Steven, and Canale, R. *Numerical Methods for Engineer*. 6th ed. Tata McGraw Hill, 2005.

Reference Books:

1. Stark, H., and Woods, J. W. *Probability and Random Processes with Applications to Signal Processing*. 3rd ed. Prentice Hall, 2001
2. Ash, R. B., and Dade, C. D. *Probability and Measure Theory*. 2nd ed. Elsevier, 2005.

Course Code: ECL555
Course Title: FIBER OPTIC COMMUNICATION SYSTEMS
Structure (L-T-P):3-0-0
Prerequisite: NIL
Contents:

Introduction to Optical Communication and Fiber Characteristics: Evolution of Light wave systems, System components, Optical fibers - Step Index & Graded index – Mode theory, Fiber modes – Dispersion in fibers, Limitations due to dispersion - Dispersion shifted and dispersion flattened fibers - Fiber Losses - Non-linear effects

Optical Transmitters: Basic concepts - LED's structures - Spectral Distribution - Semiconductor lasers - Structures – Threshold conditions - SLM and STM operation - Transmitter design.

Optical Detectors and Amplifiers: Basic Concepts - PIN and APD diodes structures, Photo detector Noise, Receiver design. Amplifiers: Basic concepts - Semiconductor optical amplifiers; Raman - and Brillouin amplifiers - Erbium-doped fiber amplifiers, pumping requirements, cascaded in-line amplifiers.

Coherent Lightwave Systems: Homodyne and heterodyne detectors - Modulation formats - Demodulation schemes - BER in synchronous receivers - Sensitivity degradation – Post - and pre compensation techniques

Optical Components for Communication & Networking: Couplers, Isolators and Circulators, Multiplexers, Bragg Gratings, Fabry-Perot Filters, Mach Zender Interferometers, Arrayed Waveguide Grating, Tunable Filters,

Link Design and Power Budget: System Model, Power Penalty in Transmitter and Receiver, Optical Amplifiers, Crosstalk and Reduction of Crosstalk, Cascaded Filters, Dispersion Limitations and Compensation Techniques.

Text Books:

1. Keiser, Gerd. *Optical Fiber Communications*. 5th Ed, Tata McGraw Hill, 2013

Reference Books:

1. Yariv, A., and Yeh, P. *Photonics – Optical Electronics in Modern Communications.* Oxford University Press, 1997.
2. Deen, M. J., and Basu, P.K. *Silicon Photonics – Fundamentals and Devices*. John Wiley & Sons Ltd., 2012.
3. Ramaswami, R., and Sivarajan, K.N. *Optical Networks- A Practical Perspective*. 3rd ed. Elsevier, 2010.
4. Agrawal, Govind. P. *Fiber Optic Communication Systems*. 4th ed. Wiley, 2010.

Course Code: **ECL556**
Course Title: RADAR SIGNAL PROCESSING
Structure (L-T-P): 3-0-0
Prerequisite: ECL464
Contents

Introduction to radar systems, Basic radar function, Radar classifications, elements of pulsed radar, The radar equation, A preview of basic radar signal processing.

Signal models, Components of a radar signal, Amplitude models, Clutter, Noise model and signal-to-noise ratio, Jamming, Frequency models: the Doppler shift, spatial models.

Sampling and quantization of pulsed radar signals, Domains and criteria for sampling radar signals, Sampling in the fast time dimension, Sampling in slow time: selecting the pulse repetition interval, Sampling the Doppler spectrum, Radar waveforms, Introduction, The waveform matched filter, Matched filtering of moving targets, The radar ambiguity function, The pulse burst waveform, frequency-modulated pulse compression waveforms, The stepped frequency waveform, Phase-modulated pulse compression waveforms, Costas frequency codes.

Doppler processing, Alternate forms of the Doppler spectrum, Moving target indication (MTI), Pulse Doppler processing, Dwell-to-dwell stagger, Additional Doppler processing issues, Clutter mapping and the moving target detector, Detection of radar signals in noise: detection fundamentals, detection criteria, Threshold detection in coherent systems, Threshold detection of radar signals, binary integration, CFAR detection, CA CFAR, Additional CFAR topics.

Text Books:

1. Richards, Mark A. *Fundamentals of Radar Signal Processing*. Tata McGraw-Hill Education, 2005.

Reference Books:

1. Haykin, Simon, ed. *Adaptive Radar Signal Processing*. John Wiley & Sons, 2007.
2. Skolnik, M.I., *Introduction to Radar Systems*, 2nd Ed., Tata McGraw-Hill, 2006.

Course Code: **ECL557**
Course Title: RF MEMS
Structure (L-T-P): 3-0-0
Prerequisite: NIL

Contents:

Introduction: RF MEMS for microwave applications, MEMS technology and fabrication, mechanical modeling of MEMS devices, MEMS materials and fabrication techniques.

MEMS Switches: Introduction to MEMS switches; Capacitive shunt and series switches: Physical description, circuit model and electromagnetic modeling; Techniques of MEMS switch fabrication and packaging; Design of MEMS switches.

Inductors and Capacitors: Micromachined passive elements; Micromachined inductors: Effect of inductor layout, reduction of stray capacitance of planar inductors, folded inductors, variable inductors and polymer-based inductors; MEMS Capacitors: Gap-tuning and area-tuning capacitors, dielectric tunable capacitors.

RF Filters and Phase Shifters: Modeling of mechanical filters, micromachined filters, surface acoustic wave filters, micromachined filters for millimeter wave frequencies; Various types of MEMS phase shifters; Ferroelectric phase shifters.

MEMS Varactors and Tunable Oscillators.

Text Books:

1. Rebeiz, Gabriel M. *RF MEMS: Theory, Design, and Technology*. John Wiley & Sons, 2004.

Reference Books:

1. Vardan, Vijay K., Vinoy, K.J., and Jose, K. A. *RF MEMS and Their Applications*. Wiley India Pvt. Ltd, 2011
2. Héctor, J. *RF MEMS circuit design for wireless communications*. Artech House, 2002.

Course Code: **ECL558**

Course Title: COMPUTATIONAL ELECTROMAGNETICS

Structure (L-T-P): 3-0-0

Prerequisite: ECL254

Contents

Review of Electromagnetic Theory: Electrostatic Fields, Magnetostatics Fields, Time-varying Fields, Boundary Conditions, Wave Equations, Time-varying Potentials, Time-harmonic Fields, Absorbing Boundary Conditions (ABCs).

Analytical Methods: Separation of Variables in Rectangular, cylindrical and spherical Coordinates, Finite Difference Schemes of Parabolic PDEs, Hyperbolic PDEs, Elliptic PDEs.

Variational Methods: Operators in Linear Spaces, Calculus of Variations, Construction of Functionals from PDEs, Rayleigh-Ritz Method, Galerkin Method, Least Squares Method.

Moment Methods: Integral Equations, Classification of Integral Equations, Connection Between Differential and Integral Equations, Green's Functions: For Free Space, For Domain with Conducting Boundaries.

Finite Element Method: Solution of Laplace's Equation, Finite Element Discretization, Element Governing Equations, Assembling of All Elements, Solving the Resulting Equations, Solution of Poisson's Equation,

Deriving Element-governing Equations, Solving the Resulting Equations, Solution of the Wave Equation.

Text Books:

1. Sadiku, M. N. O. *Numerical Techniques in Electromagnetics*, CRC Press Inc., 1992.

Reference Books:

1. Bondeson, A., Rylander, T., Ingelström, P., *Computational Electromagnetics*, Springer, 2005.
2. Sankaran, K. *Accurate Domain Truncation Techniques for Time-Domain Conformal Methods*, ETH Zurich, 2007.

Course Code: ECL559

Course Title: EVOLUTIONARY OPTIMIZATION ALGORITHMS

Structure (L-T-P): 3-0-0

Prerequisite: NIL

Contents:

Introduction to Evolutionary Optimization-Classification of Optimization-Constrained and Unconstrained, Multi-objective-Multimodal-Hill Climbing.

Genetic Algorithms-Binary and Real Coded Genetic Algorithms-Mathematical Models of Genetic Algorithms-Evolutionary Algorithm Variations-Population Diversity-Selection Options-Recombination-Mutation.

Simulated Annealing-Cooling Schedules-Implementation Issues-Ant Colony Optimization-Particle Swarm Optimization-Differential Evolution-Biogeography-Based Optimization-Cultural Algorithms-Opposition-Based Learning.

Multi-objective optimization-Nondominated Sorting Genetic Algorithm-Multi-objective Genetic Algorithm-Strength Pareto Evolutionary Algorithm-Hybrid Optimization Algorithms

Text Books:

1. Dan Simon, "Evolutionary Optimization Algorithms", John Wiley & Sons, 2013.

References Books:

1. D.K. Pratihar,"Soft Computing: Fundamentals and Applications", Alpha Science International Ltd, 2013.
2. Kalyanmoy Deb,"Multi-Objective Optimization using Evolutionary Algorithms", Wiley, 2010.
3. A.M. Gujarathi, B.V. Babu, "Evolutionary Computation: Techniques and Applications", Apple Academic Press, 2016.

Course Code: ECL560

Course Title: BIOMEDICAL IMAGE PROCESSING

Structure (L-T-P): 3-0-0

Prerequisite: ECL542

Contents:

Nature of Biomedical Images-Light Microscopy-Electron Microscopy-X-ray Imaging-Magnetic Resonance Imaging-Objectives of Biomedical Image Analysis-Computer-Aided Diagnosis

Image Quality and Information Content-Removal of Artifacts-Characterization of Artifacts-Synchronized or Multi-frame Averaging-Frequency domain filters-Optimal Filtering-Adaptive Filters

Image Enhancement-Temporal Subtraction-Histogram Transformation-Homomorphic Filtering-Adaptive contrast enhancement.

Detection of Regions of Interest-Thresholding and Binarization-Edge Detection-Segmentation and Region Growing-Case Studies-Analysis of Shape-Representation of Shapes and Contours-Shape Factors-Analysis of Texture

Pattern Classification and Diagnostic Decision-Image enhancement for Breast Cancer Screening-Classification of Breast Masses and Tumors Via Shape analysis

Text Books:

1. Rangaraj M. Rangayyan, "Biomedical Image Analysis", CRC Press, 2005.

References Books:

1. Kayvan Najarian, Robert Splinter,"Biomedical Signal and Image Processing, 2nd Edition, CRC Press, 2012.
2. John L. Semmlow, "Biosignal and Biomedical Image Processing:MATLAB-based Applications", CRC Press, New York, USA,2008.

Course Code: **ECL561**

Course Title: BIOMEDICAL SIGNAL PROCESSING

Structure (L-T-P): 3-0-0

Prerequisite: ECL251, ECL352

Contents:

Preliminaries; Biomedical signal origin & dynamics (ECG)- Biomedical signal origin & dynamics (EEG, EMG etc.)

Filtering for Removal of artifacts- Statistical Preliminaries; Time domain filtering (Synchronized Averaging, Moving Average)- Time domain filtering (Moving Average Filter to Integration, Derivative-based operator)-Frequency Domain Filtering (Notch Filter)- Optimal Filtering: The Weiner Filter-Adaptive Filtering-Selecting Appropriate Filter

Event Detection-Example events (viz. P, QRS and T wave in ECG)-Derivative based Approaches for QRS Detection-Pan Tompkins Algorithm for QRS Detection-Dicrotic Notch Detection-Correlation Analysis of EEG Signal

Waveform Analysis-Illustrations of problem with case studies-Morphological Analysis of ECG-Correlation coefficient-The Minimum phase correspondent and Signal Length- Envelop Extraction Amplitude demodulation-The Envelogram Analysis of activity-Root Mean Square value Zero-crossing rate-Turns Count-Form factor.

Frequency-domain Analysis- Periodogram-Averaged Periodogram-Blackman-Tukey Spectral Estimator- Measures derived from PSD

Text Book:

1. Rangaraj M. Rangayyan, "Biomedical Signal Analysis: A case study Approach", IEEE Press, John Wiley & Sons, Inc., 2002.

Reference Books:

1. D.C.Reddy, "Biomedical Signal Processing: Principles and techniques", Tata McGraw Hill, New Delhi, 2005.
2. C. Raja Rao and S K Guha, "Principles of Medical Electronics and Biomedical Instrumentation, Universities Press, 2001.
3. John L. Semmlow, "Biosignal and Biomedical Image Processing:MATLAB-based Applications", CRC Press, New York, USA,2008.
4. Joseph J Carr, John M Brown, "Introduction to Biomedical Equipment Technology, 4th Edition, Pearson Education, 2001.
5. Cromwell, L., Weibell, F.J. and Pfeiffer, E.A., Biomedical Instrumentation and Measurements, 2nd ed., Prentice Hall of India, 2013.
6. Webster, J.G., Medical Instrumentation: Application and Design, 4th ed., John Wiley and Sons, 2010.

Course Code: ECL562

Course Title: PRINCIPLES OF BIOMEDICAL INSTRUMENTATION DESIGN

Structure (L-T-P): 3-0-0

Prerequisite: NIL

Contents:

Introduction and basic concepts of biomedical instrumentation-Classification of Biomedical Instruments-Compensation Techniques-Generalized static and dynamic characteristics-Design Criteria- Basic Sensors and Principles

Measurement characteristics-Review of Circuit Analysis-Amplifiers and Signal Processing-Inverting, Non-inverting, Differential and logarithmic amplifiers-Integrators-Differentiators-Microcomputers in Medical Instrumentation

The origin of Biopotentials-Biopotential electrodes-Biopotential Amplifiers-Blood Pressure and Heart Sounds measurement-Measurement of Blood flow and Volume-Measurement of Respiratory System

Chemical Biosensors-Clinical Laboratory Instrumentation-Medical Imaging Systems-Therapeutic and Prosthetic Devices

Electrical Safety-Physiological effects of electricity-Macroshock and Microshock hazards-Electrical Distribution and Ground Faults-Basic protection techniques against shock and equipment damage

Recent trends in Biomedical Instrumentation

Text Books:

1. Webster, J.G., Medical Instrumentation: Application and Design, 4th ed., John Wiley and Sons, 2010.
2. Cromwell, L., Weibell, F.J. and Pfeiffer, E.A., Biomedical Instrumentation and Measurements, 2nd ed., Prentice Hall of India, 2013.

Reference Books:

1. Khandpur, R.S., Handbook of Biomedical Instrumentation, 2nd ed., Tata McGraw Hill,2012.
2. Singh, M., Introduction to Biomedical Instrumentation, PHI Learning Private Limited, 2010.
3. Ganong, W.F. et. al., Review of Medical Physiology, 24th ed., McGraw Hill, 2012.
4. Cook, A.M. and Webster, J.G., Therapeutic Medical Devices, Application and Design, Prentice-Hall, 1982.

M. Tech (Mechanical Engineering) specialization in Manufacturing Technology
OVERALL CREDIT STRUCTURE

S. No	Category	Symbol	M. Tech (Credits)
1	**PG Core**	**PC**	**30**
1.1	Departmental Core	DC	13
1.2	Project Phase-I	P1	05
1.3	Project Phase-II	P2	10
1.4	Seminar	SM	02
2	**PG Elective**	**PE**	**25**
2.1	Specialization Electives	SE	19
2.2	Open Courses	OC	06
	TOTAL REQUIREMENT		**55 (Minimum)**

Postgraduate Core (PC)		**L-T-P**	**Credit**
MED501	Project Phase –I	-	05
MED502	Project Phase-II	-	10
MED503	Seminar	-	02
MEL501	Design and Analysis of Experiments	3-0-0	03
MEL502	Modeling and Simulation	3-0-0	03
MEL503	Finite Element Method	3-0-0	03
MEP503	Finite Element Method Lab	0-0-2	01
MEL504	Product Design and Development	3-0-0	03
Specialization Elective (SE)		**L-T-P**	**Credit**
MEL505	Additive Manufacturing	3-0-0	03
MEP505	Additive Manufacturing Lab	0-0-2	01
MEL506	Industrial Automation and Robotics	3-0-0	03
MEP506	Industrial Automation and Robotics Lab	0-0-2	01
MEL507	Advanced Manufacturing Techniques	3-0-0	03
MEL508	Theory of Metal Cutting	3-2-0	04
MEL509	Non Traditional Manufacturing Processes	3-0-0	03
MEP509	Non Traditional Manufacturing Processes Lab	0-0-2	01
MEL510	Advanced Joining Processes	3-0-0	03
MEP510	Advanced Joining Processes Lab	0-0-2	01
MEL511	Theory of Plasticity and Metal Forming Processes	3-0-0	03
MEP511	Theory of Plasticity and Metal Forming Processes Lab	0-0-2	01
MEL512	Composites – Mechanics and Processing	3-0-0	03
MEL513	Precision Engineering	3-0-0	03
MEP513	Precision Engineering Lab	0-0-2	01
MEL514	Micro and Nano manufacturing	3-0-0	03

M. Tech (Mechanical Engineering) specialization in Machine Design
OVERALL CREDIT STRUCTURE

S. No	Category	Symbol	M. Tech (Credits)
1	**PG Core**	**PC**	**30**
1.1	Departmental Core	DC	13
1.2	Project Phase-I	P1	05
1.3	Project Phase-II	P2	10
1.4	Seminar	SM	02
2	**PG Elective**	**PE**	**25**
2.1	Specialization Electives	SE	19
2.2	Open Courses	OC	06
	TOTAL REQUIREMENT		**55 (Minimum)**

Postgraduate Core (PC) (Design)		**L-T-P**	**Credit**
MED501	Project Phase –I	-	05
MED502	Project Phase-II	-	10
MED503	Seminar	-	02
MEL501	Design and Analysis of Experiments	3-0-0	03
MEL502	Modeling and Simulation	3-0-0	03
MEL503	Finite Element Method	3-0-0	03
MEP503	Finite Element Method Lab	0-0-2	01
MEL504	Product Design and Development	3-0-0	03
Specialization Elective (SE)		**L-T-P**	**Credit**
MEL505	Additive Manufacturing	3-0-0	03
MEP505	Additive Manufacturing Lab	0-0-2	01
MEL506	Industrial Automation and Robotics	3-0-0	03
MEP506	Industrial Automation and Robotics Lab	0-0-2	01
MEL512	Composites: Mechanics and Processing	3-0-0	03
MEL515	Advanced Mechanics of Solids	3-0-0	03
MEP515	Advanced Mechanics of Solids Lab	0-0-2	01
MEL516	Fracture Mechanics	3-2-0	04
MEL517	Advanced Mechanical Vibration	3-0-0	03
MEP517	Advanced Mechanical Vibration Lab	0-0-2	01
MEL518	Mechanism Design	3-2-0	04
MEL519	Tribology in Design	3-0-0	03
MEL520	Smart Materials and Structures	3-0-0	03
MEL521	Rotor Dynamics and Condition Monitoring	3-0-0	03
MEP521	Rotor Dynamics and Condition Monitoring Lab	0-0-2	01
MEL522	Dynamics of Mechanical Systems	3-0-0	03

Course Syllabi (Post Graduate)
Department of Mechanical Engineering

Course Code: MEL501
Course Title: DESIGN AND ANALYSIS OF EXPERIMENTS
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Fundamentals of experimentation: role of experimentation in rapid scientific progress, historical perspective of experimental approaches, steps in experimentation, principles of experimentation; simple comparative experiments: basic concepts of probability and statistics, comparison of two means and two variances, comparison of multiple (more than two) means & ANOVA; experimental designs: factorial designs, fractional factorial designs, orthogonal arrays, standard orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data; response surface methodology: concept, linear model, steepest ascent, second order model, correlation and regression; Taguchi's parameter design: concept of robustness, noise factors, objective function & S/N ratios, inner-array and outerarray design, data analysis.

Text Book:

1. Montgomery D.C., Design and Analysis of Experiments, 7th ed., John Wiley & Sons, 2008.

Reference Books:

1. Ross P.J., Taguchi Techniques for Quality Engineering, 4th ed.McGraw-Hill, 2008.
2. Holman J.P., Gajda W.J., Experimental Method for Engineers, 7th ed., McGraw-Hill, 2007.

Course Code: MEL502
Course Title: MODELLING AND SIMULLATION
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Systems and models - Examples of models, models for systems and signals.Physical modelling - Principles of physical modelling, basic relationship. Mathematical modelling: Estimating response, spectra and frequency functions, parameter estimation in dynamic models, system identification as a tool for model building.

Simulation and Simulation application: Numerical prototyping as modelling for design and synthesis using computational tools, Introduction to techniques for validation of models, Simulation of electromechanical, thermomechanical, hydraulic and pneumatic elements.

Modelling and Simulation for Optimization: Introduction to the concept of optimization, the basic terminology and notations; modelling process; and illustration with modelling of engineeringproblems, Local and global optima; necessary and sufficient optimality conditionsfor unconstrained and constrained multivariate functions.

Text Book:

1. Bhonsle S.R. and Weinmann K.J., Mathematical Modelling for Design of Machine Components, Prentice Hall, 1999.

Reference Books:

1. Lennart L. and Torkel G., Modelling of Dynamic Systems, Prentice Hall, 1994.
2. Gordon G., System Simulation, Prentice Hall, 1978.
3. Mukherjee A. and Karmakar R., Modelling and simulation of engineering systems through bondgraphs, Alpha Science Int'l Ltd., 2000

Course Code: MEL 503
Course Title: FINITE ELEMENT METHOD
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Introduction: Structural analysis, Discrete and continuum structures, Basic steps in finite element problems formulation, general applicability of the method, strain-displacement relations, stress-strain relations, temperature effects, Rayleigh-Ritz Method, Galerkin's Method, Saint Venant's Principle, Matrix algebra, Gaussian Elimination.

1D Problems: Introduction, Finite element Modeling, Co-ordinates and Shape Functions, Convergence requirements, Potential energy approach, The Galerkin's Approach, Assembly of Global stiffness matrix and load vector, implementation of boundary conditions,

Trusses: Introduction, plane trusses, assembly of global stiffness matrices for the banded and skyline solution.

2D Problems: Introduction, finite element modeling, constant strain triangle (CST), Problem modeling and boundary conditions, four-node iso-parametric elements, higher order elements, Numerical Integration, Error analysis, Mesh refinement.

Beams and Frames: Introduction, finite element formulation, load vector, boundary considerations, shear force and bending moment, beams on elastic supports, plane frames.

Applications in Heat Transfer and Fluid Mechanics: 1D steady heat conduction, 1D heat conduction with convections and internal heat generation, 2-D Steady heat conduction, 1-D incompressible, inviscid flow acoustic flow, and viscous incompressible fluid flow.

Text Book:

1. Reddy J. N., An Introduction to Finite Element Method, 3rd ed., McGraw Hill, 2013.

Reference Books:

1. Chandrupatla, T.R. and Belegundu, A.D., Introduction to Finite Elements in Engineering, 4th ed., Pearson Education, 2012.
2. Bathe, K.J., Finite Element Procedures, PHI Learning, New Delhi, 2010.
3. Seshu, P., Textbook of Finite Element Analysis, Prentice Hall of India, New Delhi, 2012.
4. Rao, S.S., The Finite Element Method in Engineering, 5th ed., Elsevier Butterworth Heinemann, 2011.
5. Huebner, K. H., The finite element method for engineers. John Wiley & Sons., 2001
6. Krishnamoorthy C.S., Finite Element Analysis: Theory and Programming, Tata McGraw-Hill Education, 1995.
7. Hughes T.J.T., The Finite Element Method, Prentice-Hall, 1986.
8. Logan D. L., A First Course in the Finite Element Method, 5th ed., CL Engineering, 2010.

Course Code: MEL504
Course Title: PRODUCT DESIGN AND DEVELOPMENT
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Introduction: Considerations of a Good Design, Design Process, Concurrent and Computer aided engineering concepts, Design codes and Standards, Design Review and societal considerations.

Need Identification and gathering information: Evaluating Customer requirements and Bench marking, Product Design Specification, Information sources, Copyright, Expert systems.

Concept Generation and Evaluation: Creativity and Problem solving, Theory of Inventive Problem solving, Conceptual Decomposition and Axiomatic Design, Decision concept evaluation and decision making.

Embodiment Design: Product Architecture, Configuration and Parametric Design Concepts, Industrial Design, Ergonomics and Design for Environment, Modeling and Simulation for engineering design process, Material selection and detailed design.

Team Work and Ethics in engineering design: Team formation, functioning, discharge, team dynamics, Ethical issues considered during engineering design process.

Text Book:

1. George E.D., Engineering Design, McGraw Hill, 2001.

Reference Books:

1. Ken H., Engineering Design Principles, Elsevier, 1999.
2. Pahl G., Beitz W., Engineering Design: A Systematic Approach, Springer, 2013.
3. Ulrich, K. T.,Eppinger, S. D., Product Design and Development, 5th ed., McGraw Hill, 2011.
4. Boothroyd, G., Dewhurst, P., Knight, W. A., Product Design for Manufacture and Assembly, 3rd ed., CRC, 2010.

Course Code: MEL 505
Course Title: ADDITIVE MANUFACTURING
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Introduction: Prototyping, rapid prototyping, Additive Manufacturing (AM), Process chain of additive manufacturing, Advantages of AM.

Classification of AM Processes: Liquid-based, solid-based, and powder-based AM processes; Stereolithography and other liquid based systems, Fused Deposition processes, Laminated Object Manufacturing, Shape Deposition Manufacturing, Laser sintering based technologies, 3D printing, Direct Metal Deposition (DMD) and LENS.

Applications of AM: Introduction, applications of AM in different categories such as conceptual design, rapid manufacturing, rapid tooling, terrain modeling, medical AM and mass customization (most of things to be discussed in detail in the chapters on Rapid Manufacturing, Medical AM and Rapid Tooling).

Rapid Manufacturing: Different applications of AM for directly making end-use parts – industrial applications, utilizing porous property, medical applications such as dental, hearing aid and medical devices, terrain modeling, transport, military, architectural, electronics, etc. Mass customization – production of customized products in mass scale.

Medical AM: Medical applications of AM for prosthesis and implant; tissue engineering; complex surgical planning and visualization of bio-molecules with several case studies in each category.

Data Formats: Data formats for AM and associated details – STL file format, STL file errors and repair of STL files. STEP (Standard for the exchange of Product Model Data) and AMF (Additive Manufacturing File Format) – brief introduction.

Rapid Tooling (RT): Soft tooling and hard tooling, Direct methods of rapid tooling, Indirect methods of rapid tooling processes.

Textbooks:

1. Chua, C K, Leong, K F and Lim CS, Rapid Prototyping: Principles and Applications in Manufacturing, World Scientific, 2003.
2. Gibson, I., Rosen, D.W. and Stucker, B., Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, New York, 2010.

References Books:

1. Prasad, Hari and Badrinarayan, K.S., *Rapid Prototyping and Tooling*, ISBN: 978-81-923- 2065-6, 1st edition, SIP-Page Turners Publications, Surya Infotainment Products Pvt. Ltd., Bangalore, 2013.
2. Hilton, P.D. and Jacobs, P.F., *Rapid Tooling – Technologies and Industrial Applications*, Marcel Dekker AG, Basel, Switzerland, 2000.
3. Raja, V. and Fernandes K.J., *Reverse Engineering – An Industrial Perspective*, Springer- Verlag London Ltd, 2008.
4. Gibson, Ian, *Advanced Manufacturing Technologies for Medical Application – Reverse Engineering, Software Conversion and Rapid Prototyping*, John Wiley and Sons Ltd, West Sussex, England, 2005
5. Hopkinson, N, Hague, R, and Dickens, P, *Rapid Manufacturing: An Industrial Revolution for a Digital Age: An Industrial Revolution for the Digital Age*, Wiley, Jan 2006.
6. Kamrani, A.K. and Nasr, E.A., *Rapid Prototyping – Theory and Practice*, Springer Science and Business Media Inc., New York, NY 10013, USA, 2006.
7. Bartolo, P. J. (editor), *Virtual and Rapid Manufacturing: Advanced Research in Virtual and Rapid Prototyping*, Taylor and Francis, 2007.
8. Venuvinod, Patri K. and Ma, Weiyin; *Rapid Prototyping - Laser-based and Other Technologies*, Kluwer Academic Publishers, October 2003.
9. Cooper, K. G., *Rapid Prototyping Technology: Selection and Application*, CRC Press.
10. Gebhardt, A., Rapid Prototyping, Hanser Publishers, 2003
11. Liou, F. W., Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development (Mechanical Engineering), CRC Press; 1st edition, 2007.
12. Pique, A., Chrisey, DB., Direct Write Technologies for RP Applications: Sensors, Electronics and Integrated Power Sourses, Academic Press, 2002.

Course Code: MEL 506
Course Title: INDUSTRIAL AUTOMATION AND ROBOTICS
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Concept of automation in industry, mechanization and automation, classification of automation systems.

Air cylinders –their design and mounting; pneumatic and hydraulic valves- flow control valves, metering valves, direction control valves, hydraulic servo systems; pneumatic safely and remote control circuits, Programmable Logic Controller.

Basis of automated work piece handling- working principles and techniques, job orienting and feeding devices. Transfer mechanisms-automated feed cut of components, performance analysis.

Assembly automation, automated packaging and automatic inspection.

Introduction to robot technology- robot physical configuration and basic robot motions.Types of manipulators- constructional features, servo and non-servo manipulators. Feedback systems and sensors- encoders and other feedback systems, vision, ranging systems, tactile sensors.

Concept of spatial description and transformations, manipulator

Kinematics; Inverse manipulator, Kinematics Jacobians; velocities and static forces; manipulator dynamics, position control of manipulators, force control of manipulators, robot programming languages and systems.

Textbooks:

1. Craig, J. J., Introduction to Robotics: Mechanics and Control, 3rd Edition, Pearson Education Inc., 2005.
2. Groover M.P., Automation, Production Systems and Computer Integrated Manufacturing, 3rded., Pearson Education, 2014.

Reference Books:

1. Grover, M.P. and Zimmers, E.W., CAD/CAM: Computer-Aided Design and Manufacturing, Pearson Education, 2008.
2. Koren, Y., Robotics for Engineers, 1st Edition, McGraw-Hill, 1985.
3. Pressman, R. S. and Williams, J.E., Numerical Control and Computer Aided Manufacturing, John Wiley, New York, 1977.

Course Code: MEL 507
Course Title: ADVANCED MANUFACTURING TECHNIQUES
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Introduction to CIM, Types of Manufacturing, CIM hardware and software, Elements of CIM, Product development through CIM Introduction, Database requirements of CIM, Database, Database management, Database Models, Product Data Management (PDM), Advantage of PDM. Manufacturing cell, Group Technology, Cellular Manufacturing. Introduction to FMS, Manufacturing integration model, flexible manufacturing strategy, Components of Flexible Manufacturing- Pallets and fixtures, machining centers, inspection equipment, material handling stations, storage system, In-process storage, manually operated stations, allied operation centers integration of the industrial robot into CIM system, product design of automatic manufacture of robots, computer aided inspection using robots. Principles of networking, Network Techniques, Local area network (LAN), networking standards, Design Activities in a networked environment, networking in a manufacturing company, hardware elements of networking, Collaboration Engineering.

Text Book:

1. Groover M.P., Automation, Production Systems and Computer Integrated Manufacturing, 3rded., Pearson Education, 2014

Reference Books:

1. Ranky, P.G., The Design and Operation of FMS: Flexible Manufacturing Systems, IFS, 1983.
2. Harrington, J., Computer Integrated Manufacturing, Krieger Publication, 1985.
3. Shover, R.N., An Analysis of CAD/CAM Application with Introduction to CIM, Prentice Hall, 1993.
4. Bedworth, D.D. and et.al., Computer Integrated Design and Manufacturing, McGraw Hill, 1991.
5. Scholz-Reiter, B., CIM Interfaces, Chapman and Hall, 1992.
6. Goetsch, D.L., Fundamentals of CIM Technology: Automation in Design, Drafting and Manufacturing, Delmar Publication, 1988.

Course Code: MEL 508
Course Title: THEORY OF METAL CUTTING
Structure (L-T-P): 3-2-0
Prerequisite: NIL
Contents:

Introduction, system of Tool nomenclature, Tool Geometry, Mechanism of Chip formation and forces in orthogonal cutting, Merchant's force diagram. Oblique Cutting: Normal chip reduction coefficient under oblique cutting, true shear angle, effective rake, influx region consideration for deformation, direction of maximum elongation, effect of cutting variables on chip reduction co-efficient, forces system in oblique cutting, effect of wear land on force system, force system in milling, effect of helix angle.

Fundamentals of Dynamometry, Theoretical determination of forces, angle relations, heat and temperature during metal cutting; distribution, measurement, analysis, theoretical estimation of work piece temperature, hot machining Fundamental factors, which effect tool forces: Correlation of standard mechanized test. (Abuladze – relation), nature of contact and stagnant phenomenon, rates of strains, shear strain and normal strain distributions, cutting variables on cutting forces.

Cutting Tools: Tools materials analysis of plastic failure (from stability criterion), Analysis failure by brittle fracture, wear of cutting tools, criterion, flank and crater wear analysis, optimum tool life, tool life equations, (Taylor's woxenetc) Tool life test, machining optimization, predominant types of wear; abrasive, adhesive, diffusion wear models, wear measurements and techniques, theory of tool wear oxidative mathematical modelling for wear, test of machinability and influence of metallurgy on machinability. Economics of metal machining.

Abrasive Machining: Mechanics of grinding, cutting action of grit, maximum grit chip thickness, energy and grit force temperature during grinding, wheel wear, grinding, process simulation, testing of grinding wheels, mechanics of lapping and honing, free body abrasion.

Textbook:

1. Shaw, M.C., Metal Cutting Principles, 2nd Edition, Oxford University Press, 2012.

Reference Books:

1. Sen, G.C. and Bhattacharyya, A., Principles of Machine Tools, 2nd Edition, New Central Book Agency, 2009.
2. Armarego, E.J.A. and Brown, R.H., The Machining of Metals, Prentice-Hall, 1969.
3. Arshinov, V. and Alekseev, G., Metal Cutting Theory and Cutting Tool Design, MIR Publications, 1970.
4. Kronenberg, M., Machining Science and Application, Theory and Practice for Operation and Development of Machining Processes, Pergamon Press, 1966.

Course Code: MEL 509
Course Title: NON-TRADITIONAL MANUFACTURING PROCESSES
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Introduction, need for unconventional manufacturing processes, its classification and future possibilities, hybrid processes. Unconventional machining processes based on material removal by abrasion, abrasive jet machining and ultrasonic machining. Thermoelectric unconventional methods, plasma arc machining, laser beam machining, electron beam machining, Electric discharge machining, wire electric discharge machining.Electro-chemical machining processes, electro-chemical grinding, electro-chemical deburring, chemical machining.Electronic-device manufacturing, diffusion and photo- lithography process for electronic-device manufacturing, Rapid Prototyping- different techniques.

Text Book:

1. Kalpakjian S. and Schmid S.R., Manufacturing Engineering and Technology, 4th Edition, Pearson Education, 2013.

Refernce Books:

1. Benedict G.F., Unconventional Machining Process, Marcel Dekker Publication, 1987.
2. Sharma P.C., A Text book of Production Engineering, New Delhi, 1995.
3. Mishra P.K., Nonconventional machining. Narosa publishing house, 2007.
4. Jain V.K., Advanced machining processes, Allied publishers, 2009.

Course Code: MEL 510
Course Title: ADVANCED JOINING PROCESSES
Structure (L-T-P): 3-0-0
Prerequisite: MEL 257

Contents:

Introduction to joining technology, Physics of the welding arc and arc characteristics, Metal transfer & its importance in arc welding, Various forces acting on a molten droplet and melting rates, Welding consumables: fluxes, gases and filler materials, welding processes and its variants, Soldering, Brazing and diffusion bonding, Resistance welding, Thermit welding, Electro-slag and electro-gas welding, Solid-state and radiant energy welding processes, Friction stir welding, Ultrasonic joining: Metals and Non-Metals, Joining by Induction Heating Phenomenon, microwave joining, hot plate welding,under water welding. Heat flow in welds, Effect on HAZ, Development of phases, Microstructure etc, Weldability, Mechanical testing of weldments, Thermal stresses and distortion, NDT of welds, Joining metallurgy and microstructures, weld symbols, Weld joint designs for strength and quality, Welding of plastics, Automation in welding, Cost analysis.

Text Book:

1. Little R.M., Welding and Welding Technology, McGraw-Hill, 1973.b

Reference Books:

1. Cary H.B., Modern Welding Technology, Prentice-Hall, 1979.
2. Parmar R.S., Welding Engineering and Technology, Khanna Publication, 2010.
3. Handbook W., Welding Processes, American Welding Society, 1991.

Course Code: MEL 511
Course Title: ADVANCED METAL FORMING PROCESSES
Structure (L-T-P): 3-0-0
Prerequisite: MEL 257, MEL 258
Contents:

Elements of theory of plasticity, formulation of plastic deformation problems and different methods of solution, stress-strain relations in elastic and plastic deformations, yield criteria for ductile metals, work hardening and anisotropy in yielding, flow curves, slip line field theory, effect of temperature and strain rate in metal working, friction and lubrication in cold and hot working, technology and analysis of important metal forming processes–forging, rolling, extrusion, wire drawing, sheet metal forming processes like deep drawing, stretch forming, bending.

Text Book:

1. Dixit U.S., Narayanan R.G., Metal forming: technology and process modelling, Tata McGraw- Hill Education, 2013.

Reference Books:

1. Avitzur B., Metal Forming: Processes and Analysis, McGraw-Hill Inc., 1968.
2. Chakrabarty J., Theory of plasticity, Butterworth-Heinemann, 2012.
3. Kumar S., Technology of metal forming processes. PHI Learning Pvt. Ltd, 2008.
4. J uneja B.L., Fundamentals of Metal Forming Processes, New Age International, 2007.

Course Code: MEL 512
Course Title: COMPOSITES – MECHANICS AND PROCESSING
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Introduction: Basics of composite materials, Classification, FRP Composites, fiber types and properties, matrices type and properties, Applications of composites, Definition of stress, strain, mechanical properties, strain energy, lamina, laminate, laminate code.

Processing: Primary and secondary fabrication processes, Fabrication of metal matrix composites: in-situ, dispersion hardened, particle, whisker and fibre reinforced, composite coatings by electro deposition and spray forming, fabrication of polymeric and ceramic matrix composites.

Macro mechanical Analysis of a Lamina: Hooke's law for different materials, 2D unidirectional and angular lamina, stiffness and compliance matrices for different lamina, strength failure theories, effect of wear and environmental conditions.

Micro mechanical Analysis of a Lamina: Volume fraction, mass fraction, density, void content, Evaluation of elastic moduli and ultimate strengths, effect of wear and environmental conditions.

Micro mechanical Analysis of a Laminate: Stress-strain relationship for laminate, In-plane and flextural modulus of a laminate, inter laminar shear stress, free-edge effect in multi-directional laminates, Classical theory of laminated plates, laminate coupling effects, and residual stress calculation.

Failure and Analysis of Laminates: Failure criteria for unidirectional fiber-reinforced composites, mechanisms of fracture in composites, composites materials testing NDT of composites.

Text books:

1. Kaw, A. K., Mechanics of Composite Materials, 2nd ed., CRC Press, 2005.
2. Chawla K.K., Composite materials: Science and Engineering, 3rd ed., Springer, 2013.

Reference books:

1. Jones, R.M., Mechanics of Composite Materials, Taylor & Francis, 1988.
2. Ashbee, K.H.G. and Ashbee, H.G., Fundamental Principles of Fibre Reinforced Composites, 2nd ed., CRC Press, 1993.
3. Daniel, I.M. and Ishai, O., Engineering Mechanics of Composite Materials, 2nd ed., Oxford University Press, 2007.
4. Suresh G.A. and Sozer E.M., Process Modeling in Composites Manufacturing, 2nd Edition, CRC Press, 2009.
5. Schwartz M.M., Composite Materials: Processing, fabrication, and applications, 1st ed.,Prentice Hall, 1997.

Course Code: MEL 513
Course Title: PRECISION ENGINEERING
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Introduction to Precision Engineering: Need for having a High Precision, Four Classes of Achievable Machining Accuracy, Precision Machining, High-precision, Ultra-precision Processes and Nanotechnology.Introduction to Sensors and probes, Tool Materials for Precision Machining: Coated and Laminated Carbides, Ceramics, Diamonds, Cubic Boron Nitride. Mechanics of Materials Cutting: Turning Operation and Tool Signature & Mechanics. Ultra-Precision Machine Elements: Guide- ways, Drive Systems, Friction Drive, Linear Motor Drive, Spindle Drive.

Hydrodynamic and Hydrostatic Bearings: Principle of Rolling Element Bearings, Design & Selection, Bearing Life, Construction of Lubricated Sliding Bearings, Principle of Hydrodynamic Bearings, Hydrodynamic Thrust Bearings. Design of Hydrostatic Bearings, Hybrid Fluid Bearings Gas Lubricated Bearings: Aerostatic Bearings, Operation of Aerostatic Bearing Systems, Aerostatic Spindles, Hybrid Gas Bearings.

Text Book:

1. Venkatesh V.C. and Izman S., Precision Engineering, Tata Mc.Graw Hill, New Delhi 2007.

Refernce Books:

1. Kalpakjian S., Manufacturing Engineering and Technology. 3rd Ed. Addision-Wesley Publishing Co.,New York, 2001.
2. Nakzavawa H, Principles of Precision Engineering, Oxford University Press, 1994.
3. Murthy R.L., "Precision Engineering", New Age International, 2009.

Course Code: MEL 514
Course Title: MICRO AND NANO MANUFACTURING
Structure (L-T-P): 3-0-0

Prerequisite: NIL

Contents:

General principles of Micro and Nano manufacturing: Substrates, thin film deposition techniques, etching, requirements of mask materials, Typical fabrication process for an integrated circuit – Scanning probe microscopy for Nano manufacturing, Lithography: X ray lithography – steps – Synchrotron radiation – LIGA process –Methods of resist application. Etching and Micro moulding process: Dry etching and plasma etching, characteristics of plasma, effects of etching, Injection molding, Embossing, micro molding tools, Size effect in micro machining: Plastic behavior in large strain – Shear angle prediction – Mechanism of large plastic flow – Inhomogeneous train, Mechanical Micro machining: Principle and operation of Micro milling – Micro turning-Chip removal – High speed spindles – Requirements-Micro grinding process, Vapor deposition techniques: Principle and operation of Physical vapor deposition – chemical vapor deposition – thin film characteristics, Laser based Nano manufacturing: Laser fundamentals, sources, optics, Femtosecond Pulsed laser Micro and Nano fabrication – General applications. Industrial Applications of micro and Nano manufacturing - MEMS, IC and micro scale features.

Text Book:

1. Mark J. Jackson, (2010) Micro and Nano fabrication, CRC Press, Taylor & Francis Group

Reference Books:

1. Yi Qin, (2010), Micro-Manufacturing Engineering and Technology, Elevier Publisher, ISBN: 978-0-8155-1545-6
2. V.K.Jain, (2013), Micromanufacturing processes, CRC Press, Taylor and Francis Group
3. MuammerKoc, TrugelOzel, (2011) Micro manufacturing, Design and manufacturing of micro products, Wiley Publishers.

Course Code: MEL515

Course Title: ADVANCED MECHANICS OF SOLIDS

Structure (L-T-P): 3-0-0

Prerequisite: MEL 254

Contents:

Introduction: Review of Basic concepts of solid mechanics, Vector and linear algebra, Matrices and tensors, Vector and tensor calculus.

Stress in a solid: Body forces, surface forces and traction vector at a point on the surface, Stress tensor at a point, Principal stresses at a point, force and momentum equilibrium, constitutive equations.

Strain in a solid: Displacement field in a deformed solid, Strain tensor, Principal strains at a point, Compatibility conditions on a strain field, constitutive equations.

Boundary value problems for linear elastic solids: Field equations for plane strain deformation, Thick walled pressure vessel, Field equations for plane stress deformation, Plate with hole in tension, stress concentration.

Variation methods for elastic solids: Principle of virtual work, variation statement of governing equations, Work and energy theorems in solid mechanics. Boundary value problems for elastic-plastic materials:

Failure modes in solid mechanics: Fracture, Fatigue, Buckling, Large deflections, Plastic collapse.

Text Book:

1. Srinath, L.S., Advanced mechanics of solids, 3rded.,Tata McGraw-Hill, 2008.

Reference Books:

1. Dally, J. W. and Riley, W. F., Experimental Stress Analysis, 4th ed., McGraw Hill, 2005.
2. Muskhelishvili, N. I., Some Basic Problems of the Mathematical Theory of Elasticity, Springer Verlag, 2010.
3. Dove, R.C. and Adams, P.H., Experimental Stress Analysis and Motion Measurement: Theory, Instruments and Circuits, Techniques, Prentice Hall, New Delhi, 1965.
4. Sokolnikoff I.S., Mathematical Theory of Elasticity, McGraw-Hill International, 2nded, 1957.
5. Fung Y.C., Foundation of Solid Mechanics, Prentice Hall Inc., 2nd ed., 1965.

Course Code: MEL 516

Course Title: FRACTURE MECHANICS

Structure (L-T-P): 3-2-0

Prerequisite: MEL254

Contents:

Introduction to fracture mechanics, conventional failure criteria, Griffith's work, Linear Elastic Fracture Mechanics (LEFM): Crack deformation modes and basic concepts, crack tip stresses and deformation, stress intensity factor (SIF) and its criticality in different modes, superposition of SIFs; Concept of energy release rate, equivalence of energy release rate and SIF. Anelastic Deformation at the Crack tip; Effective Crack length, Irwin model, Dugdales model. Fracture toughness, Effect of temperature and loading rate on fracture toughness; Fatigue and fatigue crack propagation laws, fatigue life calculations under constant and variable amplitude loading, Strain Energy Density Failure Criterion, volume strain energy density, basic hypothesis and application of energy density based failure criteria for two and three dimensional linear elastic crack problems. Elastic Plastic Fracture Mechanics: plastic zone corrections, crack opening displacement (COD), J-contour integral and crack growth resistance (R-curve) concepts.

Text Book:

1. Kumar, P., Elements of Fracture Mechanics, Tata McGraw-Hill Education, 2009.

Reference Books:

1. Broek, D., Elementary Engineering Fracture Mechanics, 3rd ed., Springer, 1982.
2. Gdoutos, E.E., Fracture Mechanics: An Introduction, 2nd ed., Springer, 2005.
3. Kundu, T., Fundamentals of Fracture Mechanics, CRC Press, 2008.
4. Anderson, T. L., Fracture Mechanics: Fundamentals and Applications, 4th ed., CRC Press, 2016.

Course Code: MEL 517

Course Title: ADVANCED MECHANICAL VIBRATION

Structure (L-T-P): 3-0-0

Prerequisite: MEL354, MEL452

Contents:

Fundamentals of Vibration: Basic concepts of vibration, classification, importance, vibration analysis procedure.

Single degree of freedom system: Free vibration analysis of undamped translational and torsional system, Rayleigh's energy method, Free vibration with various types of dampings (viscous, coulomb, hysteresis), Free vibration response under harmonic and other general forcing conditions, transient response through Du-hamel's integral.

Two degree of freedom system, rotational vibration, free and forced, torsional stiffness, self-excitation and stability analysis, Determination of natural frequencies and mode shapes: Holzer method, Matrix iteration method, modal analysis, diagonalization, response calculations for general excitation, proportional damping.

Multi Degree of freedom system: Exact analysis-Undamped free vibration, influence, stiffness coefficients, Eigen values and vectors, orthogonal properties, normal modes. Approximate Analysis: Raylieg's method, Dunkerley, Stodola, Holzer and Matrix Iteration method.

Modal analysis of the n-DOF system, matrix formulation, harmonic response of the n-DOF system.Principle of virtual work, Lagrange's equations, Duhamel's integration, Introduction and distinguishing characteristics of nonlinear vibration.

Vibration of Continuous Systems: Wave equation, Transverse vibration of strings, longitudinal vibration of bars and lateral vibrations of beam.

Vibration Control: Control of vibration, control of natural frequencies, vibration isolation and absorbers.

Vibration measurement and applications: Role of vibration measurement and analysis in machine design and machine condition monitoring

Text Book:

1. Greenwood D.T., Principles of Dynamics, 2nd ed.Englewood Cliffs, Prentice-Hall, 1988.

2. Thomson, W.T. and Dahleh, M.D., Theory of Vibration with Applications, 5th ed., Pearson, 2014.

Reference Books:

1. Robert H.C., Dynamics of Physical Systems, 3rd ed., McGraw Hill, 2003.

2. Robert L.W. and Kent L.L., Modeling and Simulation of Dynamic Systems, 2nd ed., Prentice Hall, 2000.

3. Jordan D.W. and Smith P., Nonlinear ordinary differential equations: An Introduction to Dynamical Systems, 3rd ed., Oxford University Press, 1999.

4. Rao, S.S., Mechanical Vibrations, 4th ed., Pearson Education, 2012.

5. Meirovitch L., Fundamentals of Vibrations, 2nd ed., Waveland Press, 2010.

6. Timoshenko, S., Vibration Problems in Engineering, 2nd ed., Oxford City Press, 2011

7. Meirovitch L., Methods of Analytical Dynamics, McGraw Hill, 2010.

8. Grover, G.K, Mechanical Vibrations, 8th ed., Nem Chand & Bros, 2009

Course Code: MEL 518

Course Title: MECHANISM DESIGN

Structure (L-T-P): 3-2-0

Prerequisite: MEL 255

Contents:

Introduction: Review of concepts of kinematic analysis of mechanisms, degrees of freedom, Grashof's and Gruebler's criteria, transmission angles.

Kinematic Synthesis of Mechanisms: Type, number and dimensional synthesis, spacing of accuracy points, Chebyshev polynomials, graphical synthesis with two, three, and four prescribed positions and points, path motion and function generation.

Analytical Synthesis Techniques: dyad and standard form equation, Freudenstein's equation for three point function generation, coupler curves, Robert's law.

Path Curvature Theory: Fixed and moving centrode, inflection points and inflection circle, Euler-Savary equation.

Dynamic Force Analysis: Introduction, inertia forces in linkages, kinetic-static analysis by superposition and matrix approaches and its applications, introduction to spatial mechanisms.

Text Book:

1.Robert L.N., Kinematics & Dynamics of Machinery, 1st ed., Tata McGraw Hill, 2003.

Reference Books:

1. Sacks E. and Joskowicz L., The Configuration Space Method for Kinematic Design ofMechanisms, MIT Press,2010.

2. Erdman A.G. and Sandor G.N., Mechanism Design: Analysis and Synthesis, 3rd Edition, Prentice Hall, 1994.

3. Sandor G.N. and Erdman A.G., Advanced Mechanism Design: Analysis and Synthesis, Prentice Hall, 1994.

4.Mallik A.K., Ghosh A. and Dittrich G., Kinematic analysis and synthesis of mechanisms, CRC Press, 1994.

Course Code: MEL 519

Course Title: TRIBOLOGY IN DESIGN

Structure (L-T-P): 3-0-0

Prerequisite: NIL

Contents:

Introduction: Basic concept of friction, wear and lubrication.

Lubricants and Lubrication modes: Properties of lubricants, modes of lubrication, hydrodynamic, hydrostatic, Elasto-hydrodynamic lubrication, Reynolds' equation, Applications of hydrodynamic lubrication theory

Bearings: Bearing characteristics, Selection of bearings, Squeeze-film lubrication bearings, Thrust bearings, Journal bearings, bearing vibration measurements.

Wear: Types of wear and their mechanisms, Adhesive wear, Abrasive wear, Wear due to surface fatigue, wear due to chemical reactions, wear of bearings, wear of metallic and non-metallic bearing materials, material combination for better tribological contacts.

Text Book:

1. Basu, S.K., Sengupta, S.N. and Ahuja, B.B., Fundamentals of Tribiology, PHI Learning, 2005.

Reference Books:

1. Williams, J.A., Engineering Tribology, Oxford Univ. Press, 2001.

2. Cameron, A., Basic Lubrication Theory, Ellis Horwood Ltd., 2002.

3. Stachowaik, G.W., Batchelor A.W., Engineering Tribology, 3rd Edition, Elsevier, 2010.

4. Mang, T.,Bobzin, K.,Bartels, T., Industrial Tribology: Tribosystems, Friction, Wear and Surface Engineering, Lubrication, 1st ed., Wiley, 2011.

Course Code: MEL 520

Course Title: SMART MATERIALS AND STRUCTURES

Structure (L-T-P): 3-0-0

Prerequisite: NIL

Contents:

Classification of smart materials and structures, their history and relevance, piezo-electric materials and shape memory alloys, multi-functional smart materials and morphing materials, morphing skin, Application of smart materials as smart actuators, sensors and control, autonomous free floating flap, morphing structures, morphing leading edge, smart structures design.

Text Book:

1. Gandhi, M. V. and Thompson, B. S., Smart Materials and structures, Chapman & Hall, 1992.

Reference Books:

1. Banks, H. T., Smith, R. C. and Qang, Y. W., Smart Material structures: Modeling, Estimation and Control, John Wiley &Sons.,1996.

2. Gabbert, U. and Tzou, H. S., Smart Structures and Structronic System, Kluwer Academic Publishers, 2001.

3. Preumont, A., Vibration Control of Active Structures, Kluwer Academic Publishers, 2002.

4. Cheng, F. Y., Jiang, H. and Lou, K., Smart Structures: Innovative Systems for Seismic Response Control, CRC Press, 2008.

Course Code: MEL 521
Course Title: ROTOR DYNAMICS AND CONDITION MONITORING
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Introduction: Flexural and torsional vibration; critical speed of shafts; equivalent discreet systems; geared and branched system; gyroscopic effects on eccentric mass distribution and balancing;

Rotor –bearing interactions: rolling element bearing and its stiffness calculation; unbalanced response of an asymmetric shaft; rigid and flexible rotor balancing. Bearing modelling and dynamic parameter calculation.

Sensors: Need for sensing systems, Sensory devices, Types of sensors, Data Acquisition system.

Signal processing techniques; time and frequency domain analysis, signal decomposition and spectrum analysis; feature extraction and classification techniques; application of clustering and artificial intelligence in health assessment. Statistical and probity models.Brief introduction on fault diagnosis and prognosis.

Text Books

1. Admas M. L. Jr, Rotating Machinery Vibration: From Analysis to Troubleshooting, Marcel Dekker, 2001.

2.Rao J S., Vibratory condition monitoring of machines, Narosa Publication, 2000.

Reference Books

1. Wowk V., Machinary Vibration: Balancing, McGraw Hill, 2005.
2. Biezerno C. and Grammel R., Engineering Dynamics, Vol III of Steam Turbines D Van Nostrand Co, Inc, New York, 1959.

Course Code: MEL 522
Course Title: DYNAMICS OF MECHANICAL SYSTENS
Structure (L-T-P): 3-0-0
Prerequisite: NIL
Contents:

Basic concepts: Inertial coordinate system, laws of motion, mechanics of system of particles, principles of linear and angular momentum, Lagrangian dynamics: Degrees of freedom, generalized coordinates, holonomic and non-holonomic constraints, Lagrange‘s equation from d‘Alembert‘s principles, application of Lagrange‘s equation for conservative and non-conservative autonomous systems with holonomic and non-holonomic constraints, applications to systems with very small displacements; Hamilton principle from D‘Alembert‘s principle, Lagrange equation from Hamilton‘s principle. Multi-body dynamics: Space and fixed body coordinate systems, coordinate transformation matrix, direction cosines, Euler angles, Euler parameters, finite and infinitesimal rotations, time derivatives of transformations matrices, angular velocity and acceleration vectors, equations of motion of multi-body system, Newton-Euler equations, planar kinematic and dynamic analysis, kinematic revolute joints, joint reaction forces, simple applications of planar systems. Stability of motion: Fundamental concept in stability, autonomous systems and phase plane plots, Routh‘s criteria for stability.

Text Book:

1. Meirovitch L., Methods of Analytical Dynamics, McGraw Hill, 2010.

Reference Books:

1. Robert H.C., Dynamics of Physical Systems, McGraw Hill, 2003.
2.Robert L.W. and Kent L.L., Modeling and Simulation of Dynamic Systems, Prentice Hall, 2000.
3. Jordan D.W. and Smith P., Nonlinear ordinary differential equations: An Introduction to Dynamical Systems, Oxford University Press, 1999.
4. Greenwood D.T., Principles of Dynamics, Englewood Cliffs, Prentice-Hall, 1988.