NATIONAL INSTITUTE OF TECHNOLOGY SILCHAR

Department of Civil Engineering

Curriculum for M. Tech. in Geotechnical Engineering

1st SEM

Sl. No.	Subject Code	Subject	Type	L	T	P	Credit
1	CE 1501	Advanced Soil Mechanics	Core	3	0	0	3
2	CE 1502	Advanced Foundation Engineering	Core	3	1	0	4
3	CE 1503	Theoretical Geomechanics	Core	3	0	0	3
4	CE 1504	Advanced Geotechnical Engineering Laboratory	Core	0	0	3	2
5	CE 1530	Ground Improvement Techniques	**Elective - I**	3	0	0	3
6	CE 1531	Rock Mechanics					
7	CE 1545	Geotechnical Earthquake Engineering	**Elective - II**	3	0	0	3
8	CE 1546	Soil-Foundation Interaction					
9	CE 1544	Seismic Microzonation (No Syllabi)					
				Total Credit			18

Advanced Soil Mechanics

CE 1501

L	T	P	C
3	0	0	3

Pre-requisites: Graduate in Civil Engineering

Detailed Syllabus

Introduction to Soil Mechanics

Formation of soil, Identification and classification of soil, Soil weight volume relationship, Index properties of soils.

Introduction to Soil Mechanics

Formation of soil, Identification and classification of soil, Soil weight volume relationship, Index properties of soils.

Surface Tension and Capillary phenomenon

Measurement of capillary rise in soil, Soil moisture, Soil –water potential, Buckingham's concept, Component potential, Measurement of soil-water potential, Tentiometer, Pressure-plate apparatus.

Permeability of Soil

Permeability, Darcy's law, Kozeny- Carmans's equation, Theories of wells, flow nets and their properties.

Seepage Analysis

Seepage, Quick sand & critical hydraulic condition, Flow net in dams, Flow net by relaxation method, Seepage forces, Uplift, Piping phenomenon, Problems, Effective and Pore water pressures.

Compressibility and Consolidation

Compressibility and Consolidation, I-D & 3-D consolidation problems, Settlement of soil due to consolidation.

Shear Strength of Soil

Principal Stresses, Mohr – Coulomb Failure Criteria, Stress-Strain behaviour of granular soil, Critical void ratio, Shear strength of cohesive soil, Direct Shear Test, Triaxial Test, Unconfined Compressive strength test, Vane Shear test, Stress paths, and Yield Surfaces in three dimension.

References:

1. Advanced Soil Mechanics by B. M. Das
2. Soil Mechanics by R. F. Craig
3. An introduction to the Mechanics of soils and Foundationsby J. H. Atkinson
4. Soil Mechanics in Engineering Practice by K. Terzaghi and R. B. Peck

5. Soil Mechanics by T. W. Lambe and R. V. Whitman

Course Outcomes: At the end of the course, student will be able to:

CO1	Develop basic knowledge on mechanics of soil
CO2	Develop a clear knowledge on soil formation, soil classification, structure of soil particles, index properties of soil and clay mineralogy.
CO3	Develop a clear knowledge about Surface Tension and Capillary phenomenon
CO4	Understand and solve problems related to Permeability of soil and Seepage flow
CO5	Develop in depth understanding of problems related to Compressibility and Consolidation
CO6	Develop in depth knowledge about shear strength characteristics of soil
CO7	Be confident in solving various real life problems in geotechnical engineering

Advanced Foundation Engineering

CE 1502

L	T	P	C
3	1	0	4

Pre-requisites: Graduate in Civil Engineering

Detailed Syllabus

Shallow foundations

Design considerations- factors of safety (including limit state), allowable settlements, location and depth of foundations.Bearing capacity theories (Terzaghi, Meyerhof, Brinch Hansen, Vesic's method & IS code method of analysis), layered soils, choice of shear strength parameters, bearing capacity from N-values, static cone tests, plate load tests.Total and differential settlement, stress distribution, consolidation settlement in clays(with correction factors), immediate settlement. Settlement in sands from N-values, elastic solutions static cone tests, plate load tests.Design of shallow foundations, combined footings, strap foundation, mat foundations including floating raft.

Pilefoundations

Types of piles, construction methods, axial capacity and design of single pile & group of piles, dynamic formulae, static formula, soil mechanics approach. Skin friction and end bearing in sands and clays. Single and multiple under reamed pile. Negative skin friction, piles subjected to uplift load (including under reamed piles), pile load tests, pile integrity tests settlement of single piles and group. Influence of pile cap, influence of pile driving in sand, pull out capacity, laterally loaded piles.

Well foundations

Different types, components, construction methods, design methods (Terzaghi, IS and IRC approaches), check for stability, base pressure, side pressure and deflection.

Retaining walls

Types (types of flexible and rigid earth retention systems: counter fort, gravity, diaphragm walls, sheet pile walls, soldier piles and lagging). Support systems for flexible retaining walls (struts, anchoring), construction methods, stability calculations, design of flexible and rigid retaining walls.

Sheet pile walls

Cantilever and anchored sheet pile walls.

References:

1. Basic and Applied Soil Mechanicsby GopalRanjan& A. S. R. Rao
2. Foundation Analysis and Designby J. E. Bowles
3. Pile Foundations in Engineering Practice by Prakash and Sharma
4. Design of Foundation Systems- Principles and Practices by N. P. Kurian
5. Principles of Foundation Engineering by Braja M. Das
6. Foundation Design and Construction by M. J. Tomlinson
7. Advanced Foundation Engineering by V. N. S. Murthy.

Course Outcomes: At the end of the course, students will be able to:

CO1	Analyse given soil conditionto decide suitability of a particular foundation.
CO2	Design shallow foundations for structures.
CO3	Design deep foundations for structures.
CO4	Design retaining walls.

Theoretical Geomechanics

CE 1503

L	T	P	C
3	0	0	3

Pre-requisites: Graduate in Civil Engineering

Detailed Syllabus

Stress and strain

Introduction, soil mechanics and continuum mechanics, deformation and strain, strain compatibility, forces and tractions, concept of stress, principal stresses and strains, invariants, Mohr circles, effective stress principles, equilibrium, determination of displacements, conditions of compatibility, principle of superposition, problems and solutions.

Elastic behaviour of soil

Role of constitutive modelling, importance of laboratory testing with relation to constitutive modelling, the Winkler model, elastic continuum models, two-parameter elastic models, elastic-plastic and time-dependent behaviour of soil masses, practical applications.

Plastic behaviour of soil

Yield: Introduction, principal stress space, yield surfaces of metals, the Coulomb yield criterion, modification to Coulomb's criterion, the Cambridge models, Two-dimensional yield loci, example.

Plastic flow: Introduction, normality, associated flow rules, non-associated flow rules, a complete stress-strain relationship, example.

Collapse load theorems: Lower bound theorem, upper bound theorem, discontinuities of stress and deformation, examples.

Slip line: Two-dimensional stress state, slip line, frictional materials, effect of gravity, examples.

Work hardening theorems: Work hardening for metals, hardening soil, soft soil.

Critical state soil mechanics

Critical state concept,drained and undrainedtriaxial tests, critical state line, critical state line for sand, effect of dilation, Camclay and critical state concept, consolidation.

References:

1. Advanced Mechanics of Solids by L. S. Srinath

2. Theory of Elasticity by Timoshenko and Goodier

3. The Mechanics of Soils by Atkinson and Bransby

4. Elasticity and Geomechanics by Davis and Selvadurai

5. Plasticity and Geomechanics by Davis and Selvadurai

6. Critical State Soil Mechanics by Schofield and Wroth

7. Fundamentals of Fracture Mechanics by Kundu

8. Elastic Analysis of Soil-Foundation Interaction by A. P. S. Selvadurai

9. Dynamics of Structure and Foundation by Chowdhury and Dasgupta

Course Outcomes: At the end of the course, students will be able to:

CO1	Analyse stress and strain states in a soil mass.
CO2	Apply appropriate constitutive model to simulate behaviour of soil.
CO3	Design ground engineering problems using geomechnics concepts.
CO4	Solve geomechanics problems related to soil behaviour.

Advanced Geotechnical Engineering Laboratory

CE 1504

L	T	P	C
0	0	3	2

Pre-requisites: Graduate in Civil Engineering

Detailed Syllabus:

1. Standard Penetration Test
2. Cone Penetration Test
3. Resonant Column Testing
4. Dynamic Triaxial
5. Seismic Refraction
6. Block Vibration Test
7. Relative Density
8. Determination of properties of Geosynthetics

References:

1. Bureau of Indian Standard Codes
2. American Society for Testing and Materials Codes
3. Principles of Testing Soils, Rocks and Concrete by Nagaraj
4. Soil Testing Manual by Robert W. Day
5. Interpreting Soil Test Results by Hazelton and Murphy

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the basic principle of different laboratory tests on soil and their applicability in the field.
CO2	Analyse merits and demerits of every laboratory test.
CO3	Apply results of experiment to interpret soil condition.

Ground Improvement Techniques

CE 1530

L	T	P	C
3	0	0	3

Pre-requisites: Graduate in Civil Engineering

Detailed Syllabus

Introduction

Need for Ground Improvement, Classification and Methods of ground modification techniques, Economic considerations, Emerging trends in ground Improvement.

Mechanical modification

Soil-Mixing. Shallow surface compaction: Types of compaction equipment and their suitability for different type of soils, specification and quality control. Deep compaction: Dynamic compaction, Vibro-compaction, Vibro-replacement, Compaction piles, Blasting. Stone column.

Hydraulic modification

Ground Improvement by drainage, Dewatering methods. Design of dewatering systems, Preloading, Vertical drains, vacuum consolidation, Electro-kinetic dewatering, design and construction methods.

Soil stabilization

Cement stabilization, lime stabilization, lime pile and column, bitumen stabilization, chemical stabilization, mechanical stabilization.

Grouting

Permeation grouting, compaction grouting, jet grouting, different varieties of grout materials, grouting under difficult conditions.

Soil reinforcement

Geosynthetic materials and application in road, slope, embankment etc., design of reinforced earth walls.

In-situ soil treatment methods

Soil nailing, micro-piles, design methods, construction techniques.

References:

1. Ground Improvement Techniques by Purushothama Raj
2. Engineering Treatment of Soils by F. G. Bell
3. Engineering Principles of Ground Modification by Manfired R. Hausmann
4. Soil Improvement and Ground Modification Methods by Peter G. Nicholson
5. Designing with Geosynthetics by Koerner
6. Principles of Grouting by Shah and Shroft
7. Foundation Engineering by J. Bowles

Course Outcomes: At the end of the course, student will be able to:

CO1	Justify the requirement of ground improvement for a civil engineering project.
CO2	Analyse the ground condition to decide suitability of a ground improvement technique.
CO3	Apply appropriate ground improvement technique.
CO4	Design the implementation process of ground improvement techniques.

Rock Mechanics

CE 1531

L	T	P	C
3	0	0	3

Pre-requisites: Graduate in Civil Engineering

Detailed Syllabus

Engineering properties of rock masses, subsurface investigations in rock deposits, field and laboratory testing of rocks.

Stress- deformation characteristics of rock masses under heavy loads, flow of water through rock masses, failure theories, shear strength of rock under high pressure, friction in rocks, time dependent properties of rock masses.

Stability of rock slopes, idealized rock system, anisotropic rock system, deep cuts, deep boreholes, stability of boulder fills and embankments, lateral pressure on retaining structures for high hill slopes.

Bearing capacity of rock masses, opening in rocks, lined and unlined tunnels, pressure tunnels and tunnels for other purposes.

References:

1. A text book of Geology by P. K. Mukerjee

2. Rock Mechanics for Underground Mining by B. H. G. Brady and E. T. Brown

3.Rock Characterisation, Testing and Monitoring by E. T. Brown

4.Stresses in Rockby G. Herget

5. Underground Excavation in Rock by E. Hoek, and E. T.Brown

6. Introduction to Rock Mechanics by R. E. Goodman

7. Engineering Rock Mass Classification by Z. T. Bieniawski

8. Rock Mechanics Principles by D. F. Coates

9.Fundamentals of Rock Mechanics by J. C. Jaeger and N. G. W. Cook

10.Foundations on Rock by D. C. Wyllie

11. Comprehensive Rock Mechanics by J.A. Hudson et al.

Course Outcomes: At the end of the course, student will be able to:

CO1	Interpret behaviour of rock.
CO2	Analyse real life problems in hilly areas with exposed rock.
CO3	Design rock systemin hilly areas.

Geotechnical Earthquake Engineering

CE 1545

L	T	P	C
3	0	0	3

Pre-requisites: Graduate in Civil Engineering

Detailed Syllabus

Introduction

Scope and objective, Nature and types of earthquake loading, Importance of Geotechnical Earthquake Engineering.

Seismology and earthquakes

Basic Seismology, Earthquake, List of major earthquakes, Causes of earthquakes, Sources of earthquake data, Elastic rebound Theory, Faults, Plate tectonics, Seismograph and Seismogram, Prediction of Earthquakes, Protection against earthquake damage, Origin of universe, Layers of Earth, Theory of Continental Drift, Hazards due to Earthquakes.

Strong ground motion

Size of Earthquake: Magnitude and Intensity of Earthquake, Modified Mercalli Intensity Scale, Measuring of Earthquake, Earthquake Magnitude- Local (Richter) magnitude, surface wave magnitude, Moment magnitude, Seismic energy, Correlations. Spectral Parameters: Peak Acceleration, Peak Velocity, Peak Displacement, Frequency, Content and duration, Spatial Variability of Ground Motion, Attenuation Relationships, Fourier Amplitude Spectra, Arias Intensity.

Seismic Hazard Analysis

Magnitude Indicators, Segmentation, Deterministic Seismic Hazard Analysis (DSHA), Probabilistic Seismic Hazard Analysis (PSHA), Earthquake Source Characterization, Gutenberg-Richter recurrence law, Predictive relationships, temporal uncertainty, Probability computations, Seismic Hazard Curve, Logic tree methods.

Wave propagation

Waves in unbound media; Waves in semi-infinite media; Waves in layered media, Seismic Travel Time Curve, Three Circle Method for locating an Earthquake's Epicentre.

Dynamic soil properties

Stiffness, damping and plasticity parameters of soil and their determination (laboratory testing, intrusive and non-intrusive in-situ testing), Correlations of different soil parameters.

Ground response analysis

One dimensional ground response analysis, Two-dimensional ground response analysis, soil-structure interaction.

Local site effects and design ground motions

Effects of local site conditions on ground motions, design parameters, development of ground motion time histories.

Liquefaction

Basic concept, flow liquefaction, cyclic mobility, liquefaction susceptibility, effects.

Seismic slope stability analysis

Static slope stability analysis, seismic slope stability analysis, earthquake induced landslides.

Seismic Design of retaining wall

Types of retaining walls, static pressure, dynamic response, seismic pressures, seismic displacement.

Soil improvement techniques for remediation of seismic hazards

Densification, reinforcement, grouting, drainage.

References:

1. Geotechnical Earthquake Engineering by S. L. Kramer
2. Soil Plasticity: Theory and Implementations by W.F. Chen and G.Y. Baladi
3. Foundation Vibration Analysis using Simple Physical Models by J. P. Wolf

Course Outcomes: At the end of the course, students will be able to:

CO1	Solve problems relating to origin of earthquakes and response of structures to earthquake vibrations.
CO2	Solve problems relating to hazard analysis.
CO3	Assess properties of soil effected by seismic wave propagation
CO4	Solve problems relating to the effect of ground shaking on stability of slopes, stability of retaining wall, stability of footings etc.
CO5	Apply earthquake mitigation theories on stability of structures.

Soil-Foundation Interaction

CE 1546

L	T	P	C
3	0	0	3

Pre-requisites: Graduate in Civil Engineering

<u>Detailed Syllabus</u>

Introduction

Soil-foundation interaction problems, Soil behaviour, Foundation behaviour, Interface behaviour, Scope of soil-foundation interaction analysis, soil response models, Elastic continuum, Two-parameter elastic models, Elastic-plastic behaviour, Time-dependent behaviour.

Beams on elastic foundation

Infinite beam, Isotropic elastic half space, Analysis of beams of finite length, Classification of finite beams in relation to their stiffness.

Plates on elastic medium

Infinite plate, Winkler, Two parameters, Isotropic elastic medium, Thin and thick plates, Analysis of finite plates, rectangular and circular plates, Numerical analysis of finite plates, simple solutions.

Elastic analysis of piles

Elastic analysis of single pile, Theoretical solutions for settlement and load distribution, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap.

Laterally loaded piles

Load deflection prediction for laterally loaded piles, subgrade reaction and elastic analysis, Interaction analysis, and pile raft system, solutions through influence charts.

Dynamic Soil- Foundation Interaction

Introduction to soil and elasto-dynamics, Halfspace elasto-dynamic solution, Soil dynamics and earthquake, Waves induced by underground blast, Geotechnical analysis of machine foundations, Vibration of embedded footings.

References:

1. Foundation Analysis and Design by J.E. Bowles

2. Fundamentals of Soil Dynamics by B. M. Das

6. Dynamics of Bases and Foundations by D. D. Barkan

4. Beams on Elastic Foundation by Hetenyi

3. Pile Foundations in Engineering Practiceby S. Prakash and H. D. Sharma

4. Elastic Analysis of Soil-Foundation Interaction by A. P. S. Selvadurai

5. Dynamics of Structure and Foundation by Chowdhury and Dasgupta

Course Outcomes: At the end of the course, student will be able to:

CO1	Evaluate the soil stiffness and damping ratio.
CO2	Analyse the cases when to consider or neglect the soil-structure interaction effects.
CO3	Analyse the structure with soil-structure interaction effects by lumped mass model.

Department of Civil Engineering
Curriculum for M. Tech. in Structural Dynamics & Earthquake Engineering (SDEE)

1st SEM

Sl. No		Subject	Type	L	T	P	Credit
1	CE 2501	Theory of Vibration	Core	3	1	0	4
2	CE 2502	Engineering Seismology	Core	3	0	0	3
3	CE 2503	Matrix Methods for Dynamical Systems	Core	3	0	0	3
4	CE 2504	Dynamics Lab	Core	0	0	3	2
5	CE 1545 CE 2530 CE 2531 CE 2532 CE 2533	i). Geotechnical Earthquake Engineering ii). Plasticity in Dynamics (No Syllabi) iii). Dynamical modeling and simulation (No Syllabi) iv). Dynamic Slope Stability: dams and retaining walls (No Syllabi) v). Dynamic Soil Structure Interaction (No Syllabi)	**Elective - I**	3	0	0	3
6	CE 2544 CE 2545 CE 2546 CE 2547	i). Seismic Microzonation (No Syllabi) ii). Numerical Methods for Dynamical Systems iii). Seismic Disaster Mitigation and Management (No Syllabi) iv). Design of machine foundations (No Syllabi)	**Elective - II**	3	0	0	3
						Total Credit	18

Total Credit Required = 50

CE 2501 THEORY OF VIBRATION L=3 T=1 P=0 C=4

M. Tech. 1st Sem (Structural Dynamics and Earthquake Engineering)

Sources of vibration, types of excitations; spring action and damping : Degrees of freedom; Application of Newton's laws, D'Alembert's principle.

Single degree of freedom system: Mathematical model of physical systems; Free vibrations of undamped and viscously damped systems; Coulomb damping material and radiation damping. Logarithmic decrement and its applications.

Response of viscously damped SDOF systems to harmonic excitations. Non-periodic excitation – Duhamel's integral. Vibration isolation-Vibration arrest trench, Force transmissibility and base motion; Principle of vibration measuring instruments; Equivalent viscous damping.

Numerical evaluation of dynamic response of linear and non-linear systems.
Frequency domain analysis.

Multiple degree of Freedom systems: Vibrations of undamped 2 DOF systems; Response of 2 DOF to harmonic excitation, mode superposition, vibration absorber.

Lagranges equations and their application to lumped parameter models of MDOF. Free vibrations of MDOF systems, methods of solving eigenvalue problems; iteration methods.

Dynamic response of MDOF systems – mode superposition method.

Vibrations of Continuous systems: Free vibrations of continuous systems-axial transverse vibrations of beams. Numerical schemes for obtaining frequencies and mode shapes, vibration of elastic half space (Richart and Hall idealization).

Response of beams to harmonic excitation.

Earthquake Response of Systems : Response of SDOF and MDOF systems to earthquake excitation. Response spectra; Fourier spectra.

Pre-requisite: Nil

Objectives of the course: To familiarise the students with principles of vibrations. To familiarise the students with the theory of vibrations and various analysis processes used in dynamics for SDOF and MDOF systems. To enable the students to carry out analysis for real life dynamic problems. To expose the students to application of dynamics in code framing. To inspire students for lifelong learning.

Outcome of the course

CO-1 Students will be able to gather the understanding of the principles of vibrations.
CO-2 Students will be able to analyse SDOF and MDOF systems under dynamic loading and obtain the response of the systems.
CO-3 Students shall be able to apply the knowledge of theory of vibration in solving real life dynamic problems.
CO-4 Students shall be able to apply creative thinking in dynamics and acquire inspiration for life long learning.

Program outcome

PO-1: An ability to independently carry out research / investigation and development work to solve practical problems.
PO-2: An ability to write and present a substantial technical report/document.
PO-3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO-4: Program graduates will gain knowledge and skill in integrating Structural engineering concepts across multiple disciplines.
PO-5: Program graduates will develop understanding on project in Structural Engineering with ethical value towards social, environmental and economic development / sustainability.
PO-6: Graduates will develop interest to pursue higher studies and lifelong learning.

CO-PO mapping

CO	PO mapped
CO-1	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-2	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-3	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-4	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-5	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-6	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6

Table of Specifications for Question setting

Item	Per cent weightage
Remembering	10%
Understanding	20%
Applying	20%
Analysing	20%
Evaluating	20%
Creating	10%
Total	100%

Suggested readings

1. Chopra, A. K., Dynamics of structures, *Prentice Hall.*
2. Clough, R. W. and Penzien, J., Dynamics of structures, *Mc Graw Hill*.
3. Humar, J. L., Dynamics of Structures, *Prentice-Hall*.
4. Paz, M., Structural dynamics: theory and computation, *CBS Publishers & Distributor, Delhi.*
5. Timoshenko, S. P., and Young, D. H., Advanced dynamics, *McGraw Hill*
7. Biggs, J. M., and Testa, B, Introduction to structural dynamics.
8. Craig, R. R. and Kurdila, A. J., Fundamentals of structural dynamics, *John Wiley & Sons*.
9. Filiatrault, A., Elements of earthquake engineering and structural dynamics, *Presses inter Polytechnique.*
10. Buchholdt, H. A., Structural dynamics for engineers. *Thomas Telford*.

11. Paultre, P., Dynamics of structures, *Wiley India*.
12. T. K. Datta, Seismic Analysis of Structures, *John Wiley & Sons (Asia).*

Course Plan

Subjects:

1. **CE 2502: Engineering Seismology**: M. Tech. SDEE 1st Sem (Civil),Room No-CE-218

Course Outcomes:

CO1: Students who take this course will gain a thorough, critical understanding of advanced seismology and causes of earthquakes
CO2: Students will gain a detailed understanding of seismic hazard and a detailed understanding of wave equations and their solutions. Students will be able to use, interpret and evaluate.
CO3: Students will be able to assess the design basis ground motion parameters and its application in earthquake engineering for disaster mitigation.

Lecture Plan for Engineering Seismology

CE 2502	**Engineering Seismology**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
Course Contents				**Contact Hours**	
Propagation of earthquake Waves, Body & surface waves, laws of reflection, refraction and attenuation, travel times curves, internal structure of earth				7	
Seismicity of earth, major earthquakes in the world, important Indian Earthquakes, earthquake catalogs, plate tectonics, causes of earthquakes				8	
Magnitude, energy, intensity, acceleration, return period, frequency, Ground motion characteristics				7	
Earthquake recording instruments, seismographs, different modes of recording analogue, digital, micro earthquake, teleseismic, local, strong motion, band width and their engineering implications				8	
Processing, analysis and interpretation of earthquake data, determination of magnitude, epicentral distance, focal depth, focal mechanism, seismic hazard and risk, seismic zoning				4	
Introduction to prediction				6	
Design earthquake parameters				4	

Suggested Readings:

1. Richter,C.F. Elementary Seismology,Eurasia Publishing House (Pvt)LTD,New Delhi
2. Agrawal,P.N.,Engineering Seismology,Oxford & IBH Publishing Co.Pvt.Ltd,New Delhi
3. Aki,K and Richard, P.G.Quantitative seismology, Theory and Methods,Vol.I and II,W.H. Freeman & Co.
4. Lee,W.H.K and Stewart,S W.Principles and applications of microearthquake networks,1981,Academic Press Inc.
5. Kulhanek,O.anatomy of seismograms,1990,Elsevier Science Publications.
6. Rikitake,T.,1976 Earthquake Preduction, Elsevier Science, Amsterdam
7. Oldham,1989 Report on Great Earthquake of 12th June 1897, Memoir Geological Survey of India,V29
8. Latest Codes of IS-1893-part-I 2016

PG: Structural Dynamics and Earthquake Engineering,

Dept. of Civil Engineering, N.I.T. Silchar

Course Syllabus: CE 2503: Matrix Methods for Dynamical Systems L-T-P-C: 3-0-0-3

(New Course Prepared and Submitted by Dr. Nitesh A.)

Pre Requisites: Engineering Mathematics, Structural Analysis

General Matrix Static Analysis: Rod Structures, Beam Structures, Truss and Frame, Structural Connections, Equivalent Loads, Elastic Supports, Loads and Reactions, Substructuring, Matrix Stability Analysis of Truss, Beams, Frames,

Dynamics of Elastic Systems

Linear Elastic Structures, Harmonic Motion and Vibration, Complex Notation, Damping, Forced Response

Vibration of Rods and Beams

Rod, Beam, Spectral Analysis of Beams, Exact Dynamic Stiffness Matrix, Approximate Dynamic Stiffness Matrix, Matrix form of Dynamic Problems.

Matrix Modal Analysis of Frames

Dynamic Stiffness for Space Frames, Modal Matrix, Transformation of Principal Coordinates, Forced Damped Motion, Modal Model, Dynamic Structural Testing, Structural Modification

Structural Dynamics Principles

Elements of Analytical Dynamics, Hamilton's Principle, Approximate Structural Theories, Lagrange's Equation, Ritz Method, Discrete Systems, Rayleigh Quotient

Matrix Computer Methods

Computers and Data Storage, Structural Analysis Program, Node Renumbering, Solving Simultaneous Equations, Solving Eigen Value Problems, Finite Differences, Direct Integration Methods, Wilson (1973) Method for Nonlinear Dynamic Analysis of Complex Structures, Newmark's Method, Jacobi Method, Subspace Iteration, Selecting Dynamic Solver, Finite Element Method

References

1.James F. Doyle (1991) Static and Dynamic Analysis of Structure with Emphasis on Mechanics and Computer Matrix Methods, Kluwer Academic Publishers, Springer Science + Business Media Dordrecht

2.Madhu B. Kanchi (1993), Matrix Methods of Structural Analysis, Wiley

3.A. K. Mukherjee, P. K. Som (1985), Computer Methods of Structures, Khanna Publishers

4.A. K. Chopra (2007), Dynamics of Structures, Pearson

5.V..K. Manickha Selvam (1992), Advanced Structural Dynamics, Dhanpat Rai & Sons

6.F. Y. Cheng (2001), Matrix Analysis of Structural Dynamics: Applications and Earthquake Engineering, Marcel Dekker, Taylor and Francis

Dynamics laboratory, Code: CE 2504
PART-A (SOIL DYNAMICS)

1. **Seismic refraction survey**

Theory: In seismic refraction exploration method vibrational energy in the form of elastic waves is propagated through the ground by artificially induced shock waves. The behavior of these waves is used to identify information about geological structure. This approach is solely used for studying layers of rock with different velocities. The seismic velocity of a material is dependent on its density and mechanical strength. Lower density and mechanical strength are associated with a lower velocity. Density and mechanical strength generally increase with depth, thus, velocity increases as well. The change in velocity of the waves travelling through the rock represents the change in rock material. The velocity and time can be used to calculate the depth of the top layer of rock

Apparatus:

Sledgehammer, a metal plate, several geophones, and a recording device.

Procedure:

1. The metal plate is placed on the ground, with the geophones placed two meters from the plate and equal distances apart, ensuring they are vertically planted in the ground.

2. Next, the geophones are connected to the recording device and the trigger impulse is set up onto the shaft of the hammer

3. Before performing the test a noise test is performed by having someone run past the geophone while others monitor the computer screen.

4. Finally, data collection is begun by hitting the metal plate with the sledgehammer to send the sound waves through the ground. Results are observed on the computer screen

5. The recording device is used to record the signal from the geophones.

2. Cyclic triaxial test

Theory:

Cyclic triaxial test is a laboratory testing method used to determine the cyclic strength (sometimes called the liquefaction potential) of saturated soils in either intact or reconstituted states by the load-controlled cyclic triaxial technique. The results are used for evaluating the ability of a soil to resist the shear stresses induced in a soil mass due to earthquake or other cyclic loading.

Apparatus:

Deformation transducers, load cell, pore pressure and cell pressure transducers

Procedure:

1. Specimens having a minimum diameter of 51 mm with a height-to-diameter ratio between 2.0 and 2.5 are prepared. The specimen preparation depends on the type of the soil. Samples of cohesive soils are often prepared directly from saturated compacted samples, either undisturbed or remolded. For cohesion-less soils, however, the specimen is prepared with the help of a mold that maintains the required shape of the specimen. The specimen is then vertically enclosed in a thin rubber membrane.
2. After the sample measurement and first saturation phase, the initial drainage loading is isotropically applied to a desired confining pressure. Following consolidation, the drainage values are closed and cyclic loading started.

3. The magnitude of cyclic load to be applied is estimated for the desired stress ratio. The desired stress ratio, SR, is the ratio of the desired deviator stress to double the effective consolidation stress.

4. The cyclic loading is started with the first half cycle in compression using a 0.1 to 2 Hz sinusoidal load from where the stress varies between peak compression and peak extension values. During cyclic loading, the cell pressure is kept constant and recordings are done for the axial load, axial deformation, and change in pore-water pressure with time.

5. The loading is continued until either the cyclic double amplitude vertical strain exceeds 20%, the single amplitude strain in either extension or

compression exceeds 2%, 500 load cycles or the number of load cycles required in the testing program are exceeded, or the load wave form deteriorates beyond acceptable values.

3. **2D analysis of soil using Plaxis software**

--------------------PART-B: (Structural Dynamics)---------------------------

4. **Modal Testing**
5. **Dynamic properties estimation of a structures**
6. **Shake table testing**
7. **Softwares(SAP2000,STADPRO,&ANSYS) for structural dynamics and earthquake Engineering**

Geotechnical Earthquake Engineering

CE 1545

L	T	P	C
3	0	0	3

Pre-requisites: Graduate in Civil Engineering

Detailed Syllabus

Introduction

Scope and objective, Nature and types of earthquake loading, Importance of Geotechnical Earthquake Engineering.

Seismology and earthquakes

Basic Seismology, Earthquake, List of major earthquakes, Causes of earthquakes, Sources of earthquake data, Elastic rebound Theory, Faults, Plate tectonics, Seismograph and Seismogram, Prediction of Earthquakes, Protection against earthquake damage, Origin of universe, Layers of Earth, Theory of Continental Drift, Hazards due to Earthquakes.

Strong ground motion

Size of Earthquake: Magnitude and Intensity of Earthquake, Modified Mercalli Intensity Scale, Measuring of Earthquake, Earthquake Magnitude- Local (Richter) magnitude, surface wave magnitude, Moment magnitude, Seismic energy, Correlations. Spectral Parameters: Peak Acceleration, Peak Velocity, Peak Displacement, Frequency, Content and duration, Spatial Variability of Ground Motion, Attenuation Relationships, Fourier Amplitude Spectra, Arias Intensity.

Seismic Hazard Analysis

Magnitude Indicators, Segmentation, Deterministic Seismic Hazard Analysis (DSHA), Probabilistic Seismic Hazard Analysis (PSHA), Earthquake Source Characterization, Gutenberg-Richter recurrence law, Predictive relationships, temporal uncertainty, Probability computations, Seismic Hazard Curve, Logic tree methods.

Wave propagation

Waves in unbound media; Waves in semi-infinite media; Waves in layered media, Seismic Travel Time Curve, Three Circle Method for locating an Earthquake's Epicentre.

Dynamic soil properties

Stiffness, damping and plasticity parameters of soil and their determination (laboratory testing, intrusive and non-intrusive in-situ testing), Correlations of different soil parameters.

Ground response analysis

One dimensional ground response analysis, Two-dimensional ground response analysis, soil-structure interaction.

Local site effects and design ground motions

Effects of local site conditions on ground motions, design parameters, development of ground motion time histories.

Liquefaction

Basic concept, flow liquefaction, cyclic mobility, liquefaction susceptibility, effects.

Seismic slope stability analysis

Static slope stability analysis, seismic slope stability analysis, earthquake induced landslides.

Seismic Design of retaining wall

Types of retaining walls, static pressure, dynamic response, seismic pressures, seismic displacement.

Soil improvement techniques for remediation of seismic hazards

Densification, reinforcement, grouting, drainage.

References:

1. Geotechnical Earthquake Engineering by S. L. Kramer

2. Soil Plasticity: Theory and Implementations by W.F. Chen and G.Y. Baladi

3. Foundation Vibration Analysis using Simple Physical Models by J. P. Wolf

Course Outcomes: At the end of the course, students will be able to:

CO1	Solve problems relating to origin of earthquakes and response of structures to earthquake vibrations.
CO2	Solve problems relating to hazard analysis.
CO3	Assess properties of soil effected by seismic wave propagation
CO4	Solve problems relating to the effect of ground shaking on stability of slopes, stability of retaining wall, stability of footings etc.
CO5	Apply earthquake mitigation theories on stability of structures.

CE 2545 Numerical Methods for Dynamical Systems (Elective-II) L = 3 T= 0 P=0 C=3

M. Tech. 1st semester (Structural Dynamics & Earthquake Engineering)

Sl No	Topic	Lectures Hours
1	Elementary concepts of vector spaces, subspaces; Column and row space of a matrix; Range, null space, and rank of a matrix, ortho-normal bases, vector and matrix norms.	3
2	Systems of Linear Equations- Solving Linear Systems, Problem Transformations, Triangular Linear Systems, Elementary Elimination Matrices, LU Factorization, Implementation of LU Factorization, Complexity of Solving Linear Systems, Iterative methods- Jacobi iteration, Gauss Seidel iteration	9
3	Non Linear systems- Newton Raphson iterations for 1D nonlinear equation, Newton Iterations, Quasi Newton iterations. Programs.	5
4	Properties of Eigenvalues and Eigenvectors, Diagonalization and Numerical techniques to compute eigenvalues - Vector Iteration, QR algorithm, Jacobi Method. Programs	5
5	Numerical Integration and Differentiation Integration-Existence, Uniqueness, and Conditioning, Numerical Quadrature, Newton-Cotes Quadrature, Gaussian Quadrature, Composite Quadrature, Adaptive Quadrature Differentiation-Finite Difference Approximations, Automatic Differentiation, Richardson Extrapolation	9
6	Partial differential equations; Elliptic, parabolic and hyperbolic PDEs.	4
7	Response evaluation by the Integration of ordinary differential equations with emphasis on accuracy and stability considerations, integration of stiff ordinary differential equations, concepts of A-stability and stiff-stability	6

Objectives of the course: To obtain knowledge of how to apply numerical methods to dynamical related problems and an understanding of the mathematics and properties of these methods. To apply the numerical technique in developing programming skill and application to large scale computation structural problems.

CO-1 Students will be able to formulate structural dynamics problems using numerical methods applied to structural system.

CO-2 Students will be able to carry out numerical simulations of many structural dynamics and earthquake engineering problems.

CO-3 Students will be able to relate different aspects of the structural dynamics and earthquake engineering aspects in order to have a global picture of the behavior of a given problem.
CO-4 Ability in developing programming to solve particular problems in structural dynamics systems.

PO-1: An ability to independently carry out research / investigation and development work to solve practical problems.

PO-2: An ability to write and present a substantial technical report/document.

PO-3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO-4: Program graduates will gain knowledge and skill in integrating Structural engineering concepts across multiple disciplines.

PO-5: Program graduates will develop understanding on project in Structural Engineering with ethical value towards social, environmental and economic development / sustainability.

PO-6: Graduates will develop interest to pursue higher studies and lifelong learning.

CO-PO relationship

CO	PO satisfied
CO-1	PO-1, PO-3, PO-4, PO-6
CO-2	PO-1, PO-3, PO-4
CO-3	PO-3, PO-4
CO-4	PO-1, PO-3, PO-4, PO-6

Suggested readings

1. J. B. Scarborough, Numerical Mathematical Analysis, Oxford & IBH Publishing Co. Pvt. Ltd., 2000.
2. K. K. Jain, S. R. K Iyengar and R. K. Jain, Numerical Methods - Problem and Solutions, Wiley India Pvt. Ltd, 2001.
3. R.W. Hamming, Numerical Methods for Scientist and Engineers, McGraw Hill, 1998.
4. J. H. Mathews and K.D. Fink, Numerical Methods using MATLAB, Pearson Education, 2004.

Department of Civil Engineering
Curriculum for M. Tech. in Structural Engineering (SE)

1st SEM

Sl. No		Subject	Type	L	T	P	Credit
1	CE 3501	Structural Dynamics	Core	3	1	0	4
2	CE 3502	Continuum Mechanics	Core	3	0	0	3
3	CE 3503	Advanced Structural Analysis	Core	3	0	0	3
4	CE 3504	Structural and Concrete Lab	Core	0	0	3	2
5	CE 3530 CE 3531 CE 3532	i). Theory of Stability of Structures ii). Numerical Methods in Structural Engineering iii). Reliability Analysis of Structures	**Elective - I**	3	0	0	3
6	CE 3545 CE 3546 CE 3547 CE 3548	i). Theory of Plates and Shells ii). Construction Management iii). Design of Masonry Structures iv). Advanced Concrete Technology	**Elective - II**	3	0	0	3
						Total Credit	18

CE 3501 Structural Dynamics L = 3 T= 1 P=0 C=4

M. Tech. 1st semester (Structural Engineering)

Sl	Topic	Lectures
1	Sources of Structural vibrations; Meaning and types of excitations; spring action, spring in series and parallel. D'Alembert's principle.	3
2	Free vibrations of undamped and viscously damped SDOF systems; logarithmic decrement and its applications; Coulomb damping, material damping and radiation damping.	4
3	Response to harmonic excitations – Duhamel's integral. Vibration isolation-and vibration absorption, Force transmissibility and base motion; Equivalent viscous damping and structural damping.	5
4	MDOF systems: Vibrations of undamped 2 DOF systems; Free vibrations of MDOF systems, methods of solving eigenvalue problems; Characteristic equation method and other methods.	10
5	Modal analyses of MDOF systems: mode superposition method.	4
6	Vibrations of Continuous systems: Free vibrations of continuous systems-axial transverse vibrations of beams. Numerical schemes for obtaining frequencies and mode shapes.	8
7	Concept of Response spectrum and its applications.	2
8	Nonlinear Systems: material and geometric nonlinearity; Seismic Response of Nonlinear Systems: Earthquake analysis of multi-storey building frames – time step analysis.	5
9	Dynamic origin of Earthquake code provisions.	1

Objectives of the course: To understand the response of structures to various types of excitations including earthquake excitation. To analyze structures under excitation and to compute the responses. To apply the knowledge of structural vibration to practical cases including SDOF and MDOF systems to find their responses. To apply the knowledge of structural vibration to earthquake resistant design of structures.

CO-1 Students are able to understand the effect of vibration on structures.
CO-2 Students are able to analyze SDOF and MDOF structures under various dynamic loadings and obtain the responses.
CO-3 Students are able to understand the effect of nonlinearity in structural response.
CO-4 Students are able to conceptualize the importance of structural dynamics in design code provisions.

PO-1: An ability to independently carry out research / investigation and development work to solve practical problems.
PO-2: An ability to write and present a substantial technical report/document.
PO-3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO-5: Program graduates will develop understanding on project in Structural Engineering with ethical value towards social, environmental and economic development / sustainability.
PO-6: Graduates will develop interest to pursue higher studies and lifelong learning.

CO-PO relationship

CO	PO satisfied
CO-1	PO-1, PO-2, PO-3, PO-4, PO-6
CO-2	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-3	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-4	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6

Table of Specifications for Question setting

Item	Percent weightage
Remembering	10%
Understanding	20%
Applying	20%
Analyzing	20%
Evaluating	20%
Creating	10%
Total	100%

Suggested readings

1. Chopra, A. K, Dynamics of structures, *Prentice Hall of India*.
2. Clough, R. W., & Penzien, J., Dynamics of structures, *McGraw Hill.*
3. Humar, J. L., Dynamics of Structures, *Prentice-Hall*.
4. Paz, M., Structural dynamics: theory and computation, *CBS Publishers, Delhi*.
5. Timoshenko, S. P., & Young, D. H., Advanced dynamics. *McGraw Hill*
6. Meirovitch, L., Elements of vibration analysis, *McGraw-Hill*.
7. Biggs, J. M., & Testa, B., Introduction to structural dynamics.
8. Craig, R. R., & Kurdila, A. J., Fundamentals of structural dynamics, *John Wiley & Sons*.
9. Filiatrault, A., Elements of earthquake engineering and structural dynamics, *Presses inter Polytechnique.*
10. Buchholdt, H. A., Structural dynamics for engineers, *Thomas Telford.*
11. Paultre, P., Dynamics of structures, *John Wiley & Sons*.
12. T. K. Datta, Seismic Analysis of Structures, *John Wiley & Sons (Asia).*

Department of Civil Engineering, NIT Silchar
Subject: **Continuum Mechanics** (Code: CE 3502)
Category: Core (L-T-P-C:3-0-0-3)
PG: **Structural Engineering** (Pre-requisite: B.E/B. Tech); Semester: **1st**
Contact-Hours: Lecture: 42, Tutorial: nil, Practical: nil

Syllabus and Lesson Plan:

Sl No	Syllabus/Topics	Teaching hours	Assignments
1	Force and deformation, Problem solving	1	1
2	Stress at a point, Problem solving	3	
3	Strain at a point, Problem solving	3	
4	Constitutive modelling, Problem solving	5	1
5	Boundary value problem in linear elasticity	2	
6	Axial deformation of bar, Problem solving	2	2
7	Bending of beam, Problem solving	7	
8	Torsion of circular and non-circular bar, Problem solving	5	
9	Plane stress and plain strain, Problem solving	5	
10	Energy of deformation, Problem solving	4	1
11	Principles of variational mechanics	2	
12	Failure criteria, Problem solving	2	1
13	Introduction to nonlinear problems in mechanics	1	

Course Outcomes (COs):

(a) Understand the fundamental theories of continuum mechanics like: Force and deformation, Stress at a point, Strain at a point, Constitutive modeling, Plane stress and plain strain, Energy of deformation.
(b) Develop the understanding of applying fundamental theories of continuum mechanics in terms of: Boundary value problem, Axial deformation of bar, Bending of beam, Torsion of circular and non-circular bar.
(c) Understand the Principles of variational mechanics.
(d) Develop the understanding on Failure criteria.
(e) Understand various nonlinear problems in mechanics.

Program Outcomes (POs):

(1) An ability to independently carry out research / investigation and development work to solve practical problems.
(2) An ability to write and present a substantial technical report/document.
(3) Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the

(5) Program graduates will develop understanding on project in Structural Engineering with ethical value towards social, environmental and economic development / sustainability.
(6) Graduates will develop interest to pursue higher studies and lifelong learning.

CO-PO Mapping:

COs	CO-Statements	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	Understand the fundamental theories of continuum mechanics like: Force and deformation, Stress at a point, Strain at a point, Constitutive modeling, Plane stress and plain strain, Energy of deformation.	√		√	√		√
CO-2	Develop the understanding of applying fundamental theories of continuum mechanics in terms of: Boundary value problem, Axial deformation of bar, Bending of beam, Torsion of circular and non-circular bar.	√		√	√		√
CO-3	Understand the Principles of variational mechanics.	√			√		√
CO-4	Develop the understanding on Failure criteria.			√	√		√
CO-5	Understand various nonlinear problems in mechanics.				√		√

Marks distribution:

Minor test:2 nos. x 5 marks each :10
Assignments/Class Activity/Viva: :10
Mid-semester exam: :30
End-semester exam: :50

References:

[1] Y.C. Fung, Foundations of Solid Mechanics, Prentice Hall.
[2] I.S. Sokolnikoff, Mathematical Theory of Elasticity, Prentice Hall.
[3] C.T. Wang, Applied Elasticity, McGraw-Hill Book Company.
[4] J.N. Reddy, Principles of Continuum Mechanics, Cambridge University Press, 2010.
[5] S.P. Timoshenko, J.N. Goodier, Theory of Elasticity, 3rd Edition, McGraw Hill Publishing Co. 1970.
[6] L.S. Srinath, Advanced Mechanics of Solids, 2nd Ed., TMH Publishing Co. Ltd., New Delhi, 2003.
[7] D. S. Chandrasekharaiah, L. Debnath, Continuum Mechanics, Academic Press, 1994.
[8] A.K. Singh, Mechanics of Solids, PHI publication, 2007

Department of Civil Engineering, NIT Silchar
Subject: **Advanced Structural Analysis** (Code: CE 3503)
Category: Core (L-T-P-C:3-0-0-3)
PG: **Structural Engineering** (Pre-requisite: B.E/B. Tech); Semester: **1st**
Contact-Hours: Lecture: 42, Tutorial: nil, Practical: nil

Syllabus and Lesson Plan:

Sl No	Syllabus/Topics	Teaching hours	Assignments
1	Introduction of Matrix Method of Structural Analysis: Static and kinematics indeterminacy of structures; Fundamentals of Flexibility and Stiffness method; Basic examples of application of Flexibility and Stiffness Method.	2	1
2	Direct Stiffness Matrix Method: Derivation of local stiffness matrices for prismatic and non-prismatic members, transformation matrices and global stiffness matrices, assembling, compatibility equation. Application of Matrix Displacement Method to plane truss, space truss, beams, grids, plane frames and space frames subjected to various loadings including effects of temperature change and support displacements, Applications of software in structural analysis.	22	3
3	Introduction to Finite Element Method: Introduction to principles of Finite Element Method and its application using two/three nodded bar element, beam element, three/four nodded plane elements.	11	2
4	Special Structure: Beam on elastic foundation.	2	1
5	Introduction to nonlinear structural analysis: Material and geometric nonlinear problems, incremental and iterative procedures, Convergence criteria, P-Δ effect, buckling of frames.	5	1

Course Outcomes (COs):

(1) Develop the comprehensive understanding on matrix methods of structural analysis.
(2) Develop the understanding on fundamental principles of Finite Element Method.
(3) Extend the analysis skill for special structure.
(4) Develop the understanding on non-linear analysis of structures.
(5) Ability for structural analysis using computer software.

(7) An ability to independently carry out research / investigation and development work to solve practical problems.
(8) An ability to write and present a substantial technical report/document.
(9) Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
(10) Program graduates will gain knowledge and skill in integrating Structural engineering concepts across multiple disciplines.
(11) Program graduates will develop understanding on project in Structural Engineering with ethical value towards social, environmental and economic development / sustainability.
(12) Graduates will develop interest to pursue higher studies and lifelong learning.

CO-PO Mapping:

COs	CO-Statements	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	Develop the comprehensive understanding on matrix methods of structural analysis.	√		√	√		√
CO-2	Develop the understanding on fundamental principles of Finite Element Method.	√		√	√		√
CO-3	Extend the analysis skill for special structure.	√		√	√		√
CO-4	Develop the understanding on non-linear analysis of structures.	√		√	√		√
CO-5	Ability for structural analysis using computer software.	√		√	√		√

Marks distribution:

Minor test:2 nos. x 5 marks each	:10
Assignments/Class Activity/Viva:	:10
Mid-semester exam:	:30
End-semester exam:	:50

References:

(a) Weaver, W. and Gere J., Matrix Analysis of Framed Structures, CBS Publishers & Distributors, Delhi.
(b) Kenneth M. Leet, Chia-Ming Uang, Fundamentals of Structural Analysis, McGraw-Hill Book Company.
(c) Nicholas Willems and W.M. Lucas, Structural Analysis for Engineers, McGraw Hill Ltd.
(d) Weaver, Jr. and James M. Gere, Matrix Analysis of Framed Structures, Van Nostran Reinhold / CBS.
(e) Harry H. West and Louis F. Geschwinder, Fundamentals of Structural Analysis, , John Wiley and Sons.
(f) R.R. Craig, Matrix Analysis of Structures, Cole Publishing Company.
(g) McGuire, H.G. and Ziemian, R.D., Matrix Structural Analysis, John Wiley.
(h) Wang, C.K., Intermediate Structural Analysis, McGraw-Hill.
(i) Ghali, A. and Neville, A.., Structural Analysis, E & FN Spon, Taylor Francis.
(j) Leet, K.M. and Uang C., Fundamentals of Structural Analysis, Tata McGraw Hiil.
(k) Hibbler R.C., Structural Analysis, Pearson Education, Asia.
(l) Rajasekharan, S. and Sankarasubramanian, G., Computationsl Structural Mechanics, PHI, New Delhi.
(m) Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt, Concepts and Applications of Finite Element Analysis, John Wiley & Sons.
(n) P SESHU, TEXTBOOK OF FINITE ELEMENT ANALYSIS, PHI.

CE 3504 Structural and Concrete Lab

CE 3504 **Structural and Concrete Lab** L = 0 T = 0 P = 3 C= 2

Sl	Topic	Practical Hours
1	Basic Tests on cement, basic tests on aggregates	4
2	Evaluation of Young's Modulus of Concrete	2
3	Evaluation of modulus of rupture through prism test and split tensile test.	2
4	Normal Concrete Mix Design & casting elements	2
5	High Strength Concrete Mix Design & casting elements for strength studies	2
6	Self Compacting Concrete Mix Design & casting elements for strength studies	2
7	Geopolymer Concrete Mix Design & casting elements for strength studies	2
8	Non-Destructive testing of concrete	2
9	Determining strength of concrete elements after retrofitting with new concrete materials.	2
10	Flexural fatigue test on RC Beam member	2
11	Cyclic loading test on beam – column joint	2

Objectives of the course: To Conduct Quality Control tests on concrete making materials , to Conduct Quality Control tests on fresh & hardened concrete, to Design and test concrete mixes with different codes and to Conduct Non-destructive tests on concrete

Course Outcomes: At the end of the course, the student will be able to:
CO-1: Students will be able to Conduct Quality Control tests on concrete making materials
CO-2: Students will be able to Conduct Quality Control tests on fresh & hardened concrete
CO-3: Students will be able to Design and test concrete mixes with different codes.
CO-4: Students will be able to Conduct Non-destructive tests on concrete

PO-1: An ability to independently carry out research / investigation and development work to solve practical problems.
PO-2:An ability to write and present a substantial technical report/document.
PO-3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO-4: Program graduates will gain knowledge and skill in integrating Structural engineering concepts across multiple disciplines.
PO-5: Program graduates will develop understanding on project in Structural Engineering with ethical value towards social, environmental and economic development / sustainability.
PO-6: Graduates will develop interest to pursue higher studies and lifelong learning.

CO-PO relationship

Course	CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CE-3004: Structural & Concrete Lab	CO-1	√	√	√		√	√
	CO-2	√	√	√	√		
	CO-3	√	√	√		√	√
	CO-4	√		√	√	√	

Suggested readings

1. Neville, A.M., Properties of Concrete, *The English Language ook Society and Pitman Publishing.*
2. Raju, N. Krishna, Design of Concrete Mixes, *CBS Publishers and Distributor, Delhi*.
3. Santhakumar, A.R., Concrete Technology, *Oxford University Press*.
4. Neville AM. And Brooks J.J., Concrete Technology*, Addison Wesley*.
5. A.I.Laskar, Concrete Technology Practices , *Alpha Science Intl Ltd, India*

Table of Specifications for Question setting

Item	Percent weightage
Remembering	10%
Understanding	20%
Applying	20%
Analyzing	20%
Evaluating	20%
Creating	10%
Total	100%

Course coordinators
Dr.L.V. Prasad.M/Dr.B.K.Roy

Copy Submitted to

The HOD Civil Engineering Deptt, NIT Silchar for kind perusal and needful action.

The Dean (academic) , NIT Silchar for kind perusal and needful action.

CE 3530: Theory of Stability of Structures L = 3 T = 0 P = 0 C = 3
M. Tech. 1st semester Structural Engineering Elective I

Topic	Contents	Lectures
Basic Concepts	Concept of stability, Structural instability and bifurcation, Basic approaches to stability analysis	4
Discrete Systems	Law of minimum potential energy, Concept of dynamics and energy criteria; Stability of single and multi-degrees of freedom systems, large deflection analysis	5
Columns	Governing differential equation and boundary conditions; End-restrained columns; Effect of imperfection; Eccentrically loaded columns; Large deflection solution of elastic columns	8
Beam-Columns and Frames	Behavior of beam-columns; continuous columns and beam-columns, single-storey frames, frames with sway and no-sway, buckling analysis using stiffness and flexibility method	8
Approximate Methods	Solution of boundary value problems; Rayleigh-Ritz Method; Method of weighted residuals; Eigenvalue problems; Numerical solution of elastically supported columns	5
Stability of Plates	Governing differential equation for rectangular plates, Thin plates with all edges simply supported, plates with other boundary conditions, Plates under uniform and sinusoidal loading conditions; buckling under in-plane shear, post buckling analysis	5
Buckling	Buckling snap through and post-buckling; Inelastic buckling; Torsional buckling, torsional-flexural buckling, lateral-torsional buckling of symmetric cross-sections	7

Objectives of the course: To introduce the principles and applications of structural stability for their practical use in the design of steel frame structures, including the concepts of elastic and plastic theories. To analyze stability problems of structural members including columns, beam-columns, rigid frames, and beams. To evaluate stability problems, including energy and numerical methods.

CO-1 Students are able to understand the concept of structural stability and nonlinear structural behavior
CO-2 Students are able to determine and interpret the buckling loads for simple columns and frames
CO-3 Students are able to analyze basic structural components and systems that are susceptible to instability
CO-4 Students are able to design and evaluate advanced numerical techniques to bucking analysis of structures.

PO-1: An ability to independently carry out research / investigation and development work to solve practical problems.
PO-2: An ability to write and present a substantial technical report/document.
PO-3: Students should be able to demonstrate a degree of mastery over the area as per the

PO-4: Program graduates will gain knowledge and skill in integrating Structural engineering concepts across multiple disciplines.
PO-5: Program graduates will develop understanding on project in Structural Engineering with ethical value towards social, environmental and economic development / sustainability.
PO-6: Graduates will develop interest to pursue higher studies and lifelong learning.

CO-PO relationship

CO	PO satisfied
CO-1	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-2	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-3	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-4	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6

Textbooks and References

W. F. Chen and E. M. Lui (1987), Structural Stability: Theory and implementation, Prentice-Hall.
T. V. Galambos and A. E. Surovek (2008), Structural Stability of Steel: Concepts and applications for structural engineers, Wiley.
S. P. Timoshenko and J. M. Gere (1961), Theory of Elastic Stability, McGraw-Hill.
J.M.T. Thompson and G.W. Hunt (1973), A general theory of elastic stability, Wiley
Z.P. Bazant and L. Cedolin (1991), Stability of structures, Dover

Table of Specifications for Question setting

Item	Percent weightage
Remembering	10%
Understanding	20%
Applying	20%
Analyzing	25%
Evaluating	20%
Creating	5%
Total	100%

CE 3531 Numerical Methods in Structural Engineering (Elective-I) L = 3 T= 0 P=0 C=3

M. Tech. 1st semester (Structural Engineering)

Sl	Topic	Lectures Hours
1	Introduction to Numerical Methods, error in numerical solutions, Order of accuracy	2
2	Direct Solution of Linear systems- Gauss elimination, Gauss Jordan elimination, Pivoting, inaccuracies due to pivoting, Factorization, Cholesky decomposition, Diagonal dominance, condition number, ill conditioned matrices, singularity and singular value decomposition. Banded matrices, storage schemes for banded matrices, skyline solver.	7
3	Iterative solution of Linear systems- Jacobi iteration, Gauss Seidel iteration, Convergence criteria. Programs	3
4	Direct Solution of Non Linear systems- Newton Raphson iterations to find roots of a 1D nonlinear equation, Newton Iterations, Quasi Newton iterations. Programs.	5
5	Properties of Eigenvalues and Eigenvectors, Diagonalization and Numerical techniques to compute eigenvalues - Vector Iteration, QR algorithm, Jacobi Method. Programs	5
6	Numerical integration- Introduction, Newton – Cotes formulas, Adaptive Integration, Gaussian quadrature	5
7	Numerical differentiation- Equally Spaced Data, Taylor Series Approach, Difference Formula, Error Estimation, Programs	4
8	Partial differential equations; Elliptic, parabolic and hyperbolic PDEs.	4
9	Numerical Solution of Boundary Value Problems - Finite Difference Method, Explicit and Implicit Approaches; Method of Weighted Residuals, Galerkin's Method.	6

Objectives of the course: To understand the concept of error estimation and accuracy of numerical solutions. To understand different numerical technique like Solution of linear and non-linear equations, Numerical integration and differentiation, partial differential equations and Numerical Solution of Boundary Value Problems. To apply the numerical technique in developing programming skill and application to
large scale computation structural problems.

CO-1 Students will be able to formulate structural problems using numerical methods applied

CO-3 Students will be able to relate different aspects of the structural engineering aspects in order to have a global picture of the behavior of a given problem.
CO-4 Ability in developing programming to solve particular problems in structural systems.

PO-1: An ability to independently carry out research / investigation and development work to solve practical problems.
PO-2: An ability to write and present a substantial technical report/document.
PO-3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO-4: Program graduates will gain knowledge and skill in integrating Structural engineering concepts across multiple disciplines.
PO-5: Program graduates will develop understanding on project in Structural Engineering with ethical value towards social, environmental and economic development / sustainability.
PO-6: Graduates will develop interest to pursue higher studies and lifelong learning.

CO-PO relationship

CO	PO satisfied
CO-1	PO-1, PO-3, PO-4, PO-6
CO-2	PO-1, PO-3, PO-4
CO-3	PO-3, PO-4
CO-4	PO-1, PO-3, PO-4, PO-6

Suggested readings

1. J. B. Scarborough, Numerical Mathematical Analysis, Oxford & IBH Publishing Co. Pvt. Ltd., 2000.
2. K. K. Jain, S. R. K Iyengar and R. K. Jain, Numerical Methods - Problem and Solutions, Wiley India Pvt. Ltd, 2001.
3. R.W. Hamming, Numerical Methods for Scientist and Engineers, McGraw Hill, 1998.
4. J. H. Mathews and K.D. Fink, Numerical Methods using MATLAB, Pearson Education, 2004.

CE 3532: Reliability Analysis of Structures L = 3 T = 0 P = 0 C = 3
M. Tech. 1st semester Structural Engineering Elective I

Topic	Contents	Lectures
Introduction	Overview, Objectives of this course, Deterministic vs. Probabilistic Models, Uncertainties in Engineering Systems	2
Probability Theory	Sample Space and Random Events, Random Variables and their Functions, Set Theory, Axioms of Probability, Conditional Probability, Total Probability Theorem, Bayes' Theorem, Bayesian Inference	4
Basic Structural Reliability Methods	Concept of Safety, Failure Surface and Limit State Function, Component Reliability, Probability of Failure and Reliability Index, First Order Second Moment Methods (FOSM), Advanced First Order Second Moment Methods (AFOSM)	6
Probabilistic Simulation Methods	Monte Carlo Methods, Generation of Random Numbers, Variance Reduction Techniques, Stratified and Latin Hypercube Sampling, Importance Sampling, $2K+1$ Point Estimate Method	8
Advanced Reliability Methods	Second Order Reliability Method, Response Surface Method, Adaptive Sampling Method, Sensitivity Analysis, Random Process, Time-varying Reliability	6
Reliability-Based Design	Development of Design Codes, Load and Resistance Factor Design, Target Safety Levels, Calibration of Safety Factors	4
Structural System Reliability	Components and Systems, Series, Parallel and Hybrid Systems, System Reliability Bounds, Systems with Correlated Components, Reliability of systems for Normal and Non-Normal Random Variables, System Reliability Computation: Probabilistic Graphical Models, Bayesian Networks	8
Concepts of Structural Risk Analysis	Basic Definition of Risk, Relation between Reliability and Risk, Application of Reliability and Risk Principles to Structural Engineering Field	4

Computational Lab Component:

Experiment	**Brief description**	**Tentative hours#**
Software/Programming Language	Coding in MATLAB/Python	25

Computational lab experiments or hands-on sessions will be conducted during the lecture hours, unless otherwise instructed

Objectives of the course: To train the students/researchers on the fundamentals of safety, reliability and risk principles that can be connected mathematically and applied to problems in structural engineering science and practice.

CO-1 Students are able to review, understand, define and express safety, reliability & risk for structural engineering problems
CO-2 Students are able to interpret algorithm and implement computer codes for probabilistic simulations and basic and advanced structural reliability methods
CO-3 Students are able to analyze the reliability of structural components and systems
CO-4 Students are able to design/evaluate practical reliability and risk problems for structural engineering systems

PO-1: An ability to independently carry out research / investigation and development work to solve practical problems.
PO-2: An ability to write and present a substantial technical report/document.
PO-3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO-4: Program graduates will gain knowledge and skill in integrating Structural engineering concepts across multiple disciplines.
PO-5: Program graduates will develop understanding on project in Structural Engineering with ethical value towards social, environmental and economic development / sustainability.
PO-6: Graduates will develop interest to pursue higher studies and lifelong learning.

CO-PO relationship

CO	PO satisfied
CO-1	PO-1, PO-2, PO-3, PO-4, PO-6
CO-2	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-3	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-4	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6

Textbooks and References

Text books:

1. Ang, A. H-S., Tang, W. H. (2007). *Probability Concepts in Engineering*. Second Edition. John Wiley & Sons, Inc.
2. Nowak, A. S., Collins, K. R. (2013). *Reliability of Structures*. Second Edition. CRC Press.
3. Haldar, A., Mahadevan, S. (2000). *Probability, Reliability and Statistical Methods in Engineering Design*. Second Edition. John Wiley & Sons, Inc.

Reference books:

1. Ranganathan, R. (2006). *Structural Reliability: Analysis and Design*. Second Edition. Jaico Publishing House, India.
2. Melchers, R. E. (2002). *Structural Reliability Analysis and Predictions*. Second Edition. John Wiley & Sons, Inc.
3. Pratap, R. (2010). *Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers*. South Asia Edition. Oxford University Press.
4. Martelli, A., Ravenscroft, A., Holden, S. (2017). *Python in a Nutshell*. Third Edition. O'Reilly Media.

Table of Specifications for Question setting

Item	Percent weightage
Remembering	5%
Understanding	20%
Applying	20%
Analyzing	25%
Evaluating	25%
Creating	5%
Total	100%

CE 3545: Theory of Plates and Shells L = 3 T= 0P=0 C=3

M. Tech. 1^{st} semester Structural Engineering Elective II

Topic	Contents	Lectures
Introduction to Elastic Plates	Review of Concepts of Elasticity, Classical Plate Theory: Basic Assumptions, Formulations, Boundary Conditions, Governing Equations	5
Bending of Plates	Pure Bending, Plates with Various Loadings and Boundary Conditions, Navier's Solution for Rectangular Plates, Levy's Solution	8
Solutions by Numerical Methods	Potential Energy Minimization, Energy Principles and Rayleigh-Ritz Methods, Numerical Integration Method, Finite Element Analysis of Plates	8
Refined Plate Theories	Large Deflections of Plates, Plates with Shear Deformation, Higher Order Plate Bending Theory, Thermal Stresses in Plates	5
Introduction to Elastic Shells	Basics of Differential Geometry, Space Curves, Surfaces, Theory of Surfaces, Coordinates Systems	8
Thin Elastic Shell Analysis	Different Shell Forms, Basic Assumptions, Strain-Displacement Relations, Love Shell Theory, Axisymmetric Shells And Cylindrical Shells, Membrane Theory of Shells, Solution of Cylindrical Shells	8

Objectives of the course: To achieve fundamental understanding of the classical and refined theories of elastic plates and shells, address limitations and challenges, and present analytical and numerical solution techniques.

CO-1 Students are able to understand the action of plates and shells in structures
CO-2 Students will be able to articulate plate/shell problems and determine the component responses
CO-3 Students are able to analyze plate and shell structures using analytical and numerical methods
CO-4 Students are able to evaluate the elastic plate/shell theories and design structural engineering systems

PO-3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO-4: Program graduates will gain knowledge and skill in integrating Structural engineering concepts across multiple disciplines.
PO-5: Program graduates will develop understanding on project in Structural Engineering with ethical value towards social, environmental and economic development / sustainability.
PO-6: Graduates will develop interest to pursue higher studies and lifelong learning.

CO-PO relationship

CO	PO satisfied
CO-1	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-2	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-3	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-4	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6

Textbooks and References

1) Timoshenko, S. P. and Krieger, S. W., *"Theory of Plates and Shells"*, McGrawHill.
2) Szilard, R.,*"Theory and Analysis of Plates: Classical and Numerical Methods"*, Prentice Hall, New York
3) Gould, P. L., *"Analysis of Shells and Plates"*, Springer-Verlag
4) Bairagi, N. K., *"Shell Analysis"*, Khanna Publishers, New Delhi
5) Timishenko, S.P. and Goodier, J. N., *"Theory of Elasticity"*, McGraw-Hill

Table of Specifications for Question setting

Item	Percent weightage
Remembering	5%
Understanding	20%
Applying	25%
Analyzing	25%
Evaluating	20%
Creating	5%
Total	100%

CE 3546	Construction Management	L-T-P-C	3-0-0-3

Prerequisites: PERT & CPM

Detailed Syllabus:

Sl	Topic	Lectures
I. Introduction		
	Phase of project, project management and its relevance, stake holders of a project, structure of project organization, management levels, and traits of a project manager.	6
II. Construction Planning		
	Introduction, activities involved types of project plan, work breakdown structure. Planning terminologies, Critical path method, forward and backward pass, PERT, Ladder network, Precedence network, Line of balance.	8
III. Project scheduling and resource levelling		
	Introduction, Resource allocation and leveling for unlimited resources, Resource allocation for limited resources, Multi resource allocation, Optimal scheduling.	6
IV. Contracts Estimation and Bidding Strategy		
	Introduction, Determination of bid price, Bidding models such as EPC, Turnkey etc.	6
V. Project Monitoring and Control		
	Introduction, Project updating, Cost control.	6
VI. Construction Management		
	Construction Equipment and Management, Construction Account Management, Construction Material management, Construction Quality Management, Construction Safety Management, Computer Application In Construction Management, Workforce Motivation And Human Factors In Construction Management, Plant Management, Project Communication.	8

Objectives of the course: To Prepare work break down plan and estimate resources requirements, to solve problems of resource allocation and levelling using network diagrams, to Plan and develop management solutions to construction projects and to understand the principles of project management, resource management and inventory.

Reading:

1. Callahan, M. T., Quackenbush, D. G., and Rowings, J. E., Construction Project Scheduling, McGraw-Hill, New York, 1992.
2. Cleland, D. I. and Ireland, L. R., Project Management: Strategic Design and Implementation 4th Edition, McGraw-Hill, New York, 2002.

Course Outcomes: At the end of the course, the student will be able to:

CO1: Prepare work break down plan and estimate resources requirements.
CO2: Solve problems of resource allocation and levelling using network diagrams.

PO-1: An ability to independently carry out research / investigation and development work to solve practical problems.
PO-2: An ability to write and present a substantial technical report/document.
PO-3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO-4: Program graduates will gain knowledge and skill in integrating Structural engineering concepts across multiple disciplines.
PO-5: Program graduates will develop understanding on project in Structural Engineering with ethical value towards social, environmental and economic development / sustainability.
PO-6: Graduates will develop interest to pursue higher studies and lifelong learning.

Mapping of course outcomes with program outcomes

Course	CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CE-3032: Construction Management	CO-1	√		√	√		
	CO-2	√	√	√	√	√	√
	CO-3	√	√	√	√		√
	CO-4		√	√		√	√

Table of Specifications for Question setting

Item	Percent weightage
Remembering	10%
Understanding	20%
Applying	20%
Analyzing	20%
Evaluating	20%
Creating	10%
Total	100%

Course coordinator
Dr.L.V.Prasad.M

Copy Submitted to

The HOD Civil Engineering Deptt, NIT Silchar for kind perusal and needful action.

The Dean (academic) , NIT Silchar for kind perusal and needful action.

CE 3547 Design of Masonry Structures L =3 T=0 P =0 C = 3

M. Tech First Semester Structural Engineering Elective II

Sl. No	Topics	Lectures
1	Earthen building: Typical damage and collapse of earthen building, material properties, recommendation for seismic areas, Seismic strengthening and desirable features.	4
2	Stone building: Typical damage and failure of stone building, structure properties, general construction aspects, general recommendations for seismic areas.	5
3	Material Properties, Masonry units: clay and concrete blocks, Mortar, grout and reinforcement, Bonding patterns, shrinkage and differential movements.	5
4	Masonry in compression, Prism strength, Eccentric loading, Kem distance.	5
5	Masonry under lateral loads, in-plane and out-of-plane loads, Analysis of perforated shear walls, Lateral force distribution for flexible and rigid diaphragms.	5
6	Behavior of masonry members, Shear and flexure, Combined bending and axial loads, Reinforced Vs. unreinforced masonry, Cyclic loading, Ductility of masonry shear walls for seismic design, Infill masonry.	5
7	Structural design of masonry, working and Ultimate strength design, in-plane and out-of-plane design criteria for infills, connecting elements and ties, Consideration of seismic loads, Codal provisions.	6
8	Evaluation and existing structures, In-situ and non-destructive tests for masonry properties. Repair and strengthening of existing masonry structure for seismic loads.	5
9	Construction practices and new materials	2
	Total	42

Course Objectives: To familiarize students with the properties of masonry and masonry structures. To design masonry structures. To evaluate existing masonry structures.

Course Outcomes:

CO-1 Students learn about properties of masonry and behaviour of masonry structures, earthen structures.

CO-2 Students are able to identify the types of failures of masonry structures.

CO-3 Students are able to analyze and design masonry structures.

CO-4 Students are able to evaluate existing masonry structures.

PO-1: An ability to independently carry out research / investigation and development work to solve practical

PO-3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO-4: Program graduates will gain knowledge and skill in integrating Structural engineering concepts across multiple disciplines.
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CO-PO relationship

CO	PO satisfied
CO-1	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-2	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-3	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6
CO-4	PO-1, PO-2, PO-3, PO-4, PO-5, PO-6

Suggested readings

1. Drysdale, R.G. Hamid, A.H. and Baker, L.R., Masonry Structure: Behavior Design, *Prentice Hall.*
2. Hendry A.W., Structural Masonry, *Macmillan International*.
3. Hendry A.W., Sinha B.P. and Davis S.R., Design of Masonry Structures, *E & FN Spon, Madras*.
4. Paulay, T. and Priestley, M.J.N., Seismic Design of Reinforced Concrete and Masonry Building,*John Wiley and sons.*
5. Wakabayshi, M., Design of Earthquake resistant Buildings, *McGraw Hill.*

Table of Specifications for Question setting

Item	Percent weightage
Remembering	5%
Understanding	20%
Applying	25%
Analyzing	25%
Evaluating	20%
Creating	5%
Total	100%

CE 3548	Advanced Concrete Technology	L-T-P-C	3-0-0-3

Prerequisites: Civil Engineering Materials, Concrete Technology

Detailed Syllabus:

Sl	Topic	Lectures
I. Concrete science		
	Standards – specifications – Ingredients - cement and its types – Coarse Aggregate – Fine Aggregate.	4
	Chemical admixtures - Mineral admixtures - Polymer concrete -	3
	Mix design - Mix Design by IS :10262-2019 - Mix Design by ACI :312 - Other methods of mix design.	4
II.Concrete Types		
	Normal Vibrated Concrete - High volume fly ash concrete - High strength concrete - Reactive powder concrete & Oil well concrete - Ready mix concrete, pervious concrete.	5
	Fiber Reinforced concrete – FRP in concrete - Self compacting concrete – Bacterial Concrete - Self curing concrete - Geopolymer Concrete.	5
III.Durability and fire hazards in concrete		
	Deterioration of concrete - Factors effecting the durability - Sulphate attack - Acid attack	3
	Alkali Aggregate reaction – Carbonation - Abrasion	3
	Freezing and Thawing - Corrosion of Rebar - Rapid Chloride penetration test	3
IV.Use of waste materials in concrete		
	Waste from industry - Recycled aggregates - Sustainability	3
	Green concrete - Eco-Friendly Concrete	2
V.Non Destruct Test (NDT)		
	Rebound Hammer Test - Ultrasonic pulse velocity test - Core Extraction for Compressive Strength Test - Windsor Probe System – pull out resistance test – pull off test.	3
VI.Under Water Concrete		
	Tremie Method - Concrete in Cold weather - Concrete in Hot weather - miscellaneous topics	4

Objectives of the course: To understanding of advanced concrete terminology and studying of understanding to use plasticizers, effect of water cement ratio and super plasticizers Used in the construction works.

Course Outcomes: At the end of the course, the student will be able to:

CO1 An understanding of advanced concrete terminology.

CO2 An understanding of the mixed design of concrete, high strength of concrete requirements for advanced concrete.

CO3 An understanding to use plasticizers, effect of water cement ratio and super plasticizers

Used in the construction works.

PO-1: An ability to independently carry out research / investigation and development work to solve practical problems.
PO-2: An ability to write and present a substantial technical report/document.
PO-3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO-4: Program graduates will gain knowledge and skill in integrating Structural engineering concepts across multiple disciplines.
PO-5: Program graduates will develop understanding on project in Structural Engineering with ethical value towards social, environmental and economic development / sustainability.
PO-6: Graduates will develop interest to pursue higher studies and lifelong learning.

Mapping of course outcomes with program outcomes

Course	CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CE 352: Advanced Concrete Technology	CO-1	√		√	√		
	CO-2	√	√	√	√	√	√
	CO-3	√		√	√		√

Reference Books:

1. Concrete Materials, Properties, Specification and Testing by S. Popovics, Standard Publishers, India
2. Properties of Concrete by A.M. Neville, ELBS Ed.
3. Waste Materials in Concrete Manufacture by Satish Chandra, Indian Standard Publishers
4. Nondestructive Testing in Concrete by Bungey, Surrey University Press, London.

Table of Specifications for Question setting

Item	Percent weightage
Remembering	10%
Understanding	20%
Applying	20%
Analyzing	20%
Evaluating	20%
Creating	10%
Total	100%

Curriculum for M. Tech in Transportation Engineering
Department of Civil Engineering
NIT Silchar

1st Semester

Subject Code	Subject	Type	L	T	P	Credit
CE 4501	Urban Transportation Planning	Core	3	0	0	3
CE 4502	Pavement Materials	Core	3	0	0	3
CE 4503	Traffic Engineering	Core	3	1	0	4
CE 4504	Transportation Engineering Lab	Core	0	0	2	2
CE 4545	Hill Roads	Elective -I	3	0	0	3
CE 4546	Advanced Highway Materials					
CE 3548	Advanced Concrete Technology					
CE 1545	Geotechnical Earthquake Engineering	Elective- II	3	0	0	3
CE 1530	Ground Improvement Techniques					
CE 4547	Design and Construction of Rural Roads					
			Total Credit			**18**

DETAILED SYLLABUS

1st Semester

CODE	**Urban Transportation Planning**
CE 4501	3 – 0 - 0 : 3 Credits

Urban Transportation Planning Process, Urban Travel and Transportation Systems Characteristics, Travel Demands Forecasting - trip generation, trip distribution, modal split and trip assignment, Transport Behaviour of Individuals and Households, Land use/ Transportation systems, Introduction to Urban Freight Transportation and Urban Mass Transportation Systems.

References:

1. J. de D. Ortuzar and L.G. Willumsen, Modelling Transport, John Wiley and Sons, 2001.
2. C.J. Khisty and B.K. Lall, Transportation Engineering – An Introduction, Prentice Hall of India Pvt. Ltd., 2002.
3. C.S. Papacostas and P.D. Prevedouros, Transportation Engineering and Planning, Prentice Hall of India Pvt. Ltd., 2001.
4. P. Chakroborty and A. Das, Principles of Transportation Engineering, Prentice Hall of India Pvt. Ltd., 2003.
5. B.G. Hutchinson, Principles of Urban Transport Systems Planning, McGraw-Hill Book Co., New York, 1974.
6. L.R. Kadiyali, Traffic Engineering and Transport Planning, Khanna Publishers, New Delhi, 2000.
7. G. E. Gray and L. A. Hoel, Public Transportation, Prentice Hall, New Jersey, 1992.

CODE	**Pavement Materials**
CE 4502	3 – 0 - 0 : 3 Credits

Road Materials - classification, properties of subgrade and road aggregates; design of aggregate gradation. Bituminous road binders -bitumen, emulsions, cut backs and modified binders. Rheology of bituminous binders, modified binders, Mix design - Marshall method and Superpave procedure. Design of emulsified mixes, Visco-elastic and fatigue properties of bituminous mixtures, resilient modulus of pavement materials. Requirements of paving concrete, design of mixes for recycling of bituminous and concrete pavement surfaces. Soil stabilization techniques.

References:

1. P.H. Wright, Highway Engineering, John Wiley & Sons, 1996.
2. S.K. Khanna and C.E.G. Justo, Highway Material Testing, New Chand & Bros., 1999.
3. G.N. Durhan, W.A. Marr, and W.L. DeGroff, Resilient Modulus Testing for Pavement Components, ASTM International, U.S.A., 2003.
4. G. Correia, Flexible Pavements, A. A. Balkema Publishers, 1996.
5. S.E. Zoorob, A.C. Collop, and S.F. Brown, Performance of Bituminous and Hydraulic Materials in Pavements, A. A. Balkema Publishers, 2002.
6. R.N. Hunter, Bituminous Mixtures in Road Construction, Thomas Telford Services Ltd., 1995.
7. MOST, Specifications for Road and Bridge Work (4th Revision), Ministry of Road Transport and Highways, 2001.
8. ASTM, Annual Book of ASTM Standards – Section IV, Vol. 04.03, ASTM International, 2002.
9. D. Croney, and P. Croney, Design and Performance of Road Pavements, McGraw-Hill, 1998.

CODE	**Traffic Engineering**
CE 4503	3 – 1 - 0 : 4 Credits

Vehicle Characteristics, Human Factors and Driver behaviour, Traffic control mechanism. Traffic studies- volume, speed and delay studies, elements of traffic flow theory. Characteristics of uninterrupted traffic, Capacity and LOS of Uninterrupted facilities, Characteristics of interrupted traffic, Traffic characteristics at Un-signalised intersections, Design of Signalized intersections, Capacity and LOS of Signalized intersections, Signal control and signal coordination.

References:

1. Roger P. Roess, William R. McShane & Elena S. Prassas, Traffic Engineering, Prentice-Hall, 1990.
2. Pignataro L. J., Traffic Engineering – Theory and Practice, Prentice Hall, 1973.
3. Khisty and B. K. Lall, Transportation Engineering: An Introduction, Prentice- Hall India, 2003.
4. Wohl M. and Martin B. V., Traffic System Analysis, McGraw-Hill Book Company, 1967.
5. P. Chakroborty and A. Das, Principles of Transportation Engineering, Prentice Hall of India Pvt. Ltd., 2003.
6. L. R. Kadiyali, Traffic Engineering and Transportation Planning, Khanna Publishers, 2000.
7. D. May, Traffic Flow Fundamentals, Prentice–Hall, 1990.
8. C.S. Papacostas, Transportation Engineering and Planning, Prentice-Hall India, 2001.
   Highway Capacity Manual (HCM), Transportation Research Board, USA, 2000.

CODE	**Transportation Engineering Laboratory**
CE 4504	0 – 0 - 2 : 2 Credits

Tests on bitumen, emulsion, cutback, soil and aggregates, aggregate blending, viscosity of binders. Viscoelastic properties of bituminous mixtures and bituminous mix design. Speed, headway and travel time studies on highways. Parking surveys, Traffic data collection and analysis.

References:

1. MOST, Specifications for Road and Bridge Work (4th Revision), Ministry of Road Transport and Highways, 2001.
2. S.K. Khanna and C.E.G. Justo, Highway Material Testing, New Chand & Bros., 1999.
3. C.A.O' Flaherty, Highways – The Location, Design, Construction, & Maintenance of Pavements, Butterworth Heinemann, 2002.
4. R. N. Hunter, Bituminous Mixtures in Road Construction, Thomas Telford Services Ltd., 1995.

ELECTIVE-I

CODE	**E-I: Hill Roads**
CE 4545	3 – 0 - 0 : 3 Credits

Introduction to hill road, classification of terrains, features and planning of hill roads, development of hill roads in India. Alignment of hill roads, Geometrics of hill roads pavement formation, camber, sight distance, horizontal curves, vertical curves, hair pin bends. Construction of hill roads-formation works, rock cutting, retaining walls. Drainage systems on hill roads-components drainage system, road-side drains, cross drainage structures, sub-surface drainage. Maintenance of hill roads. Landslide-type of landslides, factors causing landslides, remedial measures of hill roads.

References:

1. Khanna, S.K., Justo, C.E.G. and Veeraragavan, A: Highway Engineering. Nem Chand & Bros Publisher, Civil Lines, Roorkee, India.
2. Ahuja, T.D.: Highway Engineering. Standard Book House Publisher, 1705-A, Nai Sarak, Delhi, India.
3. Hill Road Manual, IRC: SP 48-1998.
4. Guidelines for the design of flexible pavements for low volume rural roads, IRC: SP: 72-2007

CODE	E-I: Advanced Highway Materials
CE 4546	3 – 0 - 0 : 3 Credits

Aggregate: Nature and properties – aggregate requirements – types and processing – aggregates for pavement base – aggregate for bituminous mixture – aggregate for Portland Cement Concrete – light weight aggregate – tests on aggregate – specification.

Bituminous Materials: conventional and modified binders – production – types and grade – physical and chemical properties and uses – types of asphalt pavement construction – principles of bituminous pavement construction – tests on bituminous materials. Bituminous Mix design – modified mixtures – temperature susceptibility and performance.

Cement /concrete based materials: Cement – properties – PCC mix design and properties – modified PCC – Mix Design – Behaviour – Performance – Tests on Cement and Concrete mixes. High Performance Concrete – low shrinkage – increased strength.

Composites, Plastics and Geosynthetics: Plastics and polymerization process – properties – durability and chemical composition – Reinforced Polymer Composites – Geosynthetics – Dry Powdered Polymers – Enzymes. Reclaimed / Recycled Waste Products: Reclaimed Materials – waste products in civil engineering applications – effect of waste products on materials, structure and properties – self healing and smart materials – locally available materials.

References:

1. P. T. Sherwood, Alternative Materials in Road Construction, Thomas Telford Publication, London,1997.
2. RRL, DSIR, Soil Mechanics for Road Engineers, HMSO, London , 1995
3. Koerner, R. M. Designing with Geosynthetics, Prentice Hall, Englewood Cliffs, New Jersey, U.S.A.
4. Shan Somayaji, Civil Engineering Materials, second edition, Prentice Hall Inc., 2001.

CODE	E-I: Advanced Concrete Technology
CE 3548	3 – 0 - 0 : 3 Credits

Concrete science, standards and specifications. Chemical admixtures, mineral admixtures, polymer concrete, high volume fly ash concrete, high strength concrete, self compacting concrete, reactive powder concrete, mass concrete, roller compacted concrete, oil well concrete. Durability and fire hazards in concrete, use of waste materials in concrete, NDT.

References:

1. S. Popovics, Concrete Materials, Properties, Specification and testing, Standard Publishers, India.
2. A.M. Neville, Properties of Concrete, ELBS Ed.
3. S. Chandra, Waste Material in Concrete Manufacture, Indian Standard Publishers.
4. Bungey, Non Destructive Testing in Concrete, Surrey University Press, Lndon.

ELECTIVE -II

CODE	E-II: Geotechnical Earthquake Engineering
CE 1545	3 – 0 - 0 : 3 Credits

Introduction, Seismic risks and seismic hazards, cause and strength of earthquake, social and economical consequences, theory of dynamics and seismic response, the nature and attenuation of ground motion. Determination of site characteristics, local geology and soil condition, site investigation and soil tests. Determination of design earthquake response spectra and accelerogrames as design earthquake, criteria for earthquake resistant design. Site response to earthquake, liquefaction of saturated cohesionless soils, seismic response of soil structure system, shallow foundation, pile foundation, foundation in liquefiable ground. A seismic design of earth retaining structures.

References:

1. C.L. Kramer, Geotechnical Earthquake Engineering, Prentice Hall, New Jersey, 1996.
2. W.F. Chen and G.Y. Baladi, Soil Plasticity: Theory and Implementations, Elsevier Amsterdam, 1985.

3. J.P. Wolf, Foundation Vibration Analysis using Simple Physical Modes, PTR Prentice Hall Inc., Eaglewood Cliffs, New Jersey, 1994.

CODE	E-II: Ground Improvement Techniques
CE 1530	3 – 0 - 0 : 3 Credits

Introduction, Economic considerations, Consolidation by preloading and sand drains; strengthening by granular columns, Stone columns; lime columns; Compaction by vibrofloatation, blasting and dynamic consolidation; Improvement of deep strata of fine soils by vacuum dewatering, electroosmosis, ground freezing and thermal stabilization; Grouting techniques and principles. Reinforced earth and applications of geosynthetics; retaining walls, slopes, roads, erosion. Ground anchors and soil nailing; Problems and case histories

References:

1. Bowels, J. E., Foundation Analysis and Design, McGraw-Hill International Edition, Singapore, 1997.
2. Moseley, M. P., Ground Improvement, Blackie Academic & Professional, Boca Raton, Florida, USA, 1993.
3. Hausmann, M. R., Engineering Principles of Ground Modification, McGraw-Hill International Editions, 1990.
4. Yonekura, R., Terashi, M. and Shibazaki, M. (Ed), Grouting and Deep Mixing, A.A. Balkema, Rotterdam, The Netherlands, 1966.
5. Xanthakos, P. P., Abramson, L. W. and Bruce, D. A., Ground Control and Improvement, John Wiley & Sons, New York, USA, 1994.

CODE	E-II: Design and Construction of Rural Roads
CE 4547	3 – 0 - 0 : 3 Credits

Introduction about Rural Roads and Planning and Alignment: Importance of Rural roads, Classification of rural roads, Terrain classification, Socio-economic impact of rural roads. Data base for master plan, Concept of network planning, Rural Roads plan, Road alignment, Governing factors for route selection, Factors controlling alignment, Special considerations while aligning hill roads, Surveys, Detailed project report, Environmental issues.

Geometric Design and Road Materials: Introduction, Design speed, Basic principles of geometric design, Elements, Horizontal and vertical alignment, Alignment compatibility, Lateral and vertical clearances. General, Soil and material surveys, Soil as road construction material, Aggregates for pavement courses, Materials for bituminous construction, Materials for semi-rigid and rigid pavement, Materials for special pavements Climatic suitability of concrete materials

Pavement Design, Specifications and Construction of Rural Roads: Introduction, Design parameters, Pavement components, Design of flexible pavement, Design of semi-rigid pavement, Design of rigid pavement, Drainage and Shoulders. General, Selection of construction materials and methodology, Earthwork, Sub-base, Base course, Bituminous constructions, Semi-rigid pavement construction, Concrete pavements, Equipment required for different operations.

Use of Waste Materials in Rural Road Construction and Quality Control Tests & Maintenance: Introduction, Significance of green roads, Fly ash for road construction, Iron & steel and copper slags, Recycled concrete aggregate, Other waste materials. General, Pre-requisite, Specifications and codes of practice, Quality control tests during construction. Distresses/defects in pavements, Types of maintenance, Classification of maintenance activities, Maintenance norms of maintenance cost.

References:

1. IRC: SP 20-2002 “Rural Roads Manual”.
2. Guidelines for the design of flexible pavements for low volume rural roads, IRC: SP: 72-2007
3. Geometric design standards for Rural (Non-Urban) Highways, IRC: 73-1980.
4. Guidelines for quality systems for road construction, IRC: SP: 57-2000.

Department of Civil Engineering
Curriculum for M. Tech. in Water Resources Engineering (WRE)

1st SEM

Sl. No.	Subject Code	Subject	Type	L	T	P	Credit
1	CE 5501	Applied Hydrology	Core	3	0	0	3
2	CE 5502	Advanced Hydraulics	Core	3	0	0	3
3	CE 5503	Unsteady Open Channel Flow	Core	3	0	0	3
4	CE 5504	Computational Methods in Water Resources Engineering	Core	2	2	0	4
5	CE 5505	Water Resources Engineering Lab	Core	0	0	2	2
6	CE 5530 CE 5531 CE 5532 CE 5533	i) Application of Remote Sensing and GIS in WRE (No syllabi) ii) Economics of Water Resources Planning (No syllabi) iii) Watershed Management iv) Flood Control and Drainage Engineering	**Elective - I**	2 3 3 3	0 0 0 0	1 0 0 0	3 3 3 3
						Total Credit	18

CE 5501	APPLIED HYDROLOGY	L	T	P	C
		3	0	0	3
COURSE OUTCOMES					
At the end of the course, the student will be able to					
CO-1	Understand various hydrological processes, classification of hydrological models. They would be in a position to apply fundamental equations in solving hydrological problems.				
CO-2	Apply infiltration equations in estimating water percolation under different scenarios.				
CO-3	Understand unit hydrograph principle and apply such techniques in prediction of runoff.				
CO-4	The student is exposed to the application of statistical principles in hydrological problems.				
	Apply the principles of flood frequency techniques in estimating floods				

Physical processes in hydrology; hydrologic cycle, systems concept, hydrologic model classification; Reynold's Transport Theorem (RTT), continuity, momentum, and energy equations.

Soil moisture, porosity, saturated and unsaturated flow; Richards' equation, infiltration models; Horton's, Philip's, and Green Ampt methods, parameter estimation, ponding time concepts

Effective Rainfall, Runoff, Direct Runoff Hydrograph, Hydrograph Analysis, unit hydrograph theory and its applications; Hortonian and saturation overland flow; SCS method, overland and channel flow modeling, time area concepts, and stream networks.

Application of statistical methods in hydrology; Frequency analysis, flood routing models

References:

1. Chow, V.T., Maidment, D.R. and Mays, L.W. (2010*),"Applied Hydrology*", Tata McGraw Hill Edition

2. Warren Viessman, Jr. and G L Lewis, (2008*), "Introduction to Hydrology",* Prentice Hall India Pvt.
Ltd., New Delhi

3. McCuen R.H. (2005), *Hydrologic Analysis and Design*", Prentice Hall Inc. N York.

M.Tech Semester 1 **L-T-P-C**

3-0-0-3

<u>Advanced hydraulics (CE 5502)</u>

Dimensional analysis, equation of continuity, motion and energy, irrotational flow, laminar flow, turbulent flow, boundary layer theory, drag and lift on immersed bodies.

CE 5503	UNSTEADY OPEN CHANNEL FLOW	L	T	P	C
		3	0	0	3

COURSE OUTCOMES	
At the end of the course, the student will be able to	
CO-1	Solve uniform and non-uniform flow problems in open channel flows.
CO-2	Analyze and Solve Gradually Varied Flow (GVF)and Rapidly Varied Flow (RVF) problems.
CO-3	Understand basic concepts of Gradually Varied Unsteady Flow (GVUF) and Surges
CO-4	Design channels in mobile bed boundary conditions.

UNIT-1

Introduction to Open Channel Flow – Types of flows – Velocity and Pressure Distribution – Equation of continuity – Energy equation – Momentum equation.

UNIT-2

Energy-Depth relationship – Specific energy – Critical depth – Calculation of critical depth – Section factor – Computations.

UNIT-3

Uniform flow – Chezy equation – Darcy-Weisbach friction factor f – Manning's formula – Other resistance formulae – Velocity and Shear stress distribution – Uniform flow computations – Hydraulically efficient channel sections.

UNIT-4

Gradually varied flow – Differential equation of a GVF – Classification of flow profiles – Features of flow profiles – Control sections – Analysis of flow profiles.

UNIT-5

Rapidly varied flow – Momentum equation for jump formulation – Hydraulic jump is a horizontal rectangular channel – Jumps in horizontal non rectangular channels – Use of jump as an energy dissipator – Location of jump.

UNIT-6

Unsteady flows – Introduction to Gradually varied unsteady flow (GVUF) and Rapidly varied unsteady flow, Review of basic equations; 2 D Shallow water flow equations: Boussinesq equations, Finite - difference solutions: explicit and implicit methods; Supercritical flow computation; Sediment routing models.

UNIT-7

Mobile bed channel hydraulics – Introduction – Sediment properties – Initiation of motion of sediment – Bed forms – Sediment load – Design of stable channels carrying clear water – Regime channels – Scour.

COURSE OUTCOME – PROGRAM OUTCOME MAPPING										
Course – UNSTEADY OPEN CHANNEL FLOW										
CO/ PO	a	b	c	d	e	f	g	h	i	j
CO-1	√		√				√			√
CO-2	√		√		√		√			√
CO-3	√		√		√		√		√	√
CO-4	√		√		√		√		√	√

References:

1. Chow, V.T., Maidment, D.R. and Mays, L.W. (2010*),"Applied Hydrology*", Tata McGraw Hill Edition
2. Warren Viessman, Jr. and G L Lewis, (2008*), "Introduction to Hydrology",* Prentice Hall India Pvt.
Ltd., New Delhi
3. McCuen R.H. (2005), *Hydrologic Analysis and Design*", Prentice Hall Inc. N York.
4. K.Subrahmanya, *Open Channel Flow*, TMH

CE 5504 **Computer Methods in Water Resources Engineering** L-T-P-C: 2-2-0-4

M.Tech-1st Sem (WRE)

Numerical Methods and solution techniques. Modelling concepts and overview of computer models for: Surface and subsurface water systems, irrigation engineering and managements, coastal engineering. Practical applications and exercise on selected computer models.

CO1: Develop skill of formulation and writing computer programme in different platform.

CO2: To develop skills in formulating mathematical model for water Resources Problems.

CO3: Identify and apply specific computational models for specific water resources problems.

CE 5505	WATER RESOURCES ENGINEERING LAB	L	T	P	C
		0	0	2	2

COURSE OUTCOMES	
At the end of the course, the student will be able to	
CO-1	Understand Rainfall-Runoff relationships using Rainfall Simulator.
CO-2	Determine velocity of a river flow.
CO-3	Study various open channel flow conditions such as Critical flow, Gradually varied flow and Rapidly varied flow.
CO-4	Study characteristics and features of well hydraulics.

List of Experiments

1. Rainfall – Runoff relationships (Storm Hydrograph) using Rainfall Simulator.
2. Estimation of soil loss in a watershed using Rainfall Simulator.
3. Water abstraction from a well in an unconfined aquifer using Rainfall Simulator.
4. Water abstraction from a well in a confined aquifer using Rainfall Simulator.
5. Computation of critical flow condition in a fixed bed flume.
6. Computation of critical flow condition in a tilting bed flume.
7. Variation of flow with different depths in a fixed bed flume.
8. Variation of flow with different depths in a tilting bed flume.
9. Study of hydraulic jump in a fixed bed flume.
10. Study of hydraulic jump in a tilting bed flume.
11. Determination of Manning's and Chezy's coefficients of roughness.

COURSE OUTCOME – PROGRAM OUTCOME MAPPING

Course – WATER RESOURCES ENGINEERING LAB

CO/ PO	a	b	c	d	e	f	g	h	i	j
CO-1	√		√			√			√	√
CO-2	√		√			√			√	√
CO-3	√		√			√			√	√
CO-4	√		√			√			√	√

Course Title	**Application of Remote**	Course Code	

CE 5532	WATERSHED MANAGEMENT	L	T	P	C
		3	0	0	3

	Sensing and GIS in WRE	5530				
Contact hours	**3 Lectures per week**	Credit	L	T	P	C
			3	**0**	**0**	**3**
Core/Elective	**Elective**	Course Offered to	**M.Tech (WRE)**			
Course Prerequisite	**--**	Semester	**1st sem**			
Course coordinator	Dr. Prashanth J.					
Text Books	1. Anji Reddy M., "Textbook of Remote Sensing and Geographical Information Systems", BS Publications, 2006. 2. Demers, Michael N., "Fundamentals of Geographic Information System", 2nd Ed. Wiley. 2008.					
Reference Books	1. Lillesand. T. M. and Kiefer. R. W, "Remote Sensing and Image interpretation", 6th Edition, John Wiley & Sons, 2000. 2. Ghosh, S.K. and Chandra, A.M., "Remote Sensing and GIS", Narosa Publishing House. 2008.					
CO	After successful completion of this course, the students will be able to, 1. Develop basic knowledge about remote sensing and GIS 2. Know about various satellites launch programs and understanding their technical details 3. Analyze and rectify the errors in an image using various techniques. 4. Application of remote sensing data in solving various societal problems using GIS.					

Syllabus

Topic	CO
Remote sensing and basic principles – Introduction, Components of remote sensing, energy source and its characteristics, atmospheric interaction, types of remote sensing.	1
Platforms and sensors – Introduction, satellite system parameters, sensor parameters, sensor systems, Radar technology.	1, 2
Image interpretation – Visual techniques, Types of Pictoral Data Products, General procedure for photo interpretation, Basic elements of Image Interpretation, Key Elements of Visual Image Interpretation. Digital Techniques – Basic Characteristics of Digital Image, Preprocessing, Image Enhancement, Image classification and GIS.	1, 3
GIS – Introduction to Geographic Information system, Terminology, GIS Architecture, Raster and vector-based GIS	1, 4
GIS Applications – Land use/land cover, Classification, NDVI, DEM	2, 3, 4

COURSE OUTCOMES	
At the end of the course, the student will be able to	
CO-1	Appreciate the significance of Watershed Management.
CO-2	Understand the various statistical methods in hydrology.
CO-3	Calculate peak discharge in a watershed using SCS-CN Method
CO-4	Determine the volume and rate of sediment transport.

UNIT-1

Introduction to Watershed Management – Introduction to Watershed Management – Hydrology – Hydrologic cycle – Hydrologic design – Analysis vs. Synthesis – Hydrologic budget- Problems

UNIT-2

Statistical Methods in Hydrology –Statistical terminology – Characteristics of a Sample or Distribution Function – Hypothesis testing – Regression analysis – Stepwise Regression – Analysis of Nonlinear equations - Problems

UNIT-3

Watershed Characteristics –Watershed delineation – Drainage area – Linear measurements – Basin shape – Watershed relief – Descriptors of the drainage pattern – Uniform flow computation – Time parameters – Land cover and use – Problems.

UNIT-4

Peak Discharge Analysis and Design –Historical review – Rational Method – The SCS Rainfall-Runoff Depth Relation – Estimating Runoff Curve Numbers – Estimating runoff volumes – SCS Graphical Peak Discharge Method – Single Return-Period equations – Problems.

UNIT-5

Reservoir Routing –The routing equation – Derivation of a Stage-Storage-Discharge Relationship – Storage-Indication routing – Modified Puls Routing Method – Design Procedure – Problems.

UNIT-6

Erosion and Sedimentation – Introduction to Sediment transport - Physical processes in erosion and sedimentation – Channel stability – Splash erosion – Sheet erosion – Erosion in gullies – Suspended sediment transport – Estimating bedload transport – Tractive force approach to stable channel design – Estimating sediment yield – Problems.

UNIT-7

Watershed Modeling – SCS Watershed Model – Calibration of simple watershed models – Application with hydrologic data.

COURSE OUTCOME – PROGRAM OUTCOME MAPPING										
Course – WATERSHED MANAGEMENT										
CO/ PO	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**
CO-1	√		√				√			√
CO-2	√		√		√		√			√
CO-3	√		√		√		√		√	√
CO-4	√		√		√		√		√	√

References

1. Ghanashyam Das, *Watershed Mangement,* PHI
2. Richard H. McCuen, *Hydrologic Analysis & Design*, PHI

CE 5533- Flood Control and Drainage Engineering (Elective-I)

L	T	P	C
3	0	0	3

Introduction to flood problems, Estimates of benefits of flood control, Estimation of design of flood, flood routing, flood forecasting, flood warning, flood mitigation, flood damage, cost-benefit analysis for a flood control project, flood plain delineation and flood hazard assessment

Design of subsurface drainage system, design of surface drainage system, water logging and salinity, water logging, causes of the drainage problems, design of leaching requirement.

M.Tech. Course Structure and Syllabus (Deptt. of CSE)

Semester 1							Semester 2					
Course No	Course Name	L	T	P	C		Course No	Course Name	L	T	P	C
CS 1501	Foundations of Computing Science	3	0	0	3		CS 1511	Advanced Database Management System	3	0	0	3
CS 1502	Advanced Algorithms & Data Structure	3	0	0	3		CS 1512	High Performance Computing	3	0	0	3
CS 1503	Linear Optimization	3	0	0	3		CS 1513	Internet Protocol	3	0	2	4
CS 1504	Computer Systems Lab-I	0	0	3	2		CS 1514	Artificial Intelligence	3	0	0	3
CS 1510	Seminar-I	0	0	3	2		CS 1515	Computer Systems Lab-II	0	0	3	2
CS XXXX	Elective I	3	0	0	3		CS XXXX	Elective II	3	0	0	3
Total					16		Total					18
Semester 3							Semester 4					
CS 1610	Seminar-II	0	0	3	2		CS 6099	Thesis II (including 3rd sem)	0	0	14	14
CS 6099	Project	0	0	14								
Total					2		Total					14
Total Credit = 50 Credits												

Elective Courses

Course Code	Course Name	Course Code	Course Name
CS 1531	Game Theory	CS 1540	Natural Language Processing
CS 1532	Logic for Computer Science	CS 1541	Complex Networks
CS 1533	Distributed Systems	CS 1542	Foundation of Cryptography
CS 1534	Information Retrieval	CS 1543	Quantum Computing
CS 1535	Wireless Network	CS 1544	Kernel Methods
CS 1536	Graph Theory	CS 1545	Cloud Computing
CS 1537	Machine Learning	CS 1546	Cyber Physical Systems
CS 1538	Information Theory and Coding	CS 1547	Reinforcement Learning
CS 1539	Digital Image Processing and Its Applications	CS 1548	Searching in Big Data

CS1501 **Foundations of Computing Science** **3-0-0-3**

Discrete Structures - Sets, Relations and Functions; Proof Techniques, Algebraic Structures, Morphisms, Posets, Lattices and Boolean Algebras.

Logic - Propositional calculus and Predicate Calculus, Satisfiabiliy and validity, Notions of soundness and completeness

Languages & Automata Theory - Chomsky Hierarchy of Grammars and the corresponding acceptors, Turing Machines, Recursive and Recursively Enumerable Languages; Operations on Languages, closures with respect to the operations.

Computability - Church-Turing Thesis, Decision Problems, Decidability and Undecidability, Halting Problem of Turing Machines; Problem reduction (Turing and mapping reduction).

Computational Complexity -- Time Complexity -- Measuring Complexity, The class P, The class NP, NP-Completeness, Reduction, co-NP, Polynomial Hierarchy. Space Complexity -- Savich's Theorem, The class PSPACE.

Text Books:

1. J.P. Trembley and R. Manohar -- Discrete Mathematical Structures with Applications to Computer Science, McGraw Hill Book Co.,
2. Michael Sipser -- Introduction to the Theory of Computation, Thomson Course Technology.
3. John E. Hopcroft and J. D. Ullman -- Introduction to Automata Theory, Languages and Computation, Narosa Pub. House, N. Delhi.
4. H.R. Lewis and C. H. Papadimitrou -- Elements of the Theory of Computation, Prentice Hall, International, Inc.

CS1502 **Advanced Algorithms & Data Structure** **3-0-0-3**

Priority queue, Binomial, Fibonacci, and Pairing Heaps, Double-Ended Priority Queues, Hash tables, Balanced Binary Search trees, Splay trees, Randomized Dictionary Structures Multidimensional Spatial Data Structures, Quad trees and Octrees, Binary Space Partitioning Trees, R-trees, Tries, Suffix Trees and Suffix Arrays, PQ Trees, Application of data structure in Information retrieval, data mining, image processing.

Text Books:

1. Handbook of Data Structures and Applications – Sahni S. (CRC Press)
2. Introduction to Algorithms – Cormen T. H., Leiserson C. E., Rivest R. L., Stein C. (MIT Press)
3. Algorithm Design – Kleinberg J., Tardos E. (Addison Wesley)

CS1503 **Linear Optimization** **3-0-0-3**

Vector Spaces: bases, echelon forms, rank and determinants. Gauss elimination and its complexity, Inner products, Gram- Schmidt orthogonalization. Linear transformations. Optimization: Modeling and formulation of optimization problems. Linear costs and convex domains. Mean-square (distance) minimizations. Linear programming and the Simplex algorithm. Duality and the primal dual method. Examples from combinatorial optimization. Shortest paths, network flows and matchings. Approximation and randomized algorithms. Matrix Games.

Text Books:

1. Combinatiorial Optimization – C. Papadimitriou and K. Steiglitz (PHI)
2. Linear Algebra and its Applications – Gibert Strang. (Harcourt Brace)
3. Linear Programming and Applications – V. Chvatal

CS1504 **Computer Systems Laboratory - I** **0-0-3-2**

Object-oriented programming concepts and implementation of abstract data types. Implementation of graph algorithms. Linear programming with applications. Basics of OS programming - process creation and synchronization, shared memory and semaphore, shell programming.

CS1511 **Advanced Database Management System** **3-0-0-3**

Measures of query costs, selection operation, sorting, join operation, evaluation of expressions

Query optimization: Translation of SQL queries to relational algebra, heuristic approach and cost based optimization, Serializibility, locking, system log, undoing and redoing, Extended entity relationship model and object model, object oriented databases, Object relational and extended relational databases, Parallel and distributed databases, XML and Internet database, Active database.

Text Books:

1. Database Management Systems – Ramakrishnan R., Gehrke J. (McGraw-Hill)
2. Database Management Systems – Silberschatz, A., Korth H. F., Sudarshan S. (McGraw)
3. Fundamentals of Database Systems – Elmasri R., Navathe S. B. (Addison-Wesley)
4. Database : Principles, Programming, Performance – ONeil P. (Morgan Kaufmann)
5. Database Modeling & Design – Theorey T. J. (Morgan Kaufmann)

CS1512 **High Performance Computing** **3-0-0-3**

Introduction: review of basic computer architecture, quantitative techniques in computer design, measuring and reporting performance. CISC and RISC processors. Pipelining: Basic concepts, instruction and arithmetic pipeline, data hazards, control hazards, and structural hazards, techniques for handling hazards. Exception handling. Pipeline optimization techniques. Compiler techniques for improving performance. Hierarchical memory technology: Inclusion, Coherence and locality properties; Cache memory organizations, Techniques for reducing cache misses; Virtual memory organization, mapping and management techniques, memory replacement policies. Instruction-level parallelism: basic concepts, techniques for increasing ILP, superscalar, super-pipelined and VLIW processor architectures. Array and vector processors. Multiprocessor architecture: taxonomy of parallel architectures. Centralized shared-memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared-memory architecture. Cluster computers. Non von Neumann architectures: data flow computers, reduction computer architectures, systolic architectures.

Text Books:

1. Database Management Systems – Ramakrishnan R., Gehrke J. (McGraw-Hill)
2. Database Management Systems – Silberschatz, A., Korth H. F., Sudarshan S. (McGraw)
3. Fundamentals of Database Systems – Elmasri R., Navathe S. B. (Addison-Wesley)
4. Database : Principles, Programming, Performance – ONeil P. (Morgan Kaufmann)
5. Database Modeling & Design – Theorey T. J. (Morgan Kaufmann)

CS1513 **Internet Protocol** **3-0-2-4**

Overview of IPv4, TCP, IPv6, ICMP, ARP, DHCP; Routing Protocols: OSPF, RIP, BGP, Ad hoc network routing (AODV, DSR); IP Security: NAT, IPSEC, Socks, SSL; Quality of Service related protocols: Intserv, Diffserv, Queuing techniques (WFQ, RED, etc.); Multi-Protocol Label Switching (MPLS) and GMPLS; Virtual Private Network (VPN) Protocols: L2TP, PPTP; Overview of Application Layer Protocols: DNS, LDAP, SMTP, POP3, IMAP4, SNMP; Voice over IP Protocols (VOIP) and videoconferencing: SIP, H323. Server Load Balancing Techniques.

Text Books:

1. TCP/IP Guide – Charles. M. Kozierek (Shroff Publishers)
2. MPLS and Label Switching Networks – Uyless Black (Pearson Education)
3. Adolfo Rodriguez et. al, TCP/IP Tutorial and Technical Overview, IBM Redbook

CS1514 **Artificial Intelligence** **3-0-0-3**

Introduction, problems and techniques related to artificial intelligence, Problem spaces and search, state space graph, production systems BFS and DFS, Introduction to heuristic search, hill climbing, best first search, A* algorithm, admissibility, AND/OR graph – AO*, Predicate logic, rule-based systems, forward vs backward reasoning, non-monotonic reasoning, statistical reasoning, Dempster Shafer theory, Min-Max search, Alpha-Beta cut-offs, Case studies: MYCIN, R1

Text Books:

1. Artificial Intelligence – Rich, Knight (TMH)
2. Principles of Artificial Intelligence – Nilson N. J. (Narosa)
3. Paradigms of AI programming – Norvig P. (Elsevier)
4. Introduction to Expert System – Jackson P. (Addison-Wesley)

CS1515 **Computer Systems Laboratory - II** **0-0-3-2**

Socket programming, database creation and update, building large client server applications. Basics of compiler writing using *lex* and *yacc*.

CS1531 **Game Theory** **3-0-0-3**

Games and equilibria, two player Zero-Sum Games, proof of Nash Equilibria, complexity of finding Nash equilibria, information, strategies, dynamic and repeated games, bargaining, auctions, market equilibria, algorithmic mechanism design, inefficiency of equilibria, routing games, load balancing games.

Text Books:

1. Algorithmic Game Theory – N. Nisan, T. Roughgarden, V. Vazirani and E. Tardos (Cambridge University Press)
2. Games and Information: An Introduction to Game Theory– E. Rasmusen (Wiley)
3. A Course in Gam Theory– M. J. Osborne and A. Rubinstein (MIT Press)
4. Auction theory - V. Krishna (Elsevier)

CS1532 **Logic for Computer Science** **3-0-0-3**

Axiomatic Theory: Propositional Calculus, Predicate Calculus, First Order Theories, Peano Arithmetic. Decision Procedures in First Order Logic: Resolution Theorem Provers: some theoretical issues. Modal Logic, Temporal Logic: their applications, Model Checking. Model Theory, Proof Theory. mu Calculus, Lambda Calculus, Non-monotonic Reasoning, Intuitionistic First Order Logic, Fuzzy Logic.

Text Books:

1. Logic for Applications– N. Nisan, A. Nerode and R. A. Shore (Springer)
2. First-order Logic and Automated Theorem Proving– M. Fitting (Springer)
3. Mathematical Logic for Computer Science – Ben-Ari M. (Springer)
4. Logic for Computer Science: Foundations of Automatic Theorem Proving- J. H. Gallier (Willey)

CS 1533 **Distributed Systems** **3-0-0-3**

Introduction: Concepts of distributed system and its general architecture, basic design issues in distributed system

Naming: Naming of entities and concept of name space, name space implementation, locating mobile entities

Process Management: Basic concepts of process and thread, threads in distributed system, code migration and its models, migration in heterogeneous environment, Introduction to RPC and RMI

Synchronization: Basic synchronization techniques, physical and logical clocks, clock synchronization algorithms, global state, election algorithms

Distributed mutual exclusion: Requirements, types and models of mutual Exclusion algorithms, discussion on mutual exclusion algorithms

Distributed deadlock handling: Introduction to deadlock, deadlock prevention and avoidance techniques, deadlock detection/ resolution algorithms

Agreement protocols: Basic concept of agreement protocols, different agreement problems, Byzantine agreement problem, Consensus problem, relations among agreement problems, solution to Byzantine agreement problem, application of agreement algorithm

Text Books:

1. Distributed Systems: Concepts and Design – Coulouris G., Dollimore J., Kindberg T. (Pearson)
2. Advanced Concepts in Operating System – Singhal M., Shivaratri N. G. (TMH)
3. Distributed Systems: Principles and Paradigms – Tanenbaum A. S., Steen M. V. (Pearson Ed)
4. Distributed Operating System – Sinha P. K. (PHI)
5. Distributed Operating Systems – Tanenbaum A. S. (Pearson Ed)

CS 1534 **Information Retrieval** **3-0-0-3**

Introduction: Principles of Information Retrieval, Indexing, Zipfs Law, Search. Vector space model, cosine similarity. Scoring techniques. Stemming, Stop words, Query expansion, Rochhio. Probabilistic models language. Relevance feedback. Evaluation: Precision, recall, f-measure. TREC Text classification, clustering, query routing. Advanced topics like summarization and question answering.

Text Books:

1. Introduction to Information Retrieval – P Raghavan, M Manning and P Schutze (Kluwer)

CS 1535 **Wireless Network** **3-0-0-3**

Introduction to wireless communication systems and networks

Wireless technologies: Cellular wireless networks and systems principles, antennas and radio propagation, signal encoding and modulation techniques, spread spectrum, coding and error control

Wireless Networking: Multiple access techniques, Mobile IP and WAP, Wireless systems and standards

Wireless LANs: Wireless LAN technology, Wireless standard (IEEE 802.11 etc.), Ad-hoc Networks, Bluetooth.

Text Books:

1. Wireless Communications: Principles & Practice – Rappaport T. S. (Pearson Ed)
2. Wireless Communications and Networks – Stallings W. (Pearson Ed)

CS 1536 **Graph Theory** **3-0-0-3**

Introduction to graphs and their representation, finite and infinite graphs, incidence and degree, path

Directed graph, single source shortest path, all pair shortest path, directed acyclic graph, Euler's graphs, Hamiltonian paths and circuits

Basic results of trees, minimum cost spanning tree

Introduction to cut-sets and cut-vertices, connectivity and separability

Basic concepts of vector space of graph, sets with one or two operations, basis vector, circuit and cut-set subspaces, orthogonal vectors and spaces

Matrix representation of graph, incidence matrix, circuit matrix, path matrix, cut-set matrix and adjacency matrix.

Text Books:

1. Graph theory with applications to engineering and computer science – Deo N. (PHI)
2. Introduction to Algorithms – Cormen T. H., Leiserson C. E., Rivest R. L., Stein C. (PHI)
3. Algorithmic graph theory – Gibbons A. (Cambridge Univ. Press)
4. Schaum's outline of theory and problems of Graph theory – Balakrishnan V.K. (TMH)
5. Fundamentals of Data Structures – Horowitz E., Sahni S. (Galgotia Pub.)
6. Handbook of Graph Theory – Gross J. L., Yellen J. (CRC Press)

CS 1537 **Machine Learning** **3-0-0-3**

Introduction, Decision Trees, Probability Primer, Bayes Decision Theory, Maximum-likelihood and Bayesian Parameter Estimation, Non-parametric Techniques, Bayes Networks, Optimization Primer, Linear Discriminant Functions, Support Vector Machines, Unsupervised Learning, Semi Supervised Learning, Reinforcement Learning.

Text Books:

1. Machine Learning – Mitchell T. M. (McGraw Hill)
2. Pattern Classification – Duda R. O., Hart P. E., Strok D. G. (Wiley Interscience)

CS 1538 **Information Theory and Coding** **3-0-0-3**

Introduction: Concept of entropy and mutual information, application of entropy in feature extraction

Entropy in stochastic processes: Entropy rates, markov chains, Hidden Markov models

Data Compression: Kraft inequality and optimal coding, Huffman codes and optimality, Shanon-Fano-Elias coding, Arithmetic codes

Channel capacity and Coding: Different channel models, concept of channel capacity, channel coding theorem, Fano's inequality, Huffman codes, channel capacity theorem, Shanon's limit, Random selection of codes, noiseless coding

Error control codes: Concept of Linear block codes, cyclic codes, BCH codes, RS codes, Convolution codes

Error correcting techniques: Short-random-error correction by error-trapping, burst-error correction for block codes

Coding and Digital Modulation: Trellis coded modulation.

Text Books:

1. Elements of Information Theory – Cover T. M., Thomas J. A. (Wiley)
2. Information Theory, Coding and Cryptography – Bose R. (TMH)
3. Introduction to Coding and Information Theory – Roman S. (Springer)
4. Error Control Coding for Data Network – Reed I. S., Chen X. (Kluwer)
5. The Mathematics of Coding Theory – Garret P. (Pearson)

CS 1539 | **Digital Image Processing and Its Applications** | **3-0-0-3**

Introduction: Steps in Digital Image Processing – Image sampling and Quantization – Basic relationships between pixels – Color Fundamentals – File Formats – Image Transforms: DFT, DCT, Haar, SVD and KL-Introduction to Matlab Toolbox

Image Enhancement: Spatial Domain: Gray level transformations – Histogram processing – Basics of Spatial Filtering–Smoothing and Sharpening Spatial Filtering – Fuzzy set for spatial filters - Frequency Domain: convolution and correlation - Introduction to Fourier Transform - Other Separable Image Transforms, Walsh-Hadamard and K-L transform– Smoothing and Sharpening frequency domain filters – Ideal, Butterworth and Gaussian filters, Enhancement by point processing, Generation of Spatial Masks from Frequency Domain Specifications.

Image Restoring and segmentation: Noise models – Mean Filters – Order Statistics – Adaptive filters – Band reject Filters – Band pass Filters – Notch Filters – Optimum Notch Filtering – Inverse Filtering – Formulation, Removal of Blur Caused by Uniform Linear Motion - Wiener filtering Segmentation: Detection of Discontinuities–Edge Linking and Boundary detection – Region based segmentation-Morphological processing- erosion and dilation – Morphological Water sheds – Description: Boundary descriptors, Regional Descriptors.

Wavelets and Image compression: Wavelets – Sub-band coding – Multiresolution expansions – Fast Wavelet Transforms – lifting scheme– Compression: Fundamentals – Image Compression models – Error Free Compression – Variable Length Coding – Bit-Plane Coding – Lossless Predictive Coding – Lossy Compression – Lossy Predictive Coding – Compression Standards.

Applications: Image classification, Object recognition, Image fusion, Steganography – Current Trends: Color Image Processing, Wavelets in Image Processing, Medical Image Processing – Case studies

Text Books:

1. Digital Image Processing – R. C. Gonzalez, R. E. Woods. (Pearson Education)
2. Fundamentals of Digital Image Processing – Anil K. Jain (Prentice-Hall India)

CS 1540 **Natural Language Processing** **3-0-0-3**

Introduction, Regular Expressions, Text Normalization, Edit Distance, N-gram Language Models, Ambiguity, Naive Bayes and Sentiment Classification, Vector Semantics, Neural Networks and Neural Language Models, RNN, LSTM, GRU, Part-of-Speech Tagging, HMM, Maximum Entropy, CRF, Sequence Processing with Recurrent Networks, Formal Grammars of English, Treebanks as Grammars, Syntactic Parsing, Statistical Parsing, PCFG, Dependency Parsing, The Representation of Sentence Meaning, WSD, Information Extraction, Semantic Role Labeling, Lexicons for Sentiment, Discourse Coherence, Machine Translation, Question Answering, Dialog Systems and Chatbots, Speech Recognition and Synthesis

Text Books:

1. Speech and Language Processing – Jurafsky D., Martin J. H. (Prentice Hall)
2. Foundations of Statistical Natural Language Processing – Manning C., Schütze H. (MIT Press)

CS 1541 **Complex Networks** **3-0-0-3**

Types of network: Social networks, Information networks, Technological networks, Biological networks.

Properties of network: Small world effect, transitivity and clustering, degree distribution, scale free networks, maximum degree; network resilience; mixing patterns; degree correlations; community structures; network navigation.

Random Graphs: Poisson random graphs, generalized random graphs, the configuration model, power-law degree distribution, directed graph, bipartite graph, degree correlations.

Models of network growth: Price's model, Barabasi and Albert's model, other growth models, vertex copying models.

Processes taking place on networks: Percolation theory and network resilience, Epidemiological processes.

Applications: Search on networks, exhaustive network search, guided network search, network navigation; network visualization.

Text Books:

1. Evolution of Networks – S. N. Dorogovtsev and J. F. F. Mendes (Oxford Press)
2. The structure and dynamics of networks – M. Newman, A-L Barabasi, D. J. Watts (Princeton)

CS 1542 **Foundation of Cryptography** **3-0-0-3**

Introduction to Cryptography: Basics of Symmetric Key Cryptography, Basics of Asymmetric Key Cryptography, Hardness of Functions

Notions of Semantic Security (SS) and Message Indistinguishability (MI): Proof of Equivalence of SS and MI, Hard Core Predicate, Trap-door permutation, Goldwasser-Micali Encryption

Goldreich-Levin Theorem: Relation between Hardcore Predicates and Trap-door permutations

Formal Notions of Attacks: Attacks under Message Indistinguishability: Chosen Plaintext Attack (IND-CPA), Chosen Ciphertext Attacks (IND-CCA1 and IND-CCA2), Attacks under Message Non-malleability: NM-CPA and NM-CCA2, Inter-relations among the attack model

Random Oracles: Provable Security and asymmetric cryptography, hash functions, Weak and Strong one way functions

Pseudo-random Generators (PRG): Blum-Micali-Yao Construction, Constructionof more powerful PRG, Relation between One-way functions and PRG, Pseudo-random Functions (PRF)

Building a Pseudorandom Permutation: The Luby Rackoff Construction: Formal Definition, Application of the Luby Rackoff Construction to the construction of Block Ciphers, The DES in the light of Luby Rackoff Construction

Message Authentication Codes (MACs): Formal Definition of Weak and Strong MACs, Using a PRF as a MAC, Variable length MAC

Public Key Signature Schemes: Formal Definitions, Signing and Verification, Formal Proofs of Security of Full Domain Hashing

Assumptions for Public Key Signature Schemes: One way functions Imply Secure One-time Signatures

Shamir's Secret Sharing Scheme, Formally Analyzing Cryptographic Protocols, Zero Knowledge Proofs and Protocols.

Text Books:

1. Introduction to Cryptography: Principles and Applications – Hans Delfs and Helmut Knebl (Springer)
2. Modern Cryptography, Theory and Practice – Wenbo Mao (Pearson Ed)
3. Foundations of Cryptography, Part 1 & 2 – Oded Goldreich (CRC)

CS 1543 **Quantum Computing** **3-0-0-3**

Introduction to Quantum Computation: Quantum bits, Bloch sphere representation of a qubit, multiple qubits.

Background Mathematics and Physics: Hilber space, Probabilities and measurements, entanglement, density operators and correlation, basics of quantum mechanics, Measurements in bases other than computational basis.

Quantum Circuits: single qubit gates, multiple qubit gates, design of quantum circuits

Quantum Information and Cryptography: Comparison between classical and quantum information theory. Bell states. Quantum teleportation. Quantum Cryptography, no cloning theorem

Quantum Algorithms: Classical computation on quantum computers. Relationship between quantum and classical complexity classes. Deutsch's algorithm, Deutsch's-Jozsa algorithm, Shor factorization, Grover search

Noise and error correction: Graph states and codes, Quantum error correction, fault-tolerant computation

Text Books:

1. Quantum Computation and Quantum Information – M. A. Nielsen & I. L. Chiang (Cambridge)
2. Explorations in Quantum Computing – Colin P. Williams (Springer)
3. Quantum Computing: A Gentle Introduction – Eleanor G. Rieffel and Wolfgang H. Polak (MIT)
4. An Introduction to Quantum Computing Algorithms – A. O. Pittenger (Springer)

CS 1544 **Kernel Methods** **3-0-0-3**

Introduction: Data representation, similarity, statistical learning theory, hyper-plane classifiers, support vector classification, support vector regression, kernel principal component analysis

Kernels: Product features, representation of similarities in linear spaces, examples and properties of kernels

Risk and loss functions: Loss functions, test error, expected risk, statistical perspective, robust estimators

Regularization: Regularized risk functional, representer theorem, regularization operators, translation invariant kernels, dot product kernels

Support vector machines: Separating hyper-planes, role of margin, optimal margin hyper-planes, nonlinear support vector classifiers, soft margin hyperplanes, multi-class hyper-planes

Single class problems: introduction, algorithms, optimization, theory

Regression estimation: Linear regression with insensitive loss function, dual problems, ν-SV regression

Implementation: Tricks of the trade, sparse greedy matrix approximation, subset selection methods, sequential minimal optimization, iterative methods

Designing kernels: Tricks for constructing kernels, string kernels, natural kernels.

Text Books:

1. Learning with Kernels - support vector machines, regularization, optimization and beyond – B. SchÖlkopf and A. J. Smola (MIT Press)
2. Kernel Methods for Pattern Analysis – J. Shawe-Taylor and N. Cristianini (Cambridge)
3. Introduction to Support Vector Machines – N. Cristianini and J. Shawe-Taylor (Cambridge)

CS 1545 **Cloud Computing** **3-0-0-3**

Introduction: Definition, Characteristics, Components, Cloud provider, SAAS, PAAS, IAAS and Others, Organizational scenarios of clouds, Administering & Monitoring cloud services, benefits and limitations, Deploy application over cloud, Comparison among SAAS, PAAS, IAAS

Cloud computing platforms: Infrastructure as service: Amazon EC2, Platform as Service: Google App Engine, Microsoft Azure, Utility Computing, Elastic Computing

Cloud Technologies: Study of Hypervisors, Compare SOAP and REST

Web services: SOAP and REST, SOAP versus REST, AJAX - asynchronous 'rich' interfaces, Mashups - user interface services

Virtualization: Virtual machine technology, virtualization applications in enterprises, Pitfalls of virtualization

Multitenant software: Multi-entity support, Multi-schema approach, Multi-tenancy using cloud data stores, Data access control for enterprise applications

Data in the cloud: Relational databases, Cloud filesystems - GFS and HDFS, Big Table, HBase and Dynamo

Map-Reduce and extensions: Parallel computing, The map-Reduce model, Parallel efficiency of Map-Reduce, Relational operations using Map-Reduce, Enterprise batch processing using Map-Reduce, Introduction to cloud development, Example/Application of Map reduce, Features and comparisons among GFS, HDFS etc,

Map-Reduce model Cloud security: Vulnerability assessment tool for cloud, Privacy and Security in cloud, Architectural Considerations - General Issues, Trusted Cloud computing, Secure Execution Environments and Communications, Security challenges - Virtualization security management- virtual threats, VM Security Recommendations, VM-Specific Security techniques, Secure Execution Environments and Communications in cloud

Issues: Implementing real time application over cloud platform Issues in Inter-cloud environments, QoS Issues in Cloud, Dependability, data migration, streaming in Cloud. QoS monitoring in a Cloud computing environment

Text Books:

1. Cloud Computing for Dummies – Hurwitz J., Bloor R., Kanfman M., Halper F. (Wiley India)
2. Enterprise Cloud Computing – Shroff G. (Cambridge)
3. Cloud Security – Krutz R., Vines R. D. (Wiley India)

CS 1546 **Cyber Physical Systems** **3-0-0-3**

Introduction: Cyber-Physical Systems (CPS) in the real world, Basic principles of design and validation of CPS, Industry 4.0, AutoSAR, IIOT implications

Components: CPS HW platforms - Processors, Sensors, Actuators, CPS Network – Wireless Hart, CAN, Automotive Ethernet, CPS Sw stack – RTOS, Scheduling Real Time control tasks

Automated Control Design: Dynamical Systems and Stability, Controller Design Techniques, Stability Analysis: CLFs, MLFs, stability under slow switching, Performance under Packet drop and Noise

Implementation: Features to software components, mapping software components to ECUs, Performance Analysis - effect of scheduling, bus latency, sense and actuation faults on control performance, network congestion, Control, Bus and Network Scheduling using Truetime

Safety Assurance: Automata based modeling and analysis – Introduction, Timed and Hybrid Automata, Flowpipe construction, reachability analysis

Security: Secure Task mapping and Partitioning, State estimation for attack detection, Case study - Vehicle ABS hacking, SmartGrids attack

Text Books:

1. Introduction to Embedded Systems – A Cyber Physical Systems Approach – E. A. Lee, Sanjit Seshia (MIT)
2. Principles of Cyber-Physical Systems – Rajeev Alur (MIT)
3. Logical Foundations of Cyber-Physical Systems – André Platzer (Springer)
4. High-Performance Embedded Computing: Applications in Cyber-Physical Systems and Mobile Computing – Marilyn Wolf (Elsevier)

CS 1547 **Reinforcement Learning** **3-0-0-3**

The Reinforcement Learning problem: evaluative feedback, non-associative learning, Rewards and returns, Markov Decision Processes, Value functions, optimality and approximation.

Dynamic programming: value iteration, policy iteration, asynchronous DP, generalized policy iteration.

Monte-Carlo methods: policy evaluation, roll outs, on policy and off policy learning, importance sampling.

Temporal Difference learning: TD prediction, Optimality of TD(0), SARSA, Q-learning, R-learning, Games and after states.

Eligibility traces: n-step TD prediction, TD (lambda), forward and backward views, Q (lambda), SARSA (lambda), replacing traces and accumulating traces

Function Approximation: Value prediction, gradient descent methods, linear function approximation, ANN based function approximation, lazy learning, instability issues

Policy Gradient methods: non-associative learning – REINFORCE algorithm, exact gradient methods, estimating gradients, approximate policy gradient algorithms, actor-critic methods

Text Books:

1. Reinforcement Learning: An Introduction – Sutton R S, Barto A G (MIT)
2. Reinforcement Learning: State-of-the-Art – Marco Wiering and Martijn van Otterlo (Springer)
3. Artificial Intelligence: A Modern Approach – Peter Norvig, Stuart J. Russell (Pearson Ed)
4. Deep Learning – Ian Goodfellow, Yoshua Bengio, Aaron Courville (MIT)

CS 1548 **Searching in Big Data** **3-0-0-3**

Queries: range queries, top-k queries, reverse top-k queries, multi-attribute top-k queries, top-k diversity queries, skyline queries.

Distance measures: LP norm, normalized Euclidean distance, Mahalanobis distance, KL-divergence, earth movers distance.

Memory, disk and SSD access: the dynamics of data reads based on the underlying storage architecture and how that affects the index performance. Single-dimensional index structures: B+-tree. Memory-based index structures: kd-tree, quad trees, interval trees, trie, Voronoi diagrams

Disk-based structures: R-tree, R-tree variants R+-tree and R*-tree, X-tree, SS-tree, VA-files, M-tree Index structure Vs Hashing in high-dimensional spaces

Hashing: extensible hashing, linear hashing, bloom filters, locality sensitive hashing.

Indexing and Searching non-traditional queries: multi-attribute top-k queries (Fagins algorithm, threshold algorithm, Onion), indexing skyline queries, indexing diversity queries

Dimensionality reduction: SVD, PCA, Fastmap, Lipschitz embedding Index structures and distance functions for Non-vector datasets: text Corpus, time-series datasets, graph datasets

Text Books:

1. Foundations of Multidimensional and Metric Data Structures – H Samet (Morgan Kaufmann)
2. Computational Geometry: Algorithms and Applications – de Berg, Cheong, van Krefeld, Overmars (Springer)
3. Introduction to Algorithms – Cormen T. H., Leiserson C. E., Rivest R. L., Stein C. (MIT Press)

First semester structure of MTech Programme on "Control and Industrial Automation" at EE Department, NIT Silchar w.e.f July 2019

1st Semester:

Sub Code	Subject Name	L – T - P	Credit
EE 1501	Linear control Theory	3 – 0 - 0	3
EE 1502	Industrial Automation	3 – 0 - 0	3
EE 1503	Digital Image Processing and Applications	3 – 0 - 0	3
EE 1504	Control Systems Laboratory I	0 – 0 - 4	2
EE 1510	Seminar -I	0 – 0 - 2	1
	Elective – I	3 – 0 - 0	3
	Elective - II	3 – 0 - 0	3

List of Elective – I

EE 1531	Modelling of Dynamical Systems	3 – 0 - 0	3
EE 1532	Digital Control Systems	3 – 0 - 0	3

List of Elective – II

EE 1541	Industrial Instrumentation	3 – 0 - 0	3
EE 1542	Nonlinear Dynamics and Chaos	3 – 0 - 0	3

EE 1501	Linear Control Theory	L T P C
	M. Tech in Control and Industrial Automation	3 0 0 3
	Electrical Engineering Branch	

1st Semester:

Pre-requisites: Control Systems

Course Assessment methods (both continuous and semester end assessment): It may be class tests, assignments, attendance, quiz, poster/seminar presentation on different topics including contemporary issues, mid Semester examination, surprise tests, coding and simulation, self-learning, grand viva, group discussion, mini projects, end semester examination, etc.

Topics Covered:

Linear spaces and linear operators: fields, vectors and vector spaces; linear independence, dimension of linear space; inner product of vectors, quadratic functions and definite matrices, vector and matrix norms, scalar product and norm of vector functions; range space, rank, null space and nullity of a matrix, homogeneous equation, nonhomogeneous equation; eigenvalues, eigenvectors, generalized eigenvectors, similarity transformation, Canonical form representation of linear operators, diagonal form representation of linear operator, Jordan form matrix representation of linear operator; Cayley-Hamilton theorem.

Review of time domain and frequency domain responses, analysis of time and frequency domain common tools, time and frequency domain specifications, and their relationship; design of lag-lead compensator; PID controller tuning.

Review of state space representations, controllable canonical form, observable canonical form, diagonal form; solution of vector-matrix differential equation, modal decomposition.

Concept of controllability, observability, and their significance; state feedback controller; full order and reduced order observer design; observer based state feedback controller.

Introduction to non-linear system, common differences with linear system; concept of linearization; describing function of common nonlinearities.

Lyapunov's concept of stability, asymptotically stable, uniformly asymptotically stable, uniformly asymptotically stable in the large, instability; Lyapunov function, Lyapunov's theorems, stability analysis of linear and non-linear systems using Lyapunov concept.

Phase plane analysis, classification of singular points, limit cycle and closed trajectory; stability analysis using phase plane; stability analysis using describing function.

Reference Books:

S. N.	Name of Books	Authors	Publishers
1.	Linear Systems	Thomas Kailath	Prentice Hall
2.	Control Systems – Principles and Design	Modan Gopal	Tata McGraw Hill
3.	Linear Control System – Analysis and Design – Conventional and Modern	Johm J D'Azzo, C H Houpis	McGraw Hill International Edition
4.	Modern Control System Theory	M. Gopal	New Age Int.(P) Limited
5.	Nonlinear Systems	Hassan K. Khalil	Pearson New International Edition
6.	Nonlinear Systems Analysis	M. Vidyasagar	Society for Industrial and

Applied Mathematics

Course Outcomes: At the end of this course, students are expected to learn the following:

1) Explain the fundamental concepts of linear spaces and linear operators.
2) Analyse linear systems in time and frequency domain; compare the outcome of different common tools; relate different time and frequency domain specifications with a given description of a system; use the relations between time and frequency domain specifications.
3) Identify nonlinear systems; analyse a nonlinear system using describing function and phase plane analyses.
4) Deduce the conditions of stability and comment on the nature of stability of linear and nonlinear systems.
5) Design different types of controller and observer.

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		L	T	P	C
EE 1502	**Industrial Automation**				
	M. Tech in Control and Industrial Automation	**3**	**0**	**0**	**3**
	Electrical Engineering Branch				

Introduction to industrial automation and control, architecture of industrial automation systems. Functionality of each layer with industrial relevance. Introduction to process flow of different industries. A brief introduction to sensors and measurement systems.

Introduction to process control, PID control, controller tuning, implementation of PID controllers, special control structures: feed forward control, ratio control, predictive control, control of systems with inverse Response, cascade control, overriding control, selective control, split range control.

Introduction to sequence control, PLC and relay ladder logic, sequence control: scan cycle, RLL syntax, structured design approach, IL, SFC, PLC hardware environment.

Introduction to actuators: flow control valves, hydraulic actuator systems: principles, components and symbols, pumps and motors, proportional and servo valves, introduction to pneumatic control systems: system components, actuators, and controllers.

Electric drives: Introduction, energy saving with adjustable speed drives, DC motor drives: induction motor drives, stepper motor drives.

Introduction to industrial data communication: networking of sensors, actuators and controllers, fieldbus

Measurement of temperature, pressure, force, displacement, speed, flow, level humidity, pH etc. signal conditioning and processing, estimation of errors and calibration, data acquisition.

Reference Books:

S. N.	Name of Books	Authors	Publishers
1.	Principles of Measurement Systems	J P Bentley	Pearson Education
2.	Programmable Logic Controllers – Principles and Applications	J W. Webb, Ronald A Reis	PHI
3.	Process Control Instrumentation Technology	C D Johnson	PHI
4.	Hydraulic and Pneumatic Controls	R. Srinivasan	Vijoy Nicole Imprints Private Limited
5.	Process Control – Modelling, Design, and Simulation	B E Bequette	PHI
6.	Principles of Measurement Systems	J P Bentley	Pearson Education

Course Outcomes: At the end of this course, students are expected to learn the following:

1. Identify the control and automation levels of an industry and tell the characteristics well known industrial devices used for sensors, actuators, controllers etc.

2. Justify the choice of appropriate control scheme for well-known industrial situations and design the controller to meet the requirement.

3. Design a suitable RLL program to meet a desired sequence control requirement.

4. Recognise the well-known controller, actuators in electronic, p neumatic and hydraulic form.

5. Explain the utility and operations of various power electronic devices used for industrial control applications.

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EE 1503	Digital Image Processing and Applications	L	T	P	C
	M. Tech in Control and Industrial Automation	3	0	0	3
	Electrical Engineering Branch				

Introduction to Digital image – Digital Image Fundamentals – concept of visual perception, image sensing and acquisition, image sampling and quantization, basic relationships between pixels

Image enhancement in the spatial domain – Gray level transformations, histogram processing, enhancement using arithmetic/logic operations, spatial filtering, smoothing and sharpening of spatial filters.

Image enhancement in the frequency domain – Fourier transform, smoothing and sharpening of frequency domain filters, homomorphic filtering, implementation of these filters

Image restoration - Colour Image Processing- colour models, pseudo colour image processing, basics of full colour image processing, colour transformations, smoothing, sharpening, segmentation, compression;

Image compression – compression models, Error free compression, lossy compression, image compression standards.

Wavelets and multiresolution processing – multiresolution expansions, wavelet transform in one dimension and two dimension, fast wavelet transform.

Morphological Image processing – opening and closing, hit or miss transformation, basic morphological algorithms, extension to gray scale images.

Image segmentation – detection of discontinuities, edge linking and boundary detection, thresholding, region based segmentation, segmentation by morphological watersheds, use of motion in segmentation.

Representation and description – representation, boundary descriptors, regional descriptors, use of principal component for description; Object recognition – patterns and pattern classes, recognition based on decision theoretic methods, structural methods.

Applications – In intelligent traffic control, Machine Vision, Automation, etc.

Reference Books:

S. N.	Name of Books	Authors	Publishers
1.	Digital Image Processing	R C Gonzalez & R E Woods	Prentice Hall of India
2.	Digital Image Processing	Pratt	Willey India
3.	Digital Image Processing	S Sharma	S.K.Kataria & Sons
4.	Digital Signal & Image Processing	T. Bose	Wiley Publications

Course Outcomes: At the end of this course, students are expected to learn the following:

1. Should be able to describe an image, image processing and different components of image processing
2. Should be able to define image segmentation and should be able to develop techniques for image segmentation
3. Should be able to design and develop program for image enhancement
4. Should be able to perform different transforms such as DFT, DCT, DWT, fast wavelet and principal component analysis and apply them for image compression, image quality, object recognition or for computer vision purposes.

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EE 1504	Control Systems Laboratory-I	L	T	P	C
	M. Tech in Control and Industrial Automation	0	0	4	2
	Electrical Engineering Branch				

Pre-requisites: Control Systems

Course Assessment methods (both continuous and semester end assessment): It may be class tests, assignments, attendance, quiz, poster/seminar presentation on different topics including contemporary issues, mid Semester examination, surprise tests, coding and simulation, self-learning, grand viva, group discussion, mini projects, end semester examination, etc.

List of possible experiments Control Systems Lab -I

1. Realization of a 2nd order system using R, L, and C components and analysis of its response using ELVIS Kit and PC.
2. Realization of lead and lag compensators using Op-Amps, R and C components and analysis of its response using ELVIS Kit and PC.
3. Realization of PID controllers using Op-Amps, R and C components and analysis of its response using ELVIS Kit and PC.
4. Measurement of electrical and non-electrical quantity using Technology Tutor and evaluation of characteristics of different transducers and their behavior due to variation of some parameter.
5. Temperature control loop: Study and control of temperature.
6. Liquid level control loop: Study and control of liquid level.
7. Liquid flow control loop: Study and control of liquid flow.
8. Air flow control loop: Study and control of air flow.
9. Pressure control loop: Study and control of pressure.
10. Introduction to DCS and PLC and its operation.
11. Study and position control of a magnetic levitation system.
12. Study of ball and plate control system (both 1D and 2D).
13. Speed and position control of a DC modular servo system.

14. Speed and position control of an AC modular servo system.
15. Position control of an inverted pendulum

Course Outcomes: After completion of the course students will be able to

1. Construct a 2nd order system, lag-lead compensator, and PID controller physically using R, L, C, and Op-Amps and analyze its time and frequency domain behavior.
2. Measure of electrical and non-electrical quantities and evaluate of characteristics of different transducers using available transducer kit.
3. Explain the experiments for the level, flow, temperature, position, and speed control using available setups and the controllers provided by the manufacturer.
4. Explain the experiments for level, flow, temperature, and pressure control though PLC and DCS panel.

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EE 1510 **SEMINAR-I**

L	T	P	C
0	0	2	1

Course Outcome of Seminar:

At the end of seminar course, students are expected to

(1) Prepare good slides and present a particular topic effectively.

(2) Develop team spirit and leadership qualities through group activities.

(3) Develop confidence for self-learning and overcome the fear of public presentations.

(4) Update knowledge on contemporary issues, prepare technical report and do presentations on these issues.

(5) Learn technical editing software Latex and write technical report using Latex.

Mapping of COs to POs:

Cos\POs	a	b	c	D	e	f	g	h	i	j	k
CO1							4				
CO2				5		3					3
CO3							3		3		
CO4							5			5	
CO5							3				

Correlation Index:

5	Very Highly Correlated	2	Correlated
4	Highly Correlated	2	Weakly Correlated
3	Moderately Correlated		

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Syllabus of subject under the List of Elective – I

EE 1531	Modelling of Dynamical systems	L T P C
	M. Tech in Control and Industrial Automation	3 0 0 3
	Electrical Engineering Branch	

Pre-requisites: BE/BTech in EE/ECE/Instrumentation/EEE

Course Assessment methods (both continuous and semester end assessment): It may be class tests, assignments, attendance, quiz, poster/seminar presentation on different topics including contemporary issues, mid Semester examination, surprise tests, coding and simulation, self-learning, grand viva, group discussion, mini projects, end semester examination, etc.

Topics Covered:

Introduction to system dynamics, introduction to mathematical modelling of dynamic systems, philosophy, role, significance, and limitations of modelling in control systems.

Classification of modelling: deterministic models its characterization and analysis, continuous time modelling, discrete time modelling transfer-function approach, state-space approach, system identification, stochastic models and its characterization and analysis, Spatial modelling, two-patch models with dispersal.

Modelling of physical systems and analysis: electrical systems, mechanical systems, electromechanical Systems, mechatronic systems, hydraulic systems, pneumatic systems, thermal systems, biological systems, modelling of time variant system.

Model reduction: parameterized partial differential equation, projection-based model reduction, proper orthogonal decomposition, balanced truncation, moment matching, local parametric approaches, nonlinear model reduction.

Reference Books:

S. N. Name of Books Authors Publishers

1.	System Dynamics (4^{th} ed.)	K. Ogata	Pearson: Prentice Hall
2.	Probabilistic Modelling	Isi Mitrani	Cambridge University Press
3.	System Identification: Theory for the User (2nd Edition)	Lennart Ljung	Pearson: Prentice Hall
4.	Model Order Reduction: Theory, Research Aspects and Applications	Schilders, Wilhelmus H., van der Vorst, Henk A., Rommes, Joost	Springer

Course Outcomes: At the end of this course, students are expected to learn the following:

1. Explain the philosophy, role, significance, and limitations of modelling of a system.
2. Classify different types of modelling approaches and their applicability.
3. Develop a model a system and analyse the model.
4. Deduce a reduced order model from a higher order model using suitable techniques.

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EE 1532	Digital Control Systems	L	T	P	C
	M. Tech in Control and Industrial Automation	**3**	**0**	**0**	**3**
	Electrical Engineering Branch				

Pre-requisites: Signal and Systems, Control Systems

Course Assessment methods (both continuous and semester end assessment): It may be class tests, assignments, attendance, quiz, poster/seminar presentation on different topics including contemporary issues, mid Semester examination, surprise tests, coding and simulation, self-learning, grand viva, group discussion, mini projects, end semester examination, etc.

Topics Covered:

Introduction to Digital Control: Introduction, Discrete time system representation, Mathematical modelling of sampling process, Data reconstruction

Modelling Discrete-Time Systems by Pulse Transfer Function: Revisiting Z-transform, Mapping of s-plane to z-plane, Pulse transfer function, Sampled signal flow graph

Time Response of Discrete systems: Transient and steady-state responses

Stability Analysis of Discrete Time Systems: Jury stability test, Stability analysis using bi-linear transformation

Design of Sampled Data Control Systems: Root locus method, Nyquist stability criteria, Bode plot, Controller design using root locus, Lag-lead compensator design in frequency domain

Discrete State Space Model: Introduction to state variable model, State transition matrix, Solution of discrete state equation

Controllability, Observability and Stability of Discrete State Space Models: Controllability and Observability, Stability, Lyapunov stability theorem

State Feedback Design for Discrete Systems: Pole placement by state feedback, Full order observer, Reduced order observer

Introduction to Optimal Control for Discrete Systems: Basics of optimal control, Performance indices, Linear Quadratic Regulator (LQR) design

Reference Books:

S. N.	Name of Books	Authors	Publishers
1.	Digital Control and State Variable Methods	M. Gopal	Tata McGraw-Hill Publishing Company Limited
2.	Digital Control Systems	B. C. Kuo	Oxford University Press
3.	Discrete Time Control Systems	K. Ogata	Prentice Hall International
4.	Digital Control of Dynamic Systems	G. F. Franklin, J. D. Powell and M. L. Workman	Addison-Wesley

Course Outcomes: At the end of this course, students are expected to learn the following:

Able to:
(1) **describe** and **analyse** digital control technique
(2) **apply** digital control methods
(2) **design** a controller

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Syllabus of subject under the list of Elective – II

EE 1541	Industrial Instrumentation	L	T	P	C
	M. Tech in Control and Industrial Automation	**3**	**0**	**0**	**3**
	Electrical Engineering Branch				

Pre-requisites: Instrumentation

Course Assessment methods (both continuous and semester end assessment): It may be class tests, assignments, attendance, quiz, poster/seminar presentation on different topics including contemporary issues, mid Semester examination, surprise tests, coding and simulation, self-learning, grand viva, group discussion, mini projects, end semester examination, etc.

Topics Covered:

Basic terminologies (range, span, settling time dead zone, input impedance, etc.)

1st order and second order instruments with step, ramp and sinusoidal input/ output characteristics
Basic measurement technique, Signal conditioning

Strain gauge, derivation of gauge factor, strain gauge rosette, unbalanced Wheatstone bridge, Link type load cell, beam type load cell, ring type load cell and their sensitivities, Frequency response of link type load cell, Torque cell and its data transmission (slip ring and radio telemetry)

LVDT, phase compensation, phase sensitive demodulation, thermistor and its linearization, RTD, its construction, three wire and four wire method Muller bridge

Thermocouple, their relative comparison, cold junction compensation using AD590, grounded thermocouple

Potentiometer as displacement sensor, Capacitance as displacement and level transducer, push pull arrangement
Pressure transducer [Bourdon gauge, diaphragm gauge (metal and semiconductor), etc.], vacuum gauges

Photo electric transducer and its application, Liquid in glass thermometer, pressure spring thermometer
Venturi meter, Orifice meter, pilot tube, Rotameter, Weir, electromagnetic flow meter, turbine flow meter, Hot wire anemometer, its phase compensation and expression of volumetric flow rate or velocity in each case
Variable reluctance displacement sensor, tachogenerator
Measurement of viscosity, conductivity and pH of a liquid

Reference Books:

S. N.	Name of Books	Authors	Publishers
1.	A Course in Electrical and Electronic Measurements and Instrumentation	D. V. S. Murty	Dhanpat Rai and Co.
2.	Transducers and Instrumentation	D. Patranabis	PHI Learning Pvt. Ltd., New Delhi
3.	Principal of Industrial Instrumentation	A. K Sawhney	Mc Graw Hill India

Course Outcomes: At the end of this course, students are expected to learn the following:

Able to:
(1) **describe** different types of sensors and transducers
(2) **classify** different sensing elements
(3) **demonstrate** measurement of physical parameter

*****

EE 1542	Nonlinear Dynamics and Chaos	L	T	P	C
	M. Tech in Control and Industrial Automation	3	0	0	3
	Electrical Engineering Branch				

Pre-requisites: Basic courses in Engineering Mathematics, Control Systems

Course Assessment methods (both continuous and semester end assessment): It may be class tests, assignments, attendance, quiz, poster/seminar presentation on different topics including contemporary issues, mid Semester examination, surprise tests, coding and simulation, self-learning, grand viva, group discussion, mini projects, end semester examination, etc.

Topics Covered:

Introduction to dynamical system: Representations of dynamical Systems, discrete time dynamical systems, Vector Fields of nonlinear systems, limit cycles, nonlinear systems and their classification, Existence and uniqueness of solutions, fixed points and linearization, stability of equilibrium, dissipative, conservative and reversible systems, bifurcations in 1-D (Saddle-node, transcritical, pitchfork bifurcations). [8 hrs.]

Tools for Detecting Chaos: Analysis of chaotic time series, phase plane, stable and unstable manifolds, Center manifold theory and Poincare maps, saddle-node, transcritical, pitchfork bifurcations, hopf bifurcation, global bifurcations, Lyapunov Exponents, power spectrum, frequency spectra of orbits, Dynamics on a torus. [17 hrs.]

Analysis of some chaotic/hyperchaotic systems: Lorenz equation, strange attractors, Rossler equation, Forced Pendulum and Duffing oscillator, Chua's circuit, Logistics map. [5 hrs.]

Control of chaos: Need for control of chaos, the OGY method, PC method, PID control, optimal control, Adaptive control, Non-feedback control, and state feedback control. [5 hrs.]

Application of Chaos: Electrical and Electronic Systems (Electrical drive/power system), Communication systems, types and method of synchronization, synchronization in complex systems, synchronization technique using (PID, Adaptive, Active, Sliding Mode, Optimal) control, chaos-synchronization-based secure communications. [5 hrs.]

Reference Books:

S. N.	Name of Books	Authors	Publishers
1.	Nonlinear Systems, 2nd edition	Khalil, H. K.	Prentice Hall, NJ
2.	Nonlinear Dynamics and Chaos. Reading	Strogatz, S.	MA: Addison-Wesley
3.	Chaos in Dynamical systems,	Edward. Ott	Cambridge, UK
4.	From Chaos to Order	Parker, T. S., and L. O	World Scientific, Singapore
5.	Practical Numerical Algorithms for Chaotic Systems	Jordan, D. W., and P. Smith	New York, NY: Springer-Verlag
6.	Nonlinear Ordinary Differential Equations	Guckenheimer, J., and P. Holmes	Springer
7.	Nonlinear Oscillations, Dynamical Systems and Bifurcations of Vector Fields	K.T. Alligood, et al	New York, NY: Springer-Verlag
8.	Chaos: An Introduction to Dynamical Systems	Khalil, H. K.	New York, NY: Oxford University Press
9.	Nonlinear Systems, 2nd edition	Strogatz, S.	Prentice Hall, NJ

Course Outcomes: At the end of this course, students are expected to learn the following:

1. To introduce the fundamental concept of the dynamical system and chaos.
2. To introduce students regarding the methods for detecting the chaos.
3. To introduce students to analyse the chaotic and hyperchaotic system using the various numerical and analytical tools.

4. To make students to formulate the control objective for the dynamical system.
5. To make students to know how to apply the concept of the dynamical system and chaos to other problem.

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Structure of MTech Courses on "Power and Energy System Engineering" EE Deptt. (w.e.f. July 2019)

1st Semester:

Sub Code	Subject	L – T – P	Credits
EE 2501	Power system analysis	3 – 0 – 0	3
EE 2502	Non-conventional energy source and energy converter	3 – 0 – 0	3
EE 2503	Power system protection	3 – 0 – 0	3
EE 2504	Power systems Laboratory	0 – 0 – 4	2
EE-xxxx	Elective – I	3 – 0 – 0	3
EE-xxxx	Elective – II	3 – 0 – 0	3
EE 2510	Seminar-1	0 – 0 – 2	1
	Total		18

List of Elective – I and II

Sub Code	Subject	L – T – P	Credits
EE 2531	Energy, ecology and environment	3 – 0 – 0	3
EE 2532	HVDC and FACTS devices	3 – 0 – 0	3
EE 2533	Power quality	3 – 0 – 0	3
EE 2534	Energy policy and planning	3 – 0 – 0	3
EE 2535	Instrumentation and control in energy system	3 – 0 – 0	3
EE 2536	Embedded system and application	3 – 0 – 0	3
EE 2537	Smart grid	3 – 0 – 0	3
EE 2538	Modelling and analysis of electrical machines	3 – 0 – 0	3
EE 2539	Power Quality in Power Distribution Systems	3 – 0 – 0	3
EE 2540	Soft computing techniques and applications	3 – 0 – 0	3

EE 2501	Power system analysis	L	T	P	C
	M. Tech in Power and Energy System Engineering	3	0	0	3
	Electrical Engineering Branch				

1st Semester:

Pre-requisite: Basic Power System Courses

Course Assessment methods: It may be class tests, assignments, attendance, quiz, poster/seminar presentation, mid Semester examination, surprise tests, coding and simulation, self-learning, grand viva, group discussion, mini projects, end semester examination, etc.

Topics:

Z_{BUS} building algorithm: modification due to network changes, Analysis of Series and shunt Faults on digital computers.

Power flow studies: AC/DC load flow, solution of ill conditioned systems, Continuation Power Flow.

Contingency Evaluation: Necessity of contingency evaluation in power systems, Contingency Ranking, methods of distribution factors for line and generator outages, calculation of PTDF & LODF.

Reliability Analysis: Representation of power system components for reliability analysis, Loss of Load Expectation (LOLE), Frequency and duration approach,
State Estimation: Static as well as dynamic

References:

S.N	Name of Books	Authors	Publisher
1	Computer Methods in Power System Analysis	G. W. Stagg, El-Abaid	Tata McGraw Hill
2	Power System Analysis	John J. Grainger, William D Stevenson	Tata McGraw Hill
3	Computer Techniques in Power System Analysis	M. A. Pai	Tata McGraw Hill
4	Power Generation, Operation and Control	Allen J. Wood and Bruce F. Wollengerg	Wiley

Course Outcomes: At the end of this course, students are expected to learn the following:
1 Able to **define** the Power System Analytical (PSA) problems.
2 Able to **describe** the usefulness of each analytical problems.
3 Able to **demonstrate** the computing procedure to solve the PSA problem.
4 Able to **assess** the computational complexities involved in the solution process.

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EE 2502 Non-conventional energy source and energy converter
M. Tech in Power and Energy System Engineering
Electrical Engineering Branch

L	T	P	C
3	0	0	3

Energy scenario, review of various energy sources, importance of non-conventional sources such as solar, biogas, wind, tidal, OTEC etc. Study of typical energy converters such as high-performance motors, special generators driven by biogas engines, wind turbines, etc. mini-hydro generators, modern state-of-the-art and futuristic systems in this area.

Texts and reference materials:
1. G D Rai, Non-Conventional Sources of Energy, Khanna Publishers, 2004.
2. Chetan Singh Solanki, ‘Solar Photovoltaics-Fundamentals, Technologies and Applications’, PHI Learning Pvt. Ltd., New Delhi, 2011.
3. Thomas Ackermann, Wind Power in Power Systems, John Wiley & Sons ltd.
4. Godfrey Boyle, Renewable Energy –power for a sustainable future, Published by Oxford University Press, 2004.
5. John Twidell and Tony Weir, Renewable Energy Resources, Taylor and Francis Group 2007.
6. Dr. N K Giri, Alternatie Energy-Sources, Applications and Technologies, Khanna Publishers, 2012.

Course Outcomes: At the end of this course, students are expected to learn the following:
1. Understand the global energy scenario and the potential of renewable energy sources to address the global energy problem.
2. Able to explain the working non-conventional energy technologies to generate electricity
3. Able to design a sub-system of electrical engineering.

4. Recognize the need and ability to engage in lifelong learning for further developments in the field of non-conventional energy.

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EE 2503	Power system protection	L	T	P	C
	M. Tech in Power and Energy System Engineering	3	0	0	3
	Electrical Engineering Branch				

Prerequisite: Switchgear and industrial protection, Power system-I and Power system-II.

Course Assessment Methods: Both continuous and semester end assessment (It may be class tests, assignments, attendance, quiz, poster/seminar presentation on different topics including contemporary issues, mid Semester examination, surprise tests, coding and simulation, self-learning, grand viva, group discussion, mini projects, end semester examination, etc.)

Fundamentals of protection practice: Purpose of Power system protection, Protective gear, reliability, selectivity, zone of protection, stability, sensitivity, primary and backup protection, some commonly used definitions and terminology, relay contact systems, relay tripping circuits, unit and non-unit types of protection

Current and potential transformers (CTs and PTs): Introduction to CTs and Pts, Errors in CTs and PTs, voltage factors, protection of PTs, residually connected PTs, transient performance of PTs, capacitor voltage transformers, turn compensation in CTs, composite errors in CTs, accuracy limit of Protective CTs

Protective relays and circuit breakers: Introduction to relays, types of relays, types of measurements, static relays, circuits using digital and analogue techniques, types of circuit breakers (CBs), arc extinction, recovery voltage, re-striking voltage, fault clearing process, trip circuit of CB, miniature CB, moulded case CB, numerical protection, microprocessor based numerical relays, artificial intelligence based numerical relays, adaptive relaying.

Protection of transformer: Nature of winding connections and types of transformer fault, magnetizing current inrush, overheating protection, overcorrection protection, restricted earth fault protection, differential protection and its various types, use of interposing CTs, autotransformer protection

Protection of generator: Types of generator faults, winding protection, various schemes of protection, inter turn protections schemes, overload and over current protection, un balanced loading, negative sequence protection, rotor fault and rotor protection

Transmission line protection: Principle of distance protection, voltage limit for accurate reach point measurement, zone of protection, distance relay type and their applications, distance protection schemes.

Protection of motors: Bearing failures, heating of winding, overload protection, stalling of motors, stator protection, phase unbalanced relays, rotor protection

Protection of capacitors, rectifier, thyristors, reactors

Reference Books:

Sl No	Name of Books	Authors	Publisher
1.	Protective relaying Application Guide	General Electric Company	GE C measurements
2.	Power system Protection and switchgear	Badri Ram, D.N. Vishwakarma	Mc Graw Hill Education (India) Private LtD
3.	Switchgear Protection and power systems	S.S. Rao	Khana Publisher
4.	Switchgear and Protection	J.B. Gupta	Katson Books

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EE 2504 **Power system Laboratory** **L T P C**

M. Tech in Power and Energy System Engineering **0 0 4 2**

Electrical Engineering Branch

Course Assessment methods: performance in laboratory works, assignments, attendance, quiz, coding and simulation, self-learning, grand viva, group discussion, and end semester practical examination.

Topics:

Understanding power system behaviour though following lab works:

Software Simulation

- Economic Load Dispatch of thermal plants with various complex case studies.
- Economic Load Dispatch of thermal and hydro plants.
- Load Flow Analysis using various solution approaches.
- Eigen value and participation matrix.
- Short circuit studies.
- Formation of Zbus by Zbus building algorithm.
- Dynamic simulation of power system behavior.

Hardware Simulation

- Study of power transmission line behavior using SCADA based Power TLS hardware model.
- Study of numerical relays (over current & distance) using relay hardware setup & power TLS model.
- Assessment of power quality issues in LT systems.

The above software simulation based experiments will be conducted by using MATLAB, ETAP, MiPOWER software.

Course Outcome

1	Able to **verify** the theoretical concepts of power system studies.
2	Able to **solve** various power systems problems using modern power systems tools.
3	Able to **assess** the computational complexities involved in the solution process.

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EE 2510 **SEMINAR-I**

M. Tech in Power and Energy System Engineering
Electrical Engineering Branch

L	T	P	C
0	0	2	1

Course Outcome of Seminar:
At the end of seminar course, students are expected to

(1) Prepare good slides and present a particular topic effectively.
(2) Develop team spirit and leadership qualities through group activities.
(3) Develop confidence for self-learning and overcome the fear of public presentations.
(4) Update knowledge on contemporary issues, prepare technical report and do presentations on these issues.
(5) Learn technical editing software Latex and write technical report using Latex.

Mapping of COs to POs:

Cos\POs	a	b	c	D	e	f	g	h	i	j	k
CO1							4				
CO2				5		3					3
CO3							3		3		
CO4							5			5	
CO5							3				

Correlation Index:

5	Very Highly Correlated	2	Correlated
4	Highly Correlated	2	Weakly Correlated
3	Moderately Correlated		

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List of Elective – I and II

EE 2531 **Energy, ecology and environment**
M. Tech in Power and Energy System Engineering
Electrical Engineering Branch

L	T	P	C
3	0	0	3

Pre-requisites: Basic Science and Energy, Knowledge of Electrical Energy Conversion Systems.
Course Assessment methods (both continuous and semester end assessment): It may be class tests, assignments, attendance, quiz, poster/seminar presentation on different topics including contemporary issues, mid Semester examination, surprise tests, coding and simulation, self-learning, grand viva, group discussion, mini projects
Topics Covered: Origin of the earth, Earth's temperature and atmosphere. Sun as a source of energy, nature of its radiation. Biological processes, photosynthesis. Food chains. Marine ecosystem. Ecosystem theories. Autecology's, sources of energy, classification of energy sources, quality and concentration of an energy source, characteristics temperature. Fossil fuels: coal, oil, gas, geothermal, tidal and nuclear energy. Solar, wind, hydropower, biomass. Resources of energy and energy use pattern in different regions of the world. Environmental degradation, primary and secondary pollutants. Thermal and radioactive pollution, air and water pollution. Micro climatic effects of pollution. Pollution from stationary and mobile sources. Biological effects of radiation, heat and radioactivity disposal. Pollution abatement methods.

Reference Books:

1. D. H. Meadows, D.L. Meadows, J. Randry nd W.W. Behrens, Limits to Growth, Universe Books, New York, 1972.
2. Introduction to Environmental Engineering and Science (IInd edition) by Gilbert M. Masters, Prentice Hall of India Private Limited 1998.
3. Environmental Science by G. Ryler Miller Jr.
4. Air Pollution Control Engineering by De Nevers

Course Outcomes: At the end of this course, students are expected to learn the following:

1. Able to demonstrate knowledge of new and renewable energy and their relationship with ecology & environment.
2. Able to describe conventional and non-conventional energy scenario with respect to the environment.
3. Able to explain the Environmental Pollution and their effects on the environment
4. Able to design and develop suitable energy generation technologies on future demand.

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EE 2532	**HVDC and FACTS devices**	**L**	**T**	**P**	**C**
	M. Tech in Power and Energy System Engineering	**3**	**0**	**0**	**3**
	Electrical Engineering Branch				

Pre-requisites: Power System, Power Electronics

Course Assessment methods (both continuous and semester end assessment): It may be class tests, assignments, attendance, quiz, mid Semester examination, self-learning, end semester examination, etc.

Topics Covered:

HVDC Transmission System:

General aspects and comparison of AC and DC Transmission, Application of DC Transmission, Description of DC Transmission System: Types of DC Links, Converter stations, Different configurations for asynchronous interconnection, Modern trends in HVDC Technology

Analysis of HVDC Converters: Line commutated converters(LCC): Various possible configurations 6 pulse converters and its generalization, Choice of optimum HVDC converter configuration based on desired features; Analysis of Graetz bridge neglecting overlap (both rectifier and inverter mode operation), Analysis of Graetz bridge with overlap (both rectifier and inverter mode operation) with two and three valve conduction mode, three and four valve conduction mode; LCC bridge characteristics and boundary for rectifier and inverter operations; Analysis of 12-pulse bridge converter configuration

Control philosophy of HVDC-link: Principle of DC link control, Converter control characteristics (both for rectifier and inverter end), Power flow controller characteristics (forward and reverse power flow), HVDC system control hierarchy, starting and stopping of DC link

FACTS Devices:

General description of flexible transmission system controllers and its various classification, A general equivalent circuit for FACTS controllers and their constraint equations and control variables, benefits with the application of FACTS controllers, Application of FACTS controllers (Custom Power Devices) in distribution systems.

AC transmission line and reactive power compensation: Analysis of uncompensated line, performance of line connected to unity PF load, Performance of a symmetrical line, Concept of series and shunt passive reactive power compensation, Compensation by series and shunt capacitor at midpoint of line using equivalent circuit model and comparison between them. Compensation by STATCOM and SSSC at the midpoint of the line using equivalent circuit model and comparison between them.

Static Var Compensator (SVC): Analysis of SVC connected at the midpoint of line, control characteristic of SVC, Expression of voltage and power flow in control range and at SVC limit, Power angle curve for SVC, SVC configurations, Thyristor Controlled Reactor (TCR), Thyristor Switched Reactor (TSR), Thyristor Switched Capacitor (TSC), Modeling of SVC and its equivalent circuit, Application of SVC

Thyristor and GTO Controlled Series Capacitor (TCSC and GCSC): Basic concepts of controlled series compensation (TSSC, TCSC and GCSC, GSSC), operating modes in a TCSC, Analysis of TCSC, Control functions of TCSC, Analysis of GCSC, Mitigation of SSR with TCSC and GCSC

Static Phase Shifting Transformer (SPST): Basic principle of a PST and its equivalent circuit representation, schematic diagram of a SPST, configurations of SPST, Improvement of transient stability using SPS, Applications of SPST
Static Synchronous Compensator (STATCOM): Principle of operation of STATCOM and its control characteristics, Simplified analysis of a 3-phase 6-pulse STATCOM using switching functions, Multi-pulse and Multi-level STATCOMs, Applications of STATCOM
Static Synchronous Series Compensator (SSSC): Operation of SSSC and the control of power flow, Power flow control characteristics, SSSC with an Energy source: Active and reactive voltage control, Power flow with constant active and reactive voltage injection in the line.
Unified Power flow Controller (UPFC): Analysis of operation of a UPFC connected at the sending end/ at the receiving end/ at the midpoint, Schematic concept of IPFC, BTB HVDC link and Convertible Static Compensator (CSC)

Reference Books:

S. N.	Name of Books	Authors	Publishers
1.	HVDC Power Transmission Systems	K R Padiyar	New Age International
2.	FACTS Controllers in Power Transmission and Distribution	K R Padiyar	New Age International
3.	Understanding FACTS Concepts and Technology of Flexible AC Transmission Systems	Narain G. Hingorani and Laszlo GyuGui	IEEE Press
4.	HVDC and FACTS Controllers Applications of Static Converters in Power Systems	Vijay K. Sood	Springer
5.	POWER QUALITY ENHANCEMENT USING CUSTOM POWER DEVICES	Arindam Ghosh and Gerard Ledwich	KLUWER ACADEMIC PUBLISHERS Boston / Dordrecht / London

Course Outcomes: At the end of this course, students are able to:
(1) Understand the HVDC transmission and FACTS technologies with their application benefits
(2) Classify HVDC systems and FACTS controllers configurations
(3) Analyse HVDC converters and FACTS controllers with relevant waveforms and characteristics
(4) Describe the control philosophy of HVDC-link and various FACTS controllers

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EE 2533	Power Quality	L	T	P	C
	M. Tech in Power and Energy System Engineering	3	0	0	3
	Electrical Engineering Branch				

Prerequisites: Knowledge of Power System I & II

Course Assessment methods (both continuous and semester end assessment): It may be class tests, assignments, attendance, quiz, poster/seminar presentation on different topics including contemporary issues, mid Semester examination, surprise tests, coding and simulation, self-learning, grand viva, group discussion, mini projects, end semester examination, etc.

Topics Covered:

Overview and definition of Power Quality (PQ), classification and characteristics of different PQ problems, Sources of Pollution, International PQ standards and regulations, Power Acceptability curves- their necessity and utilization.

Voltage Sag, swell, transients and interruptions. – Characteristics, causes, effects and methods of mitigation. Voltage sag performance evaluations for transmission and distribution systems. Role of energy storage devices in mitigating poor voltage quality. Reliability indices and their importance.

High voltage transients in power systems- their causes, effects and methods of reduction. Ferro-resonance, its effect, mitigation and ways of detection of its occurrence. Devices for overvoltage protection and electrical noise.

Harmonics – Causes, effects, methods of quantitative analysis of voltage and current harmonics contamination in their respective waveforms. Relation between true power factor, displacement power factor and distortion factor and harmonic phase sequences. Waveform analysis of harmonic injection due to different non-linear loads. Harmonic Resonance – their causes, effects and mitigation. Effects of harmonics on different power system components.

Applied Harmonics – Choice of PCC, harmonic evaluations on utility systems, principles for controlling harmonics in utility distribution systems and end user facility. PQ standards regarding harmonics in particular and PQ benchmarking.

Reference Books:

S. N.	Name of Books	Authors	Publishers
1.	Understanding Power Quality Problems	Math H. J. Bollen	IEEE Press
2.	Electrical Power Systems Quality	Roger C. Dugan et.al	McGraw Hill
3.	Power Quality Enhancement Using Custom Power Devices	Arindam Ghosh and Gerard Ledwich	Springer

Course Outcomes: At the end of this course, students are expected to do the following:

1. Students will be able to **analyse** the causes of different PQ problems and the extent to which they affect different sensitive loads.

2. Students will be able to **identify** a particular PQ problem based on their characterization and evaluate the optimum solution as mitigation scheme.
3. Students will know how to **mitigate** practical problems faced in case of voltage sags and transient voltages in the system and the challenges by suggesting the optimal solutions to such problems.
4. Students will come to know how to **identify** the adverse effects of non-linear loading at the distribution end and different ways of eliminating system harmonics.
5. Students will be known how to **apply** the knowledge of international PQ standards and PQ benchmarking of sensitive loads and also to keep themselves updated to those**.**

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		L	T	P	C
EE 2534	**Energy policy and planning**	**L**	**T**	**P**	**C**
	M. Tech in Power and Energy System Engineering	**3**	**0**	**0**	**3**
	Electrical Engineering Branch				

Pre-Requisite: The students should have basic knowledge about energy systems issues related to supply and demand, as well as overall ideas about key issues in the global energy agendas. They should also be familiar with the interaction between the different parts of the energy system. In particular, the students must complete the course of power system in UG level.

Course Assessment Method (both continuous and Semester end assessment):

There will be two tests as Mid-semester (30%) and End –semester (50%), about 10 assignments (5%), Minor test (10%) and Class participation (5%).

Topics to be covered:

Energy (and power) policies in the country and global energy policy, Tariffs and Subsidies.

Energy utility interface; Private sector participation in power generation; State role and fiscal policy.

Energy and development; National energy plan; Role of modeling in energy policy analysis.

Energy data base; Energy balances; Flow diagrams; Reference energy system.

Energy demand analysis; Trend analysis, Econometric models; Elasticities approach; Input-Output models.

Energy demand supply balancing; Energy economy interaction; Energy investment planning; Energy environment interaction, Energy Pricing.

Reference Books:

1. Power System Economics, Steven Stoft, Willey Inter-Science
2. Alternating Current: Electricity Markets and Public Policy, T.J. Brennan, K. Palmer and S.A. Martinez.
3. Electricity Sector in India: Policy and Regulation, Alok Kumar, OUP India,
4. Mapping Power: The Political Economy of Electricity in India's States edited by Navroz K. Dubash, Oxford.
5. Energy for Sustainability: Technology, Planning, Policy by John Randolph, Gilbert M. Masters, Island Press, 1718, Connecticut Ave, NW, Suite 300, Washington, D.C. 20009.
6. The Economics of Electricity Markets, by Darryl R. Biggar, Mohammad Reza Hesamzadeh, Wiley

7. Electric Power Distribution by A. S. Pabla, Tata McGrawHill Publishing, New Delhi

Course Outcomes:

At the end of the course, students should be able to:

1. understand how energy policy is designed and implemented;
2. identify policy processes;
3. identify the role of different stakeholders;
4. formulate analytical strategy, collect necessary data, and perform analysis on energy policy-related problems; and
5. understand how energy policy instruments affect energy system investment decisions and public behavior.

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EE 2535	Instrumentation and Control in Energy System	L	T	P	C
	M. Tech in Power and Energy System Engineering	3	0	0	3
	Electrical Engineering Branch				

Module I

Overview of Instruments and Measurement Systems: Principles of measurements and measurement errors, Classification of instruments, static and dynamic characteristics, Input output configurations of measurement systems.

Instruments for measuring pressure, temperature, velocity and flow, heat flux, liquid level and concentration in energy systems.

Characterization of combustors, Flue gas analysers, Exhaust gas analysers, Solar energy measurement requirements and instruments, Net Metering.

Meteorological data measurements, Energy auditing instruments, Energy audit kit, Humidity measurement.

Sensor and transducers: Types, characteristics and applications of Mechanical transducers, Types, characteristics and applications of electrical transducers, Principles of Modern sensors and typical applications.

Module II

Introduction to Control Systems: Overview of control systems, types and components, Feedback and non-feedback systems and their applications, Transfer function, block diagram representation and reduction techniques.

Signal conditioning: Operational amplifier, types and characteristics, application, circuits- inverter, adder, substractor, multiplier and divider, A/D and D/A conversion techniques.

Data Acquisition Systems: Types of Instrumentation Systems and components, Working principle and application of Single channel A /D converter, Working principle and application of multi-channel A/D converter, Digital data processing and display.

Module III

Microcontrollers and compilers: Overview of microprocessor and microcontroller, architecture. Use of compilers for data acquisition, processing and display, typical microcontroller Applications for monitoring and control of electrical and
non–electrical parameters/processes.

Text Books:

1. Morris A. S., Principles of Measurements and Instrumentation, Prentice Hall of India, 1998
2. Sawhney A. K., A Course in Electrical and Electronics Measurements and Instrumentation, Dhanpat Rai, 2011
3. Murty D.V.S., Transducers and Instrumentation, Prentice-Hall of India Pvt. Ltd. 1995
4. Ogata K., Modern Control Engineering, Prentice Hall, 1997

Reference Books:

1. Bentley J. P., Principles of Measurement Systems, Fourth Edition, Pearson Prentice Hall, 2005
2. Jain R. P., Modern Digital Electronics, McGraw Hill, 1998
3. Gaonkar R., Microprocessor Architecture, Programming and Applications with 8085, Penram International Publishing, 2012
4. Raman C. S., Sharma G. R., and Mani V. S. V., Instrumentation Devices and systems, Tata McGraw Hill, 1983
5. Holman J.P., Experimental methods for engineers Sixth edition, McGraw-Hill .1994

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		L	T	P	C
EE 2536	**Embedded system and application**	**L**	**T**	**P**	**C**
	M. Tech in Power and Energy System Engineering	**3**	**0**	**0**	**3**
	Electrical Engineering Branch				

Pre-requisites: Microprocessor and Microcontroller

Course Assessment methods (both continuous and semester end assessment): It may be class tests, assignments, attendance, quiz, poster/seminar presentation on different topics including contemporary issues, mid semester examination, surprise tests, coding and simulation, self-learning, grand viva, group discussion, mini projects, semester exams etc.

Topics Covered:

Introduction to Embedded systems: Single purpose hardware and software. Architectural Issues: CISC, RISC, DSP Architectures. Component Interfacing: Interrupt.

DMA, I/O Bus structure, I/O Devices. Software for Embedded systems: Program design and Optimization techniques, O.S for Embedded Systems, Real time issues. Designing Embedded systems: Design issues, Hardware software co-design, use of UML. Embedded control Applications: open loop and closed loop control

Software coding for PID Controller, applications- washing machines, automobiles. Networked Embedded systems: Distributed Embedded Architectures, Protocol design issues, wireless network. Embedded Multimedia and Telecommunication Applications: Digital camera, Digital TV, set top box, voice and video telephony.

Reference Books:

S. N.	Name of Books	Authors	Publishers
1	Computers as components: Principles of embedded computing system design	W. Wolf	Elsevier, 2008
2	Fundamentals of Microcontrollers and Application in Embeded Systems	R. Gaonkar	Penram International Publishing, 2015
3	The 8051 Microcontroller	Kenneth J. Ayala	Thomson
4	Embedding System Building Blocks	Labrosse	CMP Publisher
5	Embedded Systems	Raj Kamal	TMH
6	Microcontrollers	Ajay V. Deshmukhi	TMH
7	Embedded system design	Frank Vahid, Tony Givargis	John Wiley
8	Microcontrollers	Raj Kamal	Pearson Education
9	An Embedded software Primer	David E. Simon	Pearson Education

Course Outcomes: At the end of this course, students are expected to learn the following:

(1) **Understand** Embedded systems and the interface issues related to it
(2) **Analyze** about different models on embedded systems
(3) **Describe** about the real time models, languages and operating systems
(4) **Analyze** real time applications, obstacles and solutions.

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EE 2537	Smart grid	L	T	P	C
	M. Tech in Power and Energy System Engineering	3	0	0	3
	Electrical Engineering Branch				

(5)

Module 1

Smart Grid Structure (7 hrs): Definition, Various components, Smart Grid architecture, Application and standards, Distributed Generation

Module 2

Communication Technologies for Smart Grid (7 hrs): Data communication, Communication Channel, Layered architecture and Protocols, Smart Grid communication layers

Module 3

Advanced Monitoring Infrastructure (6 hrs): Smart meters, Wide area monitoring system, Phasor measurement units, SCADA

Module 4

Demand Side Management (6 hrs): Definition, Impact analysis of DSM, load curve, Energy consumption scheduling, Controllable load models and challenges

Module 5
Microgrid Protection (6 hrs): Mode of microgid operations, Islanding detection of microgrid, Protection issues of microgrid

Module 6
Cyber Security in Smart Grid (4 hrs): Possible threats and cyber security challenges in smart grid, Security of Information

Books:
1. Smart Grid: Fundamentals of design and analysis by James Momoh (John Wiley & Sons publisher).
2. Smart Grid: Technology and applications by J. Ekanayake, N. Jenkins, K. Liyanage K, J. Wu, A. Yokoyama (Wiley publication).
3. Power Generation Operation and Control by A. J. Wood, B. F. Wollenberg (John Wiley & Sons publisher).

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EE 2538	**Modelling and analysis of electrical machines**	**L**	**T**	**P**	**C**
	M. Tech in Power and Energy System Engineering	**3**	**0**	**0**	**3**
	Electrical Engineering Branch				

Course Prerequisite: Electrical Machines

Course Assessment methods (both continuous and semester end assessment):
It may be class tests, assignments, attendance, quiz, poster/seminar presentation on different topics including contemporary issues, mid semester examination, surprise tests, coding and simulation, self-learning, grand viva, group discussion, mini projects, end semester examination, etc.

Topics Covered:

Principles of Electromagnetic Energy Conversion, General expression of stored magnetic energy - Energy State Functions. Modelling of Electromechanical systems - Basic Concepts of Rotating Machines - Calculation of air gap mmf and per phase machine inductance using physical machine data.

Different methods of Transformation – Phase Variable Form, Instantaneous Symmetrical Component Techniques, Reference Frame Theory (Different Reference Frames and Transformation between Reference Frames)

Basic Performance Equations and Analysis of different Rotating Machines - DC Machines, Synchronous and Induction Machines.

DC Machines - Voltage & Torque Equations, Basic types of DC Machines, Dynamic Characteristics of Permanent Magnet and DC Shunt Motors and solution using Laplace Transformation.

Synchronous and Induction Machines - Three phase symmetrical induction machine and salient pole synchronous machines in phase variable form, Application of reference frame theory to three phase symmetrical induction and synchronous machines, Dynamic direct and quadrature axis model in arbitrarily rotating reference frames. Determination of Synchronous machine dynamic equivalent circuit parameters. Analysis and dynamic modeling of two phase asymmetrical induction machine and single phase induction machine.

Transients in electrical machines - Switching Transients and surges. Transient and short circuit studies on alternators, Run-up re-switching and other transients in Induction Machines.

Modelling of Special Machines - Permanent magnet synchronous machine, Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines - Construction and operating principle - Dynamic modeling and self-controlled operation. Analysis of Switch Reluctance Motors. Brushless D.C. Motors. Recent trends.

Reference Books:

S. N.	Name of Books	Authors	Publishers
1.	Electric Machinery	Charles Kingsle, Jr., A.E. Fitzgerald, Stephen D. Umans	Tata Mcgraw Hill
2.	Electric Motor & Drives: Modeling, Analysis and Control	R. Krishnan	Prentice Hall of India
3.	Brushless Permanent Magnet and Reluctance Motor Drives	T.J.E. Miller	Clarendon Press
4.	Analysis of Electric Machine	P.C. Krause	Wiley IEEE Press 3rd Edition

Course Outcomes: At the end of this course, the students will be able to

1. **Understand** the principles of energy conversion
2. **Analyze** basic concepts of rotating machines.
3. **Construct** machine models based on different reference frames.
4. **Synthesize** equivalent circuit parameters for synchronous and asynchronous machines.
5. **Understand and analyse** special machines.

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EE 2539	Power Quality in Power Distribution Systems	L	T	P	C
	M. Tech in Power and Energy System Engineering	3	0	0	3
	Electrical Engineering Branch				

Pre-requisites: Network Theory, Power System, Power Electronics, Control systems

Course Assessment methods (both continuous and semester end assessment): It may be class tests, assignments, attendance, quiz, mid Semester examination, self-learning, end semester examination, etc.

Topics Covered:

SINGLE PHASE CIRCUITS: POWER DEFINITIONS AND COMPONENTS:
Introduction, Power Terms in a Single-Phase System, Sinusoidal Voltage Source Supplying Non-linear Load Current, Non-sinusoidal Voltage Source Supplying Non-linear Loads, Active Power, Reactive Power, Apparent Power, Non-Active Power, Distortion Power, Fundamental Power Factor, Power Factor,

THREE PHASE CIRCUITS: POWER DEFINITIONS AND VARIOUS COMPONENTS:
Three-phase Sinusoidal Balanced System, Balanced Three-phase Circuits, Three Phase Instantaneous Active Power, Three Phase Instantaneous Reactive Power, Power Invariance in abc and dq0 Coordinates, Instantaneous Active and Reactive Powers for Three-phase Circuits, Three-Phase Balance System, Three-Phase Unbalance System, Symmetrical components, Effective Apparent Power, Positive Sequence Powers and Unbalance Power, Three-phase Non-sinusoidal Balanced System, Neutral Current, Line to Line Voltage, Apparent Power with Budeanu Resolution: Balanced Distortion Case, Effective Apparent Power for Balanced Non-sinusoidal System, Unbalanced and Non-sinusoidal Three-phase System, Arithmetic and Vector Apparent Power with Budeanu's Resolution, Effective Apparent Power

3 FUNDAMENTAL THEORY OF LOAD COMPENSATION:
Introduction, Fundamental Theory of Load Compensation, Power Factor and its Correction, Voltage Regulation, An Approximation Expression for the Voltage, Some Practical Aspects of Compensator used as Voltage Regulator, Phase Balancing and Power Factor Correction of Unbalanced Loads, Three-phase Unbalanced Loads, Representation of Three-phase Delta Connected Unbalanced Load, An Alternate Approach to Determine Phase Currents and Powers, An Example of Balancing an Unbalanced Delta Connected Load, A Generalized Approach for Load Compensation using Symmetrical Components, Sampling Method, Averaging Method, Compensator Admittance Represented as Positive and Negative Sequence, Admittance Network

4 CONTROL THEORIES FOR LOAD COMPENSATION:
Introduction, State Space Modelling of the Compensator, Switching Control of the VSI, Generation of P_{loss} to maintain dc capacitor voltage, Computation of load average power (P_{lavg}), Some Misconception in Reactive Power Theory, Theory of Instantaneous Symmetrical Components, Compensating Star Connected Load, Compensating Delta Connected Load

5 SERIES COMPENSATION: VOLTAGE COMPENSATION USING DVR:
Introduction, Conventional Methods to Regulate Voltage, Dynamic Voltage Restorer (DVR), Operating Principle of DVR, General Case, Mathematical Description to Compute DVR Voltage, Transient Operation of the DVR, Operation of the DVR With Unbalance and Harmonics, Realization of DVR voltage using Voltage Source Inverter, Maximum Compensation Capacity of the DVR Without Real Power Support from the DC Link

Reference Books:

S. N.	Name of Books	Authors	Publishers
1.	POWER QUALITY ENHANCEMENT USING CUSTOM POWER DEVICES	Arindam Ghosh and Gerard Ledwich	KLUWER ACADEMIC PUBLISHERS Boston / Dordrecht / London
2.	Reactive power control in electric systems	T. J. E. Miller	Wiley, 1982.
3.	NPTEL Course on "Power Quality in Power Distribution Systems"	Mahesh Kumar	-

Course Outcomes: At the end of this course, students are able to:
(1) Understand single and three phase circuits power conditions and components
(2) Analyse fundamental theories of load compensation
(3) Model and develop control technique of the compensator for load compensation
(4) Realize the shunt and series compensator under unbalance and harmonic

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EE 2540	**Soft Computing Techniques and Applications**	**L**	**T**	**P**	**C**
	M. Tech in Power and Energy System Engineering	**3**	**0**	**0**	**3**
	Electrical Engineering Branch				

Course Assessment:
1. Problem sets for open book test
2. Minor test (closed book)
3. Mid- term examination (closed book)
4. End-Term examination (Closed book)

Overall Course Objectives:
The overall course objectives are:
(1) To make the students understand the features of intelligence of human brain, the issues while incorporation of intelligence in machines through soft computing tools for implementation.

(2) To impart knowledge of evolutionary algorithms and their applications.
(3) The students will be given the understanding of functions of neurons, mathematical model, learning through training, and testing of different categories of neural networks.
(4) To impart the understanding of representing quality attributes by fuzzy functions, forming fuzzy rule base matrix exploiting expert knowledge and application for solving problems.
(5) To impart knowledge on hybridization of EA-Neuro- Fuzzy systems and their applications

Unit –I INTRODUCTION TO SOFT COMPUTING TECHNIQUES

Introduction to intelligence, biological intelligence, artificial intelligence (AI), computational intelligence. Evolution of computational intelligence, from conventional AI to computational intelligence, soft computing constituents, machine learning basics, overview of soft computing techniques, intelligent decision systems.

Unit –II EVOLUTIONARY ALGORITHMS

Introduction to genetic algorithm, genetic operators and parameters, genetic algorithms in problem solving, theoretical foundations of genetic algorithms, evolutionary programming, particle swarm optimization, differential evolution; implementation issues and application for solving problems.

Unit –III: ARTIFICIAL NEURAL NETWORKS

Neural model and network architectures, basic-concepts-single layer perception-Multi layer perception, supervised and unsupervised learning, back propagation networks, associative learning, competitive networks, Hopfield network, computing with neural nets and applications of neural networks.

Unit –IV: FUZZY SYSTEMS

Introduction to fuzzy sets, operations on fuzzy sets, fuzzy relations, fuzzy measures, rule matrix, application of fuzzy set theory to different branches of science and engineering.

Unit –V: EA-NEURO-FUZZY MODELLING

Hybridization of EAs, Fuzzy and ANNs for increased intelligence for solving complex real-life problems.

Text Books:

1. Genetic Algorithms in Search, Optimization, and Machine Learning	D. E. Goldberg	Addison-Wesley
2. Neural Networks- A Comprehensive Foundation	S. Haykin	PH
3. Neural Networks- A Classroom Approach	Satish Kumar	TMH
4. Fuzzy Sets and Fuzzy Logic: Theory and Applications	G. J. Klir, and B. Yuan	PH

Reference books:

Genetic Algorithms in Search, Optimization, and Machine Learning	D. E. Goldberg	Addison-Wesley
Genetic Algorithms+ Data Structures = Evolution Programs	Z. Michalewicz	Springer-Verlag

Soft Computing & Intelligent Systems: Theory & Applications	N.K. Sinha & M. M. Gupta(Eds)	Academic Press
Neural Network Design Neural Networks Fuzzy Sets and Fuzzy Logic: Theory and Applications Fuzzy Set Theory and Its Applications	M.T. Hagan, H. B. Demuth, and M. Beale C. Lau (Ed) G. J. Klir, and B. Yuan H. J. Zimmerman	Thompson Learning IEEE Press PH Kluwer Academic Press

Overall Course Outcomes:

On completion of the course students will be able to:

- CO1 To use evolutionary algorithms for solving non-linear optimization problems.
- CO2 To develop solutions using fuzzy logic for systems with imprecise information and complex models.
- CO3 To develop solutions for solving complex problems using appropriate artificial neural networks.
- CO4 To develop intelligent solutions for complex problems using hybridization of EAs, Fuzzy and ANNs

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MTech in Communication & Signal Processing Engineering (ECE Deptt.)

	Semester I		
Code	**Course Name**	**L–T-P**	**Credits**
EC 1501	Linear Algebra and Random Processes	3-0-0	3
EC 1502	Communication System Theory	3-0-0	3
EC 1503	Signal Processing Algorithms and Architectures	3-0-0	3
EC 15XX	Elective I	3-0-0	3
EC 15XX	Elective-II	3-0-0	3
EC 1504	Signal Processing Lab	0-0-3	2
EC 1510	Seminar	0-0-2	1
	Total credits	**15-0-5**	**18**

List of Electives

Elective-I
EC 1531 Adhoc and Sensor Networks
EC 1532 Optical Communication and Networks
EC 1533 RF and Microwave Integrated Circuits
EC 1534 Satellite Communications
EC 1535 Information Theory and Coding
EC 1536Detection & Estimation Theory
EC 1537 EMI/EMC

Elective-II
EC 1541 Image Processing
EC 1542 Adaptive Filter Theory
EC 1543 Biomedical Signal Processing
EC 1544 Smart Antennas
EC 1545 Digital Speech Processing
EC 1546 Audio Video Coding and Standards
EC 1547 VLSI-DSP Based Design

EC 1501 LINEAR ALGEBRA AND RANDOM PROCESSES **L-T-P-C: 3-0-0-3**

Introduction to linear algebra:Field, Group, Rings, axioms of algebra, Cartesian products, vector formation, vector space, orthogonality, basis vectors, metric, norms, Lp space, norm space, Cauchy's sequence, Hilbert space, Kernel Space,

Matrices, row space column space of matrix, Rank of a matrix, Linear Transformation, Spectral Decomposition (Eigen and SVD), matrix Inverse, Elementary and Invertible matrices, LU factorization, Fourier series and Transform space and representation of frequency components as basis of these spaces.

Order statistics, Mean, variance and other moments. Conditional Mean.Covariance, correlation coefficient, Markov inequality, Chebyshev inequality, and Chernoff bound, Joint moments, covariance matrices.Characteristic function.

MMSE Estimation: definition and estimation by a constant; linear estimation, MMSE Estimation: unconstrained; Orthogonality principle.

Convergence of sequence of real numbers, Convergence of random variables (almost surely, $r^{\wedge th}$ mean, in probability, in distribution), Law of large numbers (Weak and Strong) and Central Limit Theorem, Convergence of Binomial Distribution to Poisson, Discrete-time Markov Chains, definitions, examples.

Random processes: definitions, mean, auto-correlation, and auto-covariance function. First and higher order density of random processes, Independent and Stationary Increments Property, Gaussian random process, Brownian motion, Cross-correlation and cross-covariance, Cyclo-stationary processes, Random processes in linear systems. WSS processes in LTI systems.

Discrete Random Processes in LTI systems. Ergodicity, mean ergodicity, ergodicity with respect to the first and second order density function.

Texts/References:

1. K. Hoffman and R. Kunze: Introduction to Linear Algebra; Prentice-Hall, 1996, 2/e.
2. G. Strang: Introduction to linear algebra, Wellesley-Cambridge Press and SIAM, 2009, 4/e.
3. Kai Lai Chung: A Course in Probability Theory; Academic Press, 2001, 3/e
4. A. Papoulis and S. U. Pillai: Probability, Random Variables and Stochastic Processes, 4th Edn., McGraw-Hill, 2002.
5. Robert B. Ash and C. D. Dade: Probability and Measure Theory, Academic Press; 1999, 2/e

EC 1502 COMMUNICATION SYSTEM THEORY

3-0-0-3

Review of digital modulation schemes and receivers in additive white Gaussian noise channels, continuous phase *modulation*(*CPM*),*minimum-shift keying*(*MSK*),continuous phase frequency shift keying (CPFSK); Inter-symbol interference; Adaptive receivers and channel equalization: MMSE, ZFE; Carrier and clock synchronization; Effects of phase and timing jitter; Block codes, Convolutional codes and their performance evaluation; Coded modulation schemes: TCM; Turbo codes; Digital transmission over fading channels; Multi-channel and multi-user communication systems.

Texts/References Books:

1. S Benedetto and E Biglieri, Principles of Digital Transmission with Wireless Applications, Kluwer Academic, 1999.
2. R G Gallager, Principles of Digital Communication, Cambridge University Press, 2008.
3. J G Proakis, Digital Communication, McGraw Hill, 4th edition, 2000.
4. Ha H. Nguyen and Ed Shwedyk, A First Course in Digital Communications, Cambridge University Press, 2011
5. U Madhow, Fundamentals of Digital Communication, Cambridge University Press, 2008

EC 1503 SIGNAL PROCESSING ALGORITHMS AND ARCHITECTURES

3-0-0-3

Orthogonal transforms: DFT, DCT and Haar; Properties of DFT; Computation of DFT: FFT and structures, Decimation in time, Decimation in frequency; Linear convolution using DFT;
Digital filter structures: Basic FIR/IIR filter structures, FIR/IIR Cascaded lattice structures, Parallel all pass realization of IIR transfer functions, Sine- cosine generator; Computational complexity of filter structures;
Multirate signal processing: Basic structures for sampling rate conversion, Decimators and Interpolators; Multistage design of interpolators and decimators; Poly-phase decomposition and FIR structures; computationally efficient sampling rate converters; Arbitrary sampling rate converters based on interpolation algorithms: Lagrange interpolation, Spline interpolation; Quadrature mirror filter banks; Conditions for perfect reconstruction; Applications in sub-band coding;
Digital Signal Processors introduction: Computational characteristics of DSP algorithms and applications; Techniques for enhancing computational throughput: Harvard architecture, parallelism, pipelining, dedicated multiplier, split ALU and barrel shifter;
TMS320C64xx architecture: CPU data paths and control, general purpose register files, register file cross paths, memory load and store paths, data address paths, parallel operations, resource constraints.

Texts/References:

1. J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Pearson Prentice Hall, 2007
2. A.V. Oppenheim and R.W. Schafer, Discrete- Time Signal Processing, PHI, 2000.
3. S. K. Mitra, Digital Signal Processing: A Computer Based Approach, 3rd Edn., TMH, 2008.
4. R. Chassaing and D. Reay, Digital signal processing and applications with TMS320C6713 and TMS320C6416, Wiley, 2008.
5. RulphChassaing and Donald Reay, Digital signal processing and applications with TMS 320C6713 and TMS320C6416, Wiley, 2008.
6. TMS320C64x Technical Overview, Texas Instruments, Dallas, TX, 2001.
7. TMS320C6000 Peripherals Reference Guide, Texas Instruments, Dallas, TX, 2001.
8. TMS320C6000 CPU and Instruction Set Reference Guide, Texas Instruments, Dallas, TX, 2000.

EC 1504 SIGNAL PROCESSING LABORATORY

Cycle I

1. Introduction to MATLAB and perform Wave form generation (Sine Wave, Triangular wave, Stair case wave form etc.), Linear and Circular Convolutions, sampling rate conversion, Quantization, difference equations using MATLAB.
2. Implementation of FFT, Decimation and Interpolationusing MATLAB.
3. Implementation of IIR, FIR filter using MATLAB.
4. Implementation digital resonator using MATLAB.
5. Design and implementation of LPF, HPF BPF and Notch Filterusing MATLAB.
6. DTMF Signal Detection using FFT, Correlation Scheme and Goertzel Algorithm Onboard LEDs for Verifying Detection using MATLAB.
7. Implementation of Beat Detection Using Onboard LEDs using MATLAB.
8. Implementation of Audio Effects (Echo and Reverb, Harmonics, and Distortion) using MATLAB.

Cycle II

9. Introduction to Code Composer Studio (CCS) and perform Wave form generation (Sine Wave, Triangular wave, Stair case wave form etc.) using TMS3206713DSP processor.
10. Sampling and sampling rate conversion using TMS3206713DSP processor.
11. Implementation of Fast Fourier Transform (FFT) using TMS3206713DSP processor.
12. Implementation of Linear and Circular Convolutions using TMS3206713DSP processor.
13. Implementation of Decimation and Interpolation using TMS3206713DSP processor.
14. Implementation of Quantization using TMS3206713DSP processor.
15. Implementation of difference equations using TMS3206713DSP processor.
16. Implementation of DTMF Signal Detection using FFT using TMS3206713DSP processor.
17. Implementation of echo detection and delay estimation using TMS3206713 DSP processor.
18. Implementation of basic algorithms in Communication and Signal processing using TMS3206713 DSP processor.

Cycle III (Mini project)

19. Mini-project in speech processing
20. Mini-project in Optical Character Recognition
21. Mini-project in Computer Vision
22. Mini-project in Image Processing
23. Mini-project in Medical Imaging
24. Mini-project in Human Computer Interface

Elective-I

EC 1531	ADHOC AND SENSOR NETWORK	3-0-0-3
	Pre-requisite- Computer Networks	

Introduction of ad-hoc/sensor networks: Key definitions of ad-hoc/sensor networks, Advantages of ad-hoc/sensor networks, Unique constraints and challenges, Driving Applications.

Wireless Communications/Radio Characteristics

Ad-Hoc wireless networks

Media Access Control (MAC) Protocols: Issues in designing MAC protocols, Classifications of MAC protocols, MAC protocols.
*Routing Protocols:*Issues in designing routing protocols, Classification of routing protocols, Routing protocols.
Networking Sensors: Unique features, Deployment of ad-hoc/sensor network, Sensor tasking and control, Transport layer and security protocols.
Sensor Network Platforms and Tools: Sensor network programming challenges, Embedded Operating System.
Applications of Ad-Hoc/Sensor Network and Future Directions: Ultra wide band radio communication, Wireless fidelity systems.

Text/Reference books:

1.	Adhoc Sensor Network Theory and applications	Dharma Prakash Aggarwal	World Scientific Publishing Company
2.	Wireless Sensor Networks	Karl and Willig	Willey publication Ltd
3.	Adhoc Wireless Network	Murthy	Pearson publication

EC 1532	**OPTICAL COMMUNICATION AND NETWORKS**	**3-0-0-3**
	Pre-requisite- Opto Electronics, Computer Networks	

Introduction to optical networks: Telecommunication network architecture, services, circuit switching, and packet switching, optical networks, the optical layer, transparency and all-optical networks, optical packet switching, transmission basics, network evolution.
I. Technology:
Propagation of signals in optical fiber: Light propagation in optical fiber, loss and bandwidth, chromatic dispersion, nonlinear effects, solitons and problems.
Components: Couplers, isolators and circulators, multiplexers and filters, optical amplifiers, transmitters, detectors, switches, wavelength converters and problems.
Modulation and Demodulation: Modulation, Subcarrier modulation and multiplexing, spectral efficiency, demodulation, error detection and corrections and problems.
Transmission system engineering: System model, power penalty, transmitter, receiver, optical amplifier, crosstalk, dispersion, fiber nonlinearities, wavelength stabilization, design of soliton systems, design of dispersion managed soliton system, overall design considerations and problems.
II. Networks:
Client layers of the optical layer: SONET/SDH, Multiplexing, SONET/SDH layers, SONET frame structures, SONET/SDH physical layers ATM, IP, storage area networks, ESCON, HIPPI and problems.
WDM Network elements: Optical line terminals, optical line amplifiers, optical add/drop multiplexers, optical crossconnects and problems.
WDM Network Design: Cost trade-offs: A detailed ring network example, LTD and RWA problems, Dimensioning Wavelength-Routing networks, statistical dimensioning models, maximum load dimensioning models and problems.
Control and Management: Optical layer services and interfacing, layers within the optical layer, multivendor interoperability, performance and fault management, configuration management and problems.
Network Survivability: Basic concepts, protection in SONET/SDH, protection in IP networks, why optical layer protection, optical layer protection scheme, internetworking between layers and problems.
Access Networks: Network architecture overview, enhanced HFC, FTTC and problems.
Photonic packet switching: Optical time division multiplexing, synchronization, header processing, buffering, burst switching, test beds and problems.
Development Consideration: The evolving telecommunications network, designing the transmission layer (using TDM, SDM, WDM), unidirectional versus bidirectional WDM systems.

Text Books:

1.	Optical Networks	R.Ramaswami, K.N.Sivarajan	Elsevier

References Books:

1.	Optical Communication System	J.Gower	Prentice Hall of India
2.	Optical Fiber Communication	John M. Senior	Pearson Education
3.	Optical Fiber Communication	Gerd Keiser	Mc Graw Hill
4.	Optical Networks	Rajiv Ramaswami	Elsevier
5.	Fiber-optic communication systems	Govind P. Agrawal	John Wiley & sons
6.	Fiber Optics and Optoelectronics	R.P. Khare	Oxford University Press

EC 1533	RF AND MICROWAVE INTEGRATED CIRCUITS	3-0-0-3
	Pre-requisite- Electrical Network Analysis, Electronic Devices, Electromagnetic Engineering and Electronic Circuits	

Introduction: Lower Frequency Analog Design and Microwave Design Versus Radio Frequency Integrated Circuit Design, RFIC used in a Communication Transceiver, Review of Transmission Line Theory, Distributed Transmission Lines, Smith Chart, Impedance Matching, Microstrip and Coplanar Waveguide Implementations, S Parameters, Components and Interconnects at High frequencies.
Issues in RFIC Design: Noise – Thermal Noise, Noise Power, Noise Figure, Phase Noise; Linearity and Distortion in RF Circuits – Third Order Intercept Point, Second Order Intercept Point, 1-dB Compression Point, Relationships between 1-dB compression point and IP3 Points, Broadband Measures of Linearity; Modulated Signals – PM, FM, MSK, QAM, OFDM.
LNA Design: Basic Amplifiers, Feedback Techniques, Noise in Amplifiers, Linearity in Amplifiers, Stability Analysis, Differential Amplifiers, Low Voltage Topologies and Use of on-chip Transformers, DC Bias, Broadband LNA Design, CMOS LNA Example.
Mixers: Basic Mixer Operation, Transconductance Controlled Mixer, Double Balanced Mixer, Mixer Noise, Linearity, Isolation, Genera Design Comments, Image Reject and Single-Sideband Mixer, Alternative Mixer Designs, CMOS Mixer Example.
Voltage Controlled Oscillators: LC Resonator, Analysis of Oscillator as Feedback System, Negative Resistance Oscillator, Differential Topologies, Colpitts Oscillator, Phase Noise Reduction Techniques, Quadrature Oscillators and Injection Locking. CMOS Example.
Frequency Synthesis: PLL Components, Continuous Time Analysis of PLL Synthesizers, Discrete Time Analysis for PLL Synthesizers, Transient Behaviors, Fractional – N PLL Frequency Synthesizers, CMOS Example.
Power Amplifiers: Introduction, Power Capability, Efficiency, Matching Considerations, Class A,B,C,D,E,F,G amplifiers, AC Load line, Transistor Saturation, Power Combining Techniques, Effects and Implications of Nonlinearity – Cross Modulation, AM – PM Conversion, Spectral Regrowth, Linearization Techniques, Feedforward, Feedback, Predistortion, CMOS Power Amplifier Example.

Text/Reference books:

1.	The Design of CMOS Radio-Frequency Integrated Circuits	Thomas H. Lee	Cambridge University Press
2.	Radio Frequency Integrated Circuit Design	Rogers and Plett	Artech House Publishers
3.	RF Power Amplifiers for Wireless Communications	Steve C. Cripps	Artech House Publishers
4.	Analysis and Design of Analog Integrated Circuits	Gray, Hurst, Lewis & Meyer	Wiley India Pvt Ltd
5.	Design of Analog CMOS Integrated Circuits	B. Razavi	TMH

EC 1534	SATELLITE COMMUNICATIONS	3-0-0-3
	Pre-requisite- Basics of electromagnetics, signalprocessing, antennas and digital communications	

Evolution and growth of communication satellites, Kepler's laws of motion, orbits, altitude control; Satellite launch vehicles-Arianne, SLV space shuttle; Subsystems of communication satellite; Spectrum allocation and Bandwidth considerations; Propagation characteristics, Satellite transponders and other sub systems; Earth station technology; Analog and digital link design; Multiple access techniques-FDMA, TDMA, SS-TDMA; Interference in FDMA systems, Modern satellite communications.

Texts/References Books:

1. Satellite Communications	Dennis Roddy	TMH
2. Satellite Communications	Timothy Pratt, Charles W. Bostian, Jeremy E. Allnutt	Wiley India Pvt Ltd.
3. Digital Satellite Communication	T.T.Ha	MHE
4. Satellite Communications	Maini & Agrawal	Wiley India Pvt Ltd

EC 1535 Information Theory and Coding

3-0-0-3

Information Theory: Entropy and mutual information for discrete ensembles; asymptotic equi-partition property; Markov chains; Entropy Rates of a Stochastic Process.
Shannon's noiseless coding theorem: Encoding of discrete sources; Universal Source Coding; Discrete memory less channels; Shannon's noisy coding theorem and converse for discrete channels; Calculation of channel capacity and bounds for discrete channels; Differential entropy; Calculation of channel capacity for Gaussian channels.
Coding Theory: Linear Codes, distance bounds, generator and parity check matrices, error-syndrome table; Cyclic codes, generator and parity check polynomials; BCH codes and Reed-Solomon Codes; An overview of convolutional codes; Maximum likelihood decoding; MAP decoder; Introduction to turbo codes and LDPC codes.
Texts/ References:
1. T. M. Cover and J. A. Thomas, *Elements of Information Theory*, John Wiley, New York, 1991
2. R. W. Yeung, *Information Theory and Network Coding*, Springer, 2008
3. R.G. Gallagar, *Information Theory and Reliable Communication*, John Wiley & Sons, 1976.
4. R.B. Ash, *Information Theory*, Dover Publications, 1990.
6. D. J. Mackay, *Information Theory, Inference and Learning Algorithms*, Cambridge University Press, 2003.
7. W. Ryan and S. Lin, *Channel Codes: Classical and Modern*, Cambridge University Press, 2009.
8. R. W. Yeung, *A First Course in Information Theory*, Kluwer Academic,2002.

EC 1536	**DETECTION AND ESTIMATION THEORY**	**3-0-0-3**
	Pre-requisite- Probability & Random Process, Digital Communication.	

Detection theory, hypothesis testing, Bayes, minimax, and Neyman-Pearson criteria, signaling in additive Gaussian noise, receiver operating characteristic, M-ary hypothesis testing, MAP and ML decision rules. Estimation of random parameters, MMS and MAP estimates. Estimation of nonrandom parameters, Cramer-Rao inequality, consistent estimate, Bounds on estimation errors, composite hypotheses, Elements of sequential and non-parametric detection, Wiener-Hopf and Kalman filtering.

Reference/Text Books:

1.	An Introduction to Signal Detection and Estimation	H Vincent Poor	Springer
2.	Detection, Estimation and Modulation Theory, Vol-I	Harry L Van Trees	John Wiley & Sons

EC 1537 EMI/EMC

3-0-0-3

BASIC THEORY: Intra and inter system EMI, Elements of Interference: Conducted and Radiated EMI emission and susceptibility, EMC Engineering Application.
COUPLING MECHANISM : Coupling paths, Coupling via the supply network, Common mode coupling, Differential mode coupling, Impedance coupling, Radiative coupling, Ground loop coupling, Cable related emissions and coupling, Transient sources, Automotive transients. Categorization of the electromagnetic interference: emission, susceptibility, transients, crosstalk, shielding and compatibility, signal integrity.
EMI MITIGATION TECHNIQUES: Working principle of Shielding, LF Magnetic shielding, Apertures and shielding effectiveness, Choice of Materials for H, E, and free space fields, Gasketting and sealing, PCB Level shielding, Principle of Groundin.
STANDARDS AND REGULATION: Need for Standards, EMI Standardizing for different application. IEC, ANSI, FCC, AS/NZS, CISPR, BSI, CENELEC, ACEC. MIL461E
EMI TEST METHODS AND INSTRUMENTATION: Fundamental considerations, EMI Shielding effectiveness tests, Open field test, TEM cell for immunity test, Shielded chamber , Shielded anechoic chamber,

EMI test receivers, Spectrum analyzer, EMI test wave simulators, EMI coupling networks, Line impedance stabilization networks, Feed through capacitors, Antennas, Current probes.
BASICS OF BIOLOGICAL EFFECTS OF EM WAVES: Ionizing and non-ionizing radiation. Theoretic and diagnostic use of EM waves.Measurement techniques of EM radiation.Protective design techniques.

Text/References

Henry W. Ott, “Electromagnetic Compatibility Engineering”, John Wiley & Sons Inc, Newyork, 2009.
Guide to Electromagnetic Compatibility”, Elsevier Science & Technology Books, 2002.
W Scott Bennett, “Control and Measurement of Unintentional Electromagnetic Radiation”, John Wiley & Sons Inc., (Wiley Interscience Series) 1997.
Dr Kenneth L Kaiser, “The Electromagnetic Compatibility Handbook”, CRC Press 2005.
Paul, C.R., “Introduction to Electromagnetic Compatibility”, 2nd ed., Wiley (2010).
David K. Cheng, “Field and Wave Electromagnetics” 2nd ed. Pearson Education, (2009).

Elective-II

EC 1541	IMAGE PROCESSING	3-0-0-3
	Pre-requisite- Digital Signal Processing	

Digital image fundamentals: Visual perception, image sensing and acquisition, sampling and quantization, basic relationship between pixels and their neighbourhood properties.
*Image Transformation:*2D DFT, DCT, Walsh-Hadamard transform, KLT, Harr transform and discrete wavelet transform.
Image enhancement in spatial domain: Fundamental concepts, enhancement by point processing, Gray-level transformations, histogram processing, spatial filters- averaging, order statistics; image sharpening.
Image filtering in frequency domain: Fundamental concepts, Smoothing and sharpening filtering in frequency domain, homomorphic filtering;
Image restoration: Degradation/ restoration process, noise models, restoration in presence of noise-only spatial filtering, linear position-invariant degradations, estimating the degradation function, inverse filtering, Wiener filtering, constrained least squares filtering.
*Image compression:*Lossy and lossless compression, entropy coding, transform coding, image coding standards.
Image analysis: edge and line detection, segmentation, feature extraction, classification; image texture analysis.
Morphological Image Processing: Basic operations- dilation, erosion, opening, closing, Hit-Miss transformations, Basic morphological algorithms and applications.
*Color image processing:*Color models RGB, HSI, YUV, pseudo-color image processing, full-color image processing, color transformation, color segmentation.

Texts/References Books:

1.	Fundamentals of Digital Image processing	A. K. Jain	Pearson Education, 1989
2.	Digital Image Processing	R. C. Gonzalez and R. E. Woods	Pearson Education, 2001
3.	Digital Image Processing using MATLAB	R. C. Gonzalez , R. E. Woods and S. L. Eddins	Pearson Education, 2004
4.	Digital Image Processing	G. A. Baxes	John Wiley, 1994
5.	Digital Image Processing and Computer Vision	R.J. Schalkoff	John Wiley, 1989
6.	Image Processing	Sid Ahmed	McGraw -Hill, 1994
7.	S.J. Solari	Digital Video and Audio Compression	McGraw-Hill, 1996

EC 1542	ADAPTIVE FILTER THEORY	3-0-0-3

	Pre-requisite- DSP, Adaptive Control Theory.	

Introduction to Adaptive Filters: Adaptive filter structures, issues and examples, Applications of adaptive filters: Channel equalization, active noise control, Echo cancellation and beamforming.
Discrete time stochastic processes: Re-visiting probability and random variables, Discrete time random processes, Power spectral density – properties, Autocorrelation and covariance structures of discrete time random processes, Eigen-analysis of autocorrelation matrices.
Wiener filter, search methods and the LMS algorithm: Wiener FIR filter (real case), Steepest descent search and the LMS algorithm, Extension of optimal filtering to complex valued input, The Complex LMS algorithm.
Convergence and Stability Analyses: Convergence analysis of the LMS algorithm, Learning curve and mean square error behavior, Weight error correlation matrix, Dynamics of the steady state mean square error, Misadjustment and stability of excess mean square error.
Variants of the LMS Algorithm: The sign-LMS and the normalized LMS algorithm, Block LMS, Review of circular convolution, Overlap and save method, circular correlation, FFT based implementation of the block LMS Algorithm.
Vector space framework for optimal filtering: Axioms of a vector space, examples, subspace, Linear independence, basis, dimension, direct sum of subspaces, Linear transformation, examples, Range space and null space, rank and nullity of a linear operator, Inner product space, orthogonality, Gram-Schmidt orthogonalization, Orthogonal projection, orthogonal decomposition of subspaces, Vector space of random variables, optimal filtering.
The lattice filter and estimator: Forward and backward linear prediction, signalsubspace decomposition using forward andbackward predictions, Order updating the prediction errors and predictionerror variances, basic lattice section, Reflection coefficients, properties, updatingpredictor coefficients, Lattice filter as a joint process estimator, AR modeling and lattice filters, Gradient adaptive lattice.
RLS lattice filter: Least square (LS) estimation, pseudo-inverse of a data matrix, optimality of LS estimation, Vector space framework for LS estimation, Time and order updating of an orthogonal projection operator, Order updating prediction errors and prediction error power, Time updating PARCOR coefficients.

Text Books/ References:

1.	Adaptive Filter Theory	S. Haykin	Prentice Hall, Englewood Cliffs, NJ
2.	Adaptive Filters – Theory and Applications	B. Farhang-Boroujeny	John Wiley and Sons
3.	Fundamentals of Adaptive Filtering	Ali H. Sayed	John Wiley
4.	Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing	D. Manolakis, V. Ingle and S. Kogan	McGraw Hill
5.	Adaptive Signal Processing	B. Widrow and S. Stearns	Prentice-Hall

EC 1543	**BIOMEDICAL SIGNAL PROCESSING**	**3-0-0-3**
	Pre-requisite- DSP, Signal & System, Signal Processing.	

Introduction to Biomedical Signals: Examples and acquisition of Biomedical signals - ECG, EEG, EMGetc - Tasks in Biomedical Signal Processing - Computer Aided Diagnosis. Origin of bio potentials.
Review of linear systems: Fourier Transform and Time Frequency Analysis (Wavelet) of biomedical signals- Processing of Random & Stochastic signals - spectral estimation – Properties and effects of noise in biomedical instruments - Filtering in biomedical instruments.
Concurrent, coupled and correlated processes: illustration with case studies - Adaptive and optimal filtering- Modeling of Biomedical signals - Detection of biomedical signals in noise - removal of artifacts of one signal embedded in another -Maternal-Fetal ECG - Muscle-contraction interference. Event detection – case studies with ECG & EEG - Independent component Analysis - Cocktail party problem applied to EEG signals - Classification of biomedical signals.
Cardio vascular applications: Basic ECG - Electrical Activity of the heart- ECG data acquisition – ECG parameters & their estimation - Use of multiscale analysis for ECG parameters estimation - Noise &Artifacts- ECG Signal Processing: Baseline Wandering, Power line interference, Muscle noise filtering – QRS detection - Arrhythmia analysis - Data Compression: Lossless &Lossy- Heart Rate Variability – Time Domain measures - Heart Rhythm representation - Spectral analysis of heart rate variability – interaction with other physiological signals.
Neurological Applications: The electroencephalogram - EEG rhythms & waveform - categorization of EEG activity - recording techniques - EEG applications- Epilepsy, sleep disorders, brain computer interface.

Modeling EEG- linear, stochastic models - Nonlinear modeling of EEG - artifacts in EEG & their characteristics and processing - Model based spectral analysis - EEG segmentation - Joint Time-Frequency analysis - correlation analysis of EEG channels - coherence analysis of EEG channels.

Text books:

1.	Biomedical Signal Processing: Principles and techniques	D.C.Reddy	Tata McGraw Hill, New Delhi, 2005
2.	Biosignal and Biomedical Image Processing	Marcel Dekker	Semmlow, 2004

Reference books:

1.	Biomedical Signal Processing & Signal Modeling	Bruce	Wiley, 2001
2.	Bioelectrical Signal Processing in Cardiac & Neurological Applications	Sörnmo	Elsevier
3.	Biomedical Signal Analysis	Rangayyan	Wiley 2002
4.	Introduction to Biomedical Engineering	Enderle	Elsevier, 2/e, 2005

EC 1544 SMART ANTENNAS

3 0 0 3

INTRODUCTION: Antenna gain, Phased array antenna, power pattern, beam steering, degree of freedom, optimal antenna, adaptive antennas, smart antenna - key benefits of smart antenna technology, wide band smart antennas, Digital radio receiver techniques and software radio for smart antennas.

(5)

NARROW BAND PROCESSING: Signal model conventional beam former, null steering beam former, optimal beam former, Optimization using reference signal, beam space processing.

(7)

ADAPTIVE PROCESSING: Sample matrix inversion algorithm, unconstrained LMS algorithm, normalized LMS algorithm, Constrained LMS algorithm, Perturbation algorithms, Neural network approach, Adaptive beam space processing, Implementation issues.

(9)

BROADBAND PROCESSING: Tapped delay line structure, Partitioned realization, Derivative constrained processor, Digital beam forming, Broad band processing using DFT method.

(7)

DIRECTION OF ARRIVAL ESTIMATION METHODS: Spectral estimation methods, linear prediction method, Maximum entropy method, Maximum likelihood method, Eigen structure methods, Music algorithm – root music and cyclic music algorithm, the ESPRIT algorithm.

(7)

DIVERSITY COMBINING: Spatial diversity selection combiner, switched diversity combiner, equal gain combiner, maximum ratio combiner, optical combiner.

(7)

REFERENCES:

1. Lal Chand Godara, "Smart Antennas" CRC press, 2004.
2. Joseph C Liberti.Jr and Theodore S Rappaport, "Smart Antennas for Wireless Communication: IS-95 and Third Generation CDMA Applications", Prentice Hall 1999.
3. Balanis, "Antennas", John Wiley and Sons, 2005.

EC 1545	**DIGITAL SPEECH PROCESSING**	**3-0-0-3**
	Pre-requisite-Digital Signal Processing	

Fundamentals of Digital Speech Processing: Anatomy & Physiology of Speech Organs, The process of Speech Production, The Acoustic Theory of Speech Production, Digital models for speech signals.

Time Domain Models For Speech Processing: Introduction, Window considerations, Short time energy and average magnitude Short time average zero crossing rate, Speech vs. silence discrimination using energy and zero crossing, Pitch period estimation using a parallel processing approach, The short time autocorrelation

function, The short time average magnitude difference function, Pitch period estimation using the autocorrelation function.
Linear Predictive Coding (LPC): Basic principles of Linear Predictive Analysis: The Autocorrelation Method, The Covariance Method, Solution of LPC Equations: Cholesky Decomposition Solution for Covariance Method, Durbin's Recursive Solution for the Autocorrelation Equations, Pitch Detection and using LPC Parameters.
Homomorphic Speech Processing: Introduction, Homomorphic Systems for Convolution: Properties of the Complex Cepstrum, Computational Considerations, The Complex Cepstrum of Speech, Pitch Detection, Formant Estimation, Mel frequency cepstrum computation.
Speech Enhancement: Nature of interfering sounds, Speech enhancement techniques: spectral subtraction, Enhancement by re-synthesis, Comb filter, Wiener filter.
Automatic Speech Recognition: Basic pattern recognition approaches, parametric representation of speech, evaluating the similarity of speech patterns, Isolated digit Recognition System, Continuous digit Recognition System.
Hidden Markov Model for Speech Recognition: Hidden Markov Model (HMM) for speech recognition, Viterbi algorithm, Training and testing using HMMs, Adapting to variability in speech (DTW), Language models.
Speaker Recognition: Issues in speaker recognition and speech synthesis of different speakers. Text to speech conversion, Calculating acoustic parameters, synthesized speech output performance and characteristics of text to speech, Voice processing hardware and software architectures.

Text Books:

1.	Digital processing of speech signals	L.R Rabiner and S.W. Schafer	Pearson Education, Delhi, India
2.	Speech Communications: Human & Machine	Douglas O'Shaughnessy	IEEE Press
3.	Fundamentals of Speech Recognition	L.R Rabinar and B.H. Juang and B. Yegnanarayana	Pearson Education
4.	Discrete time processing of speech signal	J. R. Deller, Jr., J. H. L. Hansen and J. G. Proakis	Wiley-IEEE Press, NY, USA

References:

1.	Discrete Time Speech Signal Processing: Principles and Practice	Thomas F. Quateri	Pearson Education
2.	Speech and Audio Signal Processing	Ben Gold and Nelson Morgan	Wiley
3.	Speech Recognition	Claudio Becchetti and Lucio PrinaRicotti	Wiley

EC 1546	**AUDIO VIDEO CODING AND STANDARDS**	**3-0-0-3**
	Pre-requisite- Digital Signal Processing, Digital Image Processing	

Introduction, basics of multimedia compression and coding, multimedia compression systems, loss less and lossy compression, Huffman coding, arithmetic coding, Lempel ziv coding, run-length coding, theory of quantization, lossy predictive coding, transform coding,

Video coding basics, temporal redundancy, motion estimation, block based motion estimation--- full search, 2D logarithmic search, cross search, three step search, new three step search, diamond search, video coding standards---MPEG-1/2/4, H.261/263/264, scalable video coding, High Efficiency Video Coding (HEVC), error resiliency, error concealment, video quality assessment index—MSE, SNR, PSNR, SSIM etc.

Basics of audio coding, human auditory perception, perceptual coding, transforms and filter banks, analysis and synthesis filter, poly-phase filter for audio coding, psychoacoustic model, audio coding standards, MPEG-4 audio coding, G.721.

Text/Reference Books:

1.	264 and MPEG-4 Video Compression: Video Coding for Next-generation Multimedia	**I. Richardson**	John Wiley & Sons, 2003
2.	Digital Video Processing	T. Murat	Prentice-Hall, 1995
3.	Voice and Audio Compression for Wireless Communication	L. Hanzo, F. C. Sommerville and J. Woodland	John Wiley and IEEE Press, 2nd Edition, 2007
4.	Multidimensional Signal, Image and Video Proceesing and Coding	J.M.Woods	Academic Press/Elsevier, 2nd Edition, 2012

EC 1547	**VLSI-DSP BASED DESIGN**	**3-0-0-3**
	Pre-requisite- VLSI, DSP.	

IC basics - power, delay, throughput, bandwidth, non-linearity.
Algorithm transforms, retiming, pipelining, parallel processing, unfolding, folding and dynamic algorithm transforms (DAT).
Signal processing kernels for communications, analog filters, digital filters, adaptive filters, finite-precision filters.
Detection kernels and architectures for communications, symbol-by- symbol (SBS) detectors (with and without ISI), sequence detectors.
Source compression, lossless (Huffman, arithmetic coding), lossy (quantization, DCT, DPCM, ADPCM, Motion estimation.
Single-carrier Systems and Architectures, constellations, waveform shaping, Nyquist signaling, partial-response signaling, equalization.
Multi-carrier (DMT and OFDM) Systems and Architectures.Architectures for multi-input, multi-output (MIMO) receivers.
Introduction to ECC, finite-field arithmetic, architectures for algebraic codes (Reed-Solomon, BCH). Convolutional codes, Viterbi algorithm and architecture, soft-output Viterbi architecture (SOVA), and the MAP architecture, Turbo and LDPC decoder architectures

Text/Reference books:

1.	VLSI for Wireless Communication	B. Leung,	Springer/Dorling Kinderslay/Pearson
2.	RF Microelectronics	B. Razavi,	Dorling Kinderslay/Pearson
3.	CMOS Integrated Analog-to-Digital and Digital-to-Analog Converters	R. J. Plassche	Springer/BSP Books
4.	Digital Compensation for Analog Front-Ends: A New Approach to Wireless Transceiver Design	F. Horlin and A. Bourdoux	John Wiley & Sons
5.	VLSI Digital Signal Processing Systems, Design and Implementation	K. K. Parhi	Wiley India Pvt Ltd
6.	Design of Analog-Digital VLSI Circuits for Telecommunication and Signal Processing	J.E. Franca and Y. Tsividis	Prentice Hall- Gale
7.	Digital Signal Processing – A Practical Approach	E. C. Ifeachor and B. W. Jervis	Dorling
8.	Digital Communications	B. Sklar	Prentice Hall
9.	Synthesis and Optimization of Digital Circuits	Micheli Giovanni De	Tata Mcgraw Hill

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

Course Structure

M. Tech. in Microelectronics & VLSI Design

Semester I			
Code	**Course Name**	**L–T-P**	**Credits**
EC 2501	Semiconductor Device Physics	3-0-0	3
EC 2502	Digital VLSI Design	3-0-0	3
EC 2503	Device Modelling	3-0-0	3
EC 25XX	Elective I	3-0-0	3
EC 25XX	Elective II	3-0-0	3
EC 2504	VLSI Lab I	0-0-3	2
EC 2510	Seminar	0-0-2	1
	Total Credits	**15-0-5**	**18**

Elective - I

EC 2531: Design and Synthesis using Verilog HDL

EC 2532: Nanoelectronics

EC 2533: Embedded System

EC 2534: VLSI DSP Design

EC 2535: Semiconductor Optoelectronics, theory & Design

Elective -II

EC 2541: ASIC design & FPGA

EC 2542: Foundation of VLSI CAD

EC 2543: MEMS Analysis

EC 2544: Low Power VLSI

EC 2545: RF Design

Detailed Syllabi

FIRST SEMESTER

EC 2501	SEMICONDUCTOR DEVICE PHYSICS	L	T	P	C
	First Semester	3	0	0	3

Introduction to semiconductor physics: review of crystal structure and harmonic wave motion, evolution of quantum mechanics, Schrodinger's wave theory, bound and scattering states, quantum tunneling, one electron theory – Bloch theorem, Kronig-Penney model, crystal momentum and effective mass, 3D lattice – $E-k$ diagram, allowed and forbidden bands, density of states, carrier statistics and distribution functions, generation and recombination - excess carriers in semiconductors, Boltzmann transport equation, Continuity equation, Poisson's equation and their solution; High field effects: velocity saturation, hot carriers and avalanche breakdown.

Semiconductor junctions: Schottky and Ohmic contacts, homo- and hetero-junction band diagrams and I-V characteristics, small signal switching models.

Texts/References:

1. D. J. Griffiths , Introduction to Quantum Mechanics
2. D. A. Neamen, Semiconductor Physics and Devices
3. R. L. Liboff, Introductory Quantum mechanics
4. N. W. Ashcroft and N. D. Mermin, Solid State Physics
5. J. P. Mckelvey, Solid State and Semiconductor Physics, Harper and Row, 1966.
6. D.K. Schroder, Semiconductor Material and Device Characterization, John Wiley, 1990.
7. C.T. Sah, Fundamentals of Solid-State Electronic Devices, Allied Publishers and World Scientific, 1991.
8. E.F.Y. Waug, Introduction to Solid-State Electronics, North Holland, 1980

EC 2502	DIGITAL VLSI DESIGN	L	T	P	C
	First Semester	3	0	0	3

Review of MOSFET operation and CMOS process flow: MOS Threshold voltage, MOSFET I-V characteristics: Long and short channel, MOSFET capacitances, lumped and distributed RC model for interconnects, transmission lines, CMOS process flow, Layout and design rules.

CMOS inverter: Static characteristics, power consumption, dynamic behavior, buffer design using the method of logical effort.

Combinational logic: Transistor sizing in static CMOS logic gates, static CMOS logic gate sizing considering method of logical effort, dynamic logic, pass-transistor logic, common mode and other cross-coupled logic families.

Sequential logic: Static latches and flip-flops (FFs), dynamic latches and FFs, sense-amplifier based FFs, NORA-CMOS, Schmitt trigger, monostable and astable circuits.

VLSI system design: Data and control path design.

Design and implementation strategies of digital VLSI systems:
Full and Semi-custom; Static and Dynamic MOS Logic design and Characteristics

Memories and array structures: MOS-ROM, SRAM cell, memory peripheral circuits

Introduction to ASIC and FPGA based system Design.

Texts/References:

1. Jan M. Rabaey, AnanthaChandrakasan, Borivoje Nikolic, "Digital Integrated Circuits: A Design Perspective," Prentics Hall, 2003.
2. Sung-Mo Kang, Yusuf Liblebici, "CMOS Digital Integrated Circuits," Tata Mc Graw Hill, 2003.
3. R. Jacob Baker, "CMOS Mixed-Signal Circuit Design," Wiley India Pvt. Ltd, 2009
4. Ivan Sutherland, R. Sproull and D. Harris, "Logical Effort: Designing Fast CMOS Circuits", Morgan Kaufmann, 1999.

EC 2503	DEVICE MODELLING	L T P C
	First Semester	3 0 0 3

Contact Potentials: Overview.

Two-terminal MOS structure: flat-band voltage, potential and charge balance, channel charge, accumulation, depletion, inversion, threshold voltage, small signal capacitances.

Three-terminal MOS structure: effect of channel-body potential, body effect, inversion regions, contacting the inversion layer, region of inversion: approximate limits, threshold voltage, V_{CB} control point of view, pinch-off voltage.

Four-terminal MOS Transistor: Complete charge-sheet model, simplified charge-sheet model, strong and weak inversion approximation to the channel current, effective surface mobility, field dependence of the surface mobility, breakdown.

Small-Dimensional Effects: Long- and short-channel MOS transistor, carrier velocity saturation, channel length modulation, charge sharing, DIBL, threshold voltage rolls-off, narrow channel effects, punch-through, hot-carrier effects, GIDL, scaling: constant field and constant voltage scaling, non-scaling effects, modern scaling.

Texts/References:

1. YannisTsividis , Operation and Modeling of the MOS Transistor, Oxford University Press.-

2. N. Arora, MOSFET models for VLSI Circuit Simulation, Springer-Verlag.
3. Ning and Taur, Fundamentals of modern VLSI devices, Oxford university press.

Elective – I

EC 2531	Design and Synthesis using Verliog HDL	L T P C
		3 0 0 3

Design Concepts – Digital Hardware, Design Process, and Design of digital hardware, Introduction to CAD tools, and introduction to verilog/VHDL.

Logic system, data types and operators for modeling in verilog HDL. Verilog Models of propagation delay and net delay path delays and simulation, inertial delay effects and pulse rejection. Behavioral descriptions in Verilog HDL.

Synthesis of combinational logic – multiplexers, decoders, encoders, code converters, arithmetic comparison circuits, verilog/vhdl for combinational circuits.

Synthesis of Sequential logic- Flip-Flops- SR, D, Master slave edge triggered D, T, JK, registers – shift registers, parallel access shift registers, counters – asynchronous, synchronous, counters with parallel load, reset synchronization, other counters, simple processor

Synchronous sequential circuits – basic design steps, state assignment problem, serial adder, state minimization, design of counter using the sequential circuit approach, FSM as an arbiter circuit, ASM.

Asynchronous Sequential Circuit – Analysis and synthesis of asynchronous circuits, state assignment, state reduction, hazards

Testing of Logic circuits – Fault models, path sensitizing, built-in self-test (BIST),

Text Books

1. M.D.Ciletti, “Modeling, Synthesis and Rapid Prototyping with the Verilog HDL”, PHI, 1999.
2. S. Palnitkar, “Verilog HDL – A Guide to Digital Design and Synthesis”, Pearson, 2003.

Reference Books

1. J Bhaskar, “A Verilog HDL Primer (3rd edition)”, Kluwer, 2005.
2. M.G.Arnold, “Verilog Digital – Computer Design”, Prentice Hall (PTR), 1999.

3. Recent literature in Modeling and Synthesis with Verilog HDL.

EC 2532	Nanoelectronics	L T P C
		3 0 0 3

Classification of Materials and Devices, Various Semiconductor materials and their advantages & disadvantages, Properties of Semiconductor, Band model for semiconductors, bonding forces and energy bands in solids, charge carriers in semiconductors. MOS Scaling theory, Issues in scaling MOS transistors: Short channel effects, Requirements for Non classical MOS transistor. Solid State Devices.
Schottky and Ohmic contact, Tools used for Nanoelectronics, Fabrication/ Synthesis techniques of thin film devices, Characterization of thin film devices.

Texts/References:

1. S.M. Sze, "Physics of semiconductor devices", Wiley Pub.
2. B.G. Streetman, "Solid State Electronics Devices", Prentice Hall, 2002.
3. M.S.Tyagi, "Semiconductor Materials and Devices," Wiley Pub.
4. D. J. Griffiths , Introduction to Quantum Mechanics
5. D.K. Schroder, Semiconductor Material and Device Characterization, John Wiley, 1990.
6. C.T. Sah, Fundamentals of Solid-State Electronic Devices, Allied Publishers and World Scientific, 1991.

EC 2533	Embedded system	L T P C
		3 0 0 3

Introduction: Embedded system Overview, Design challenge, processor Technology, IC Technology, Full custom, VLSIDesign technology (Compilation/Systhesis), Custom Single–purpose Processor: HardwareTransistor and logic gatecustom single purpose processor design, Optimizing custom single-purpose processor design, Bus architecture

General purpose Processor: Basic architecture, Operation, Programmer view, Development environment, ASIP micro controller, Bus architecture.

Standard single purpose processor: Timer, counter, UART, LCD Contorller, Key pad controller, Stepper motor controller.

Memory Technology, Multilevel Bus Architecture, Interface technology, Parallel /Serial Communication Technology, Serial protocols(I^2C,CAN,USB, Parallel protocols PCI BUS, ARM Bus.

References:

1. Embedded System Design by Vahid/Givargis
2. The Power PC Architecture - Cathy May and Ed Silha, Morgan Kauffmann, 1998.
3. The Programming Environment for 32-Bit Microprocessors - Motorola
4. MPC860 User's Manual - Motorola.
5. An Implementation guide to Real Time Programming - David L. Ripps, Yourdon Press, 1990.
6. Programming Microsoft Windows CE - Douglas Boling, Microsoft Press, 2001.
7. Building Powerful platform with Windows CE - James Y. Wilson and Havewala, Addison Wesley, 2001.
8. Embedded Systems : Architecture, Programming and Design- RajKamal, TMH,2003
9. Frank Vahid and Tony Givargis, Embedded system design: A unified hardware/software introduction, John Wiley and Sons, 2002.

EC 2534	**VLSI DSP Design**	**L T P C**
		3 0 0 3

Computational characteristics of DSP algorithms and applications; their influence on defining a generic instruction-set Architecture for DSPs.

Architectural requirement of DSPs: high throughput, low cost, low power, small code size, embedded applications. Techniques for enhancing computational throughput: parallelism and pipelining.

Data-path of DSPs: multiple on-chip memories and buses, dedicated address generator units, specialized processing units (hardware multiplier, ALU, shifter) and on-chip peripherals for communication and control.

Control-unit of DSPs: pipelined instruction execution, specialized hardware for zero-overhead looping, interrupts.

Architecture of Texas Instruments fixed-point and floating-point DSPs: brief description of TMS320 C5x /C54x/C3x DSPs; Programmer's model.

Architecture of Analog Devices fixed-point and floating-point DSPs: brief description of ADSP 218x / 2106x DSPs; Programmer's model.

Advanced DSPs: TI's TMS 320C6x, ADI's Tiger-SHARC, Lucent Technologies' DSP 16000 VLIW processors. Applications: a few case studies of application of DSPs in communication and multimedia.

References:

1. P. Pirsch: Architectures for Digital Signal Processing; John Wiley, 1999.
2. R. J. Higgins: Digital Signal Processing in VLSI; Prentice-Hall, 1990.
3. Texas Instruments TMSC5x, C54x and C6x Users Manuals.
4. Analog Devices ADSP 2100-family and 2106x-family Users Manuals.
5. K. Parhi: VLSI Digital Signal Processing Systems; John Wiley, 1999.
6. K. Parhi and T. Nishitani: Digital Signal Processing for Multimedia Systems; Marcel Dekker, 1999.
7. IEEE Signal Processing Magazine: Oct 88, Jan 89, July 97, Jan 98, March 98 and March 2000.

EC 2535	Semiconductor Optoelectronics, theory & Design	L T P C
		3 0 0 3

Introduction:

Energy levels & bands in solids, Spontaneous & stimulated transitions: the creation of light Transverse confinement of carriers' and photons in Diode Lasers: the double Heterostructure. Semiconductor materials for Diode Lasers. Epitaxial Growth Technology. Lateral confinement of current carriers and photons for practical lasers.

A Pbel1omenologicat approach to Diode Lasers:

Carrier generation and recombination in active regions. Spontaneous photon generation and LED. Photon generation and loss in laser cavities. Threshold or steady state gain in lasers. Threshold current and Power out vs. current. Relaxation resonance and frequency response. Characterizing real Diode Lasers.

Mirrors and Resonator for Diode Lasers:

Scattering theory. S and T matrices for some common elements. Three and four mirror laser cavities.

Gratings, DaR Lasers and DFB Lasers. Mode suppression ratio in single frequency lasers.

Gain and Current relations: ' Introductions. Radiative transitions. Optical gains. Spontaneous - emission. Nonradiative transitions. Active materials and their characteristics.

Dynamic Effect: I J The rate equations. Steady state solutions. Steady state multimode solutions. Differential analysis of the, rate equations. Large signal analysis. Relative intensity noise and linewidth. Carrier transport effect.

Feedback effect.

Perturbation and Coupled Mode Theory:

Dielectric Waveguide:

Introduction. Plane wave incident on a planar dielectric boundary. Dielectric waveguide analysis technique. Guided mode power and effective width. Radiation losses for nominally guided mode.

Topics in the Application of Diode Lasers in Fiber Optic Communication.

Texts/References:

1. Larry A Coldren& S W Corzine: Diode Lasers & Photonic Integrated Circuits, Willey Interscience ISBN : 04711 18753
2. S L Chuang: Physics of Optoelectronic Devices, Willey Interscience ISBN: 0471109398.

Elective II

EC 2541	**ASIC design & FPGA**	**L T P C**
		3 0 0 3

Introduction to ASICs and FPGAs, Fundamentals in digital IC design, FPGA & CPLD Architectures, FPGA Programming Technologies, FPGA Logic Cell Structures, FPGA Programmable Interconnect and I/O Ports, FPGA Implementation of Combinational Circuits, FPGA Sequential Circuits, Timing Issues in FPGA Synchronous Circuits, Introduction to Verilog HDL, FPGA design flow with Verilog HDL, FPGA Arithmetic Circuits, FPGAs in DSP Applications, FPGA Microprocessor design, Design Case Studies, FPGA High-level Design Techniques, Programming FPGAs in Electronic Systems, Dynamically Reconfigurable Systems, Latest Trends in Programmable ASIC and System Design.

References:

1. Wayne Wolf, FPGA -Based System Design, Prentice Hall, 2004
2. M. D. Ciletti, Advanced Digital Design with Verilog HDL, Prentice Hall, 2002
3. John P. Hayes, Computer Architecture and Organization, Third Edition, Magraw-Hill, 1998
4. Michael Smith, Application-Specific Integrated Circuits, Addison-Wesley, 1997
5. Keshab K. Parhi, VLSI Digital Signal Processing Systems: Design and Implementation, Wiley, 1998
6. Xilinx User Manuals and Application Notes

EC 2542	**Foundations of VLSI CAD**	**L T P C**
		3 0 0 3

Layout Environment, layout methodologies, packaging, Delay models, rise-time & fall time delay, Gate delay, Power Dissipation, Static & Dynamic power dissipation, total power dissipation, power minimization.

Design Strategies, Design Synthesis.

Placement - portioning, floor-planning, placement.

Routing – Global & Detailed Routing, Routing in FPGA.

Design Verification & Testing.

References:

1. M. Sarrafzadeh& C.K Wong – An Introduction to Physical VLSI Design
2. Neil Weste& K Eshraghian – Principles of CMOS VLSI Design.

EC 2543	**MEMS Analysis**	**L T P C**
		3 0 03

Introduction: What is MEMS? Unique Characteristics of MEMS and Typical Application Areas of MEMS

IC fabrication vs MEMS Fabrication: Deposition, lithography, oxidation, etching, Plasma etching, Sputtering, RIE, 1, 2 and 3 mask level processes, wet etching (anisotropic and isotropic), crystal directions in Si, Bulk micro-machining, Surface micro-machining, wafer bonding, Electroplating, Molding etc.

Introduction to Beam Mechanics: Relationship between tensile stress and stain- mechanical properties of silicon and thin films, Flexural beam bending analysisunder single loading condition- Types of beam- deflection of beam-longitudinal stain under pure bending spring constant, torsional deflection, intrinsic stress, resonance and quality factor.

Sensing and Actuation: Electrostatic sensing and actuation-parallel plate capacitor – Application-Inertial, pressure and tactile sensor parallel plate actuator- comb drive.

Thermal sensing and Actuations-thermal sensors-Actuators- Applications- Inertial, Flow and Infrared sensors.

Piezoresistive sensors- piezoresistive sensor material- stress in flexural cantilever and membrane Application-Inertial, pressure, flow and tactile sensor.

Piezoelectric sensing and actuation- piezoelectric material properties-quartz-PZT-PVDF –ZnO Application-Inertial, Acoustic, tactile, flow-surface elastic waves

Magnetic actuation- Micro magnetic actuation principle- deposition of magnetic materials- Design and fabrication of magnetic coil.

Electrothermal MEMS: Flow Sensors, Gas Detectors, Uncooled Infrared Sensors, Bimorph Actuators, Bent-Beam Actuators.

RF MEMS: Switches, active and passive components, static and dynamic modeling.

CMOS-MEMS Integration: Overview, different techniques, packaging and integration.

Overview of BioMEMS, Microfluidics: Biosensor and BioMEMS; Microfluidics; Digital Microfluidics; Ink jet printer.

Text/References

1. Chang Liu, Foundations of MEMS, Pearson Education Asia, 2012.
2. S. D. Senturia, Microsystem Design, Springer, India, 2006.

EC 2544	Low Power VLSI	L T P C
		3 0 03

Introduction: Introduction, Motivation for low power design, need and application low power design, Low power design space: voltage, Physical Capacitance, Switching Activity.

Sources of power consumption and Power estimation: Static power and dynamic power: switching component of power, short circuit component of power, leakage component of power and other component of power consumption. Power estimation considering node transition activity factor, glitchingeffect and glitching power

Voltage Scaling approaches for low power design: reliability driven voltage scaling, technology driven voltage scaling, energy-delay minimum based voltage scaling, voltage scaling through threshold reduction, architecture driven voltage scaling.
Adiabatic Switching for low power design: concept of adiabatic charging, adiabatic amplification. Adiabatic logic gates, stepwise charging, pulsed power supply.

Switching Capacitance minimization for low power design: Algorithmic approaches, Architecture optimization, Logic optimization, Circuit optimization, physical design optimization.

Low power adder design: introduction, Standard adder: half adder, full adder, CMOS adder architectures: Ripple carry adder (RCA), Carry look- Ahead adder (CLA), Carry Select Adder (CSL), Carry Save Adder (CSA), Carry Skip Adder (CSK), Conditional Sum Adder (COS), Performances of all the adders with low power design, BiCMOS adders.

Texts/References

1. Low Power Digital CMOS Design - Anantha P. Chandrakasan and Robert W. Broderson.
2. Low Power CMOS VLSI Circuit Design- Kaushik Roy and Sarat C. Prasad
3. Low – Voltage, Low – Power VLSI Subsystems"- Kiat-Seng Yeo and Kaushik Roy.

EC 2545	**RF Design**	**L T P C**
		3 0 03

Passive/active IC devices, Passive RLC network, Distributed systems, Smith chart, Bandwidth estimation tech., RF amplifier design, Voltage reference & biasing, Noise, LNA design, Mixers, RF power amplifiers, Feedback systems, Phase-locked loop, Oscillator, synthesizer, Phase noise, Resonant Circuits, Filter Design, Impedance Matching, The Transistor at Radio Frequencies, Small-Signal RF Amplifier Design, RF Power Amplifiers.

Texts/References:

1. R. Ludwig and P. Bretchko, RF Circuit Design. Prentice Hall, 2000.
2. Chris Bowick, RF Circuit Design, Newens, 1997.

EC 2504	**VLSI Lab – I**	**L T P C**
	First Semester	0 0 32

The laboratory course consists of experiments and simulation with analog and digital circuits and microprocessor applications. Around 10 experiments from the list will be assigned.

1. Two stage CE amplifier.
2. Automatic Gain control circuit using JFET as Voltage controlled resistance.
3. Programmable gain amplifier using CD4066 analog switch.
4. Wein bridge oscillator with amplitude stabilization using JFET.
5. Regulated power supply with short circuit protection.
6. Regulated power supply with fold back current limiting and crowbar protection.
7. Frequency multiplier using phase locked loop.
8. Differential amplifier using IC transistor array.
9. Digital circuit to implement given task or truth table.
10. Stopwatch using TTL ICs.
11. PRBS generator.
12. Arbitrary waveform generator using RAM and D/A converter.
13. Logic probe
14. Stopwatch using interrupt on microprocessor kit
15. TTL IC tester using 8255 on microprocessor kit.
16. Analog Signal input and output using A/D and D/A converters interfaced to microprocessor kit.

Course Structure for
M.Tech. (Instrumentation Engineering)

Subject Code	Subject		L	T	P	C
Semester I						
EI 1501	Advanced Sensing Technology		3	0	0	3
EI 1502	Advanced Signal Processing		3	0	0	3
EI 1503	Modern Control Systems		3	0	0	3
EI 1511	Design, Simulation and Development Lab		0	0	3	2
EI xxxx	Elective I		3	0	0	3
EI xxxx	Elective II		3	0	0	3
		Total	17	0	0	17

ELECTIVES

Subject Code	Subject	L	T	P	C
	Elective I				
EI 1541	Intelligent Control	3	0	0	3
EI 1542	Smart Sensors	3	0	0	3
EI 1543	Optimization Techniques	3	0	0	3
EI 1544	Artificial Intelligence	3	0	0	3
EI 1545	Microelectronics and VLSI Design	3	0	0	3
EI 1546	Advanced Wireless Communication	3	0	0	3
EI 1547	Fibre Optics and LASER Instrumentation	3	0	0	3
EI 1548	Testing and Calibration of instruments	3	0	0	3
EI 1549	Industrial Instrumentation	3	0	0	3
	Elective II				
EI 1551	Robotics & Automation	3	0	0	3
EI 1552	PC Based Instrumentation	3	0	0	3
EI 1553	Information and Communication Theory	3	0	0	3
EI 1554	Intelligent Instrumentation	3	0	0	3
EI 1555	Computer Controlled Processes	3	0	0	3
EI 1556	Biomedical Signal Processing	3	0	0	3
EI 1557	IC Technology & Applications	3	0	0	3
EI 1559	Data Acquisition and Signal Conditioning	3	0	0	3

DETAILED SYLLABUS

EI 1501	Advanced Sensing Technology	L	T	P	C
	First Semester	3	0	0	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:
CO1: Understand the application of different chemical sensors for chemical process industry.
CO2: Apply the principles of optic fiber system and mode of light transfer to the various applications.
CO3: Apply the different sensors to the various biomedical applications.
CO4: Understand the different type of electrodes and its usage.
CO5: Understand and design signal conditioning circuits.

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓							
CO2				✓	✓		✓		✓
CO3	✓		✓			✓			
CO4		✓		✓	✓				✓
CO5	✓						✓	✓	✓

SYLLABUS

INTRODUCTION

Review of sensors principles and applications. Basic sensors signal processing requirements and description. Basic elements of data acquisition and signal conditioning.

CHEMICAL SENSORS

Physical Sensors – Surface Micro Machined Capacitive Pressure sensor, integrated flow sensor, Chemical and Biochemical Sensors – Conductivity sensor, Hydrogen Sensitive MOSFET, Tri-OxideSensors, Schottky diode type sensor, Solid Electrolyte, Electrochemical Sensors. Sensor Matrix forTwo dimensional measurement of concentrations

OPTICAL SENSOR

Holography, Echolocation and bio holography, Sensors used in space and environmental applications.Application in meterorology, natural resources application sensor used in Instrumentation methods. Fibre-optic sensors and their applications.

BIOMEDICAL SENSORS

Biological Sensors in Human Body – Different types of Transducer system – Physiological Monitoring – chemo receptors – Hot and cold receptors – sensors for smell, sound, vision taste ELECTRODESpH –EEG – ECG, EMG, Bio sensors – Plethysmography, Instruments based on knot of sound.Ultrasonic Transducers for Measurement and therapy – radiation detectors – NIR spectroscopy –NMR. MRI

ADVANCED SENSOR DESIGN

Sensor design a sensor characteristics, Design of signal conditioning devices for sensors. Design of
2& 4 wire transmitters with 4 – 20 mA output. Pressure Sensor using SiSi bonding, Catheter pressuresensors, TIP pressure sensors, High pressure sensors, Silicon accelerometers.Aerospace SensorGyroscope laser and fibre optic gyroscopes, accelerometers. Laser, Aerospace application of laser,Resolvers, Altimeters, Angle of attack sensors, servos.

SMART SENSORS

Introduction, Basics of smart sensor, Micromachining Techniques, signal conditioning circuits.

TEXT BOOKS

1. Sabaree Soloman, Sensors Hand Book, McGraw Hill, 1998
2. Carr and Brown, Introduction to Medical Equipment Technology, Addison Wesley, 1999

REFERENCES

1. Smith H. M. Principles of Holography, John Wiley & Sons, New York, 1975
2. J. G. Webster, Medical instrumentation Application and Design, Houghton Mifilin Co.

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EI 1502	AdvancedSignalProcessing	L	T	P	C
	First Semester	3	0	0	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:

CO1 : understand basics of digital signal processing to analyze Linear Time Invariant systems and various transforms.

CO2: acquire the knowledge to design FIR and IIR filters for signal conditioning circuits.

CO3: apply the knowledge of signal processing to design a multi-rate signal processing system.

CO4: analyze different wave-shaping circuits and signal conditioning circuit for the sensor output.

CO5: acquire knowledge to design and analyze active filters for analog signal processing.

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓							
CO2				✓	✓		✓		
CO3	✓		✓			✓			
CO4				✓	✓				
CO5							✓	✓	

SYLLABUS

Unit I: REVIEW OF DIGITAL SIGNAL PROCESSING

Discrete Time Signals & System: Review, Analysis of Discrete time LTI systems, Representation of Discrete Time systems by LTI systems, Z-Transform and inverse Z-transform, Frequency domain analysis of LTI systems, DFT: Properties and Applications, Radix-2 FFT algorithm and its implementation.

Unit II: DESIGN OF DIGITAL FILTER

Design of FIR Filters: Symmetric and Anti-symmetric FIR filters, Design using windowing method and frequency sampling method, Design of IIR Filters from Analog Filters using Impulse invariance and Bilinear Transformation, Frequency Transformations.

Unit III: MULTIRATE SIGNAL PROCESSING

Introduction to Multi-rate Digital Signal Processing, sample rate reduction, decimation by integer factors,sampling rateincrease,interpolation byintegerfactor,Design of practical sampling rate converters,FilterSpecification,filterrequirementfor individualstages,Determiningthenumberof stagesand decimation factors,Sampling rateconversion using poly-phasefilter structure,poly-phase implementationof interpolators.

Unit IV:

Bipolar operational amplifiers, MOS diode,activeresistor and current mirrors,CMOS amplifierand operationalamplifier.Logarithmicandexponentialamplifiers,analogmultipliersanddivider,Voltage controlled oscillator, Phaselockedloop.Waveform generator andOscillator.

Unit V:

Continuoustimefilter:Activefilter;Secondorderfilter:Single amplifierandmultiple amplifierstructures and filterparametersensitivities. Cascadefilter. Sampled datafilter:Switched Capacitorfilter;Switched capacitorintegratorand filter. Filtertransferfunction in z-domain,Filterparametersensitivitieswith respecttocapacitorratios.

Text Books:

1. Digital Signal Processing: principles, Algorithms, and Applications, J.G. Proakis and D.G. Manolakis, Pearson
2. Digital Signal Procesing, A.V. Oppenheim and R.W. Schafer, PHI Publications.

Reference Books:

1. R.GregorianandG.C.Temes,*AnalogMOSIntegratedCircuitsforSignalProcessing*;JohnWileyandSons, 2004.
2. Sedra and Smith,"Microelectronic Circuits", OxfordUniversityPress,2003
3. ThomasL.Floyd,"ElectronicsFundamentals:Circuits,DevicesandApplications",7th editionPrenticeHall.
4. MillmanandHalkias,"ElectronicDevices&Circuits",McGraw-Hill.
5. Rybin, Yu. K., "Electronic Devices for Analog Signal Processing", Springer Series in AdvancedMicroelectronics,Vol. 33, 2012.

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EI 1503	**Modern Control Systems**	**L**	**T**	**P**	**C**
	First Semester	**3**	**0**	**0**	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:

CO1 : Understands the fundamental concepts of control system

CO2 : Mathematical modeling of the system can be analyzed.

CO3 : Understands the concepts of stability of the system

CO4 : The graduate understands the concept of time response and frequency response of the system.

CO5 : Capable of analyzing stability of the system.

MAPPING OF COs WITH POs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**

CO1	✓	✓							
CO2				✓	✓		✓		
CO3	✓		✓			✓			
CO4				✓	✓				
CO5							✓	✓	

SYLLABUS

UNIT I STATE VARIABLE ANALYSIS AND DESIGN

State models – solution of state equations – controllability and observability- pole assignment by statefeedback – full and reduced order observers. .

UNIT II NONLINEAR SYSTEMS

Common types of non-linear phenomena – Linearisation – singular points – phase plane method –construction of phase trajectories – system analysis by phase plane method – describing function method –describing function of non-linear elements

UNIT III STABILITY ANALYSIS OF NON LINEAR SYSTEM

Stability analysis by describing function method – jump resonance – Liapunov's and Popv's stabilitycriteria.

UNIT IV OPTIMAL CONTROL

Problem formulation – necessary conditions of optimality – state regulator problem – Matrix Riccati equation – infinite time regulator problem – output regulator and tracking problems – Pontryagin's minimum principles – time - optimal control problem.

UNIT V ADAPTIVE CONTROL

Classification – MRAC systems – Different configuration, classification, mathematical description – direct and indirect MRAC – self tuning regulator – different approach to self tuning, recursive parameter estimation, implicit and explicit STR.

Text Books:

1. Nagrath I.J., and Gopal, M., Control system Engineering Wiley Eastern Reprint 1995.
2. Kirk D.E., "Optimal control theory-an introduction", Prentice Hall, N.J. 1970.

Reference Books:

1. Chalam V.V., Adaptive control systems Marcel Dekker, INC New York and Bassel, 1987
2. Stanley M.Shinners, Modern Control System Theory and Design, John Wiley and Sons, 1998.

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EI 1511	Design, Simulation and Development Lab	L	T	P	C
	FirstSemester	0	0	3	2

COURSE OUTCOMES:

After successful completion of the course students can be able to:

CO1: apply several signal processing algorithms on digital signals using MATLAB and DSP boards.
CO2: generate different test signals in time domain and demonstrate the same.
CO3: write different programs in PLC
CO4: visualize the key concepts using MATLAB.
CO5: design digital filters of different kinds in MATLAB.

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓							✓	
CO2		✓			✓		✓		
CO3	✓		✓			✓			
CO4				✓	✓				✓
CO5								✓	

SYLLABUS

1. Familiarization of signal processing commands used in MATLAB Software.
2. Developing elementary signal function modules (m-files) for unit impulse, step, exponent and ramp sequence.
3. Generating continuous and discrete time sequences.
4. Carrying out mathematical operations on signals
5. Response of LTI system described by difference and differential equation
6. Developing a program for computing inverse Z-Transform.
7. Developing program for finding magnitude & phase response of LTI System
8. Developing program for computing DFT & IDFT
9. Developing a program for computing circular convolution.
10. Design of filter: FIR, IIR, ECG Signal filter.
11. Getting started with LabVIEW: Basic operations, controls, indicators, and simple Programming structures.
12. Debugging a VI and sub-VI.
13. Familiarization of DAQ card
14. PLC programming: familiarization of instruction set
15. PLC programming: simulation of process control
16. SCADA interface
17. Familiarization of Distributed Control System (DCS) with different process stations pressure, flow and level
18. Familiarization of MATLAB commands used in control system design
19. Representation of system in MATLAB: state space representation & transfer function representation
20. Stability analysis using Bode plot, root locus & their pole-zero-gain representation
21. Implementation of Ziegler- Nicholas/ Cohen-coon tuning method for 1^{st}order system

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ELECTIVE-I

EI 1541	Intelligent Control	L	T	P	C
		3	0	0	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:

CO1: Understand difference between conventional and expert system

CO2: Understand the ideas of knowledge Acquisition.

CO3: Understand expert system tool
CO4: Understand about Fuzzy modeling
CO5: Understand about control with Neural Controllers.

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓				✓		✓		
CO2				✓		✓	✓		
CO3	✓		✓						✓
CO4		✓							✓
CO5					✓	✓		✓	

SYLLABUS

UNIT I INTRODUCTION
Definition – architecture – difference between conventional and expert system.

UNIT II KNOWLEDGE ACQUISITION
Knowledge representation and formal logic-knowledge engineer – knowledge acquisition techniques –concept formalisation – knowledge representation development – knowledge acquisition for core problemknowledge acquisition without knowledge engineers.

UNIT III EXPERT SYSTEM TOOLS
Problem solving start engines – languages for expert system development – expert system shells – LISPmachines – PC-based expert system tools.

UNIT IV FUZZY MODELLING AND CONTROL
Fuzzy sets – Fuzzy set operators – Fuzzy Reasoning – Fuzzy propositions – Linguistic variable –
Decomposition and Defuzzification – Fuzzy systems- Case studies

UNIT V NEURAL CONTROLLERS
Introduction: Neural networks – supervised and unsupervised learning – neural network models – singleand multilayers – back propagation – learning and training. Neural controllers case studies

Text Books

1. Rolston, D.W., ‘Principles of Artificial and Expert Systems Development’, McGrawHill Book
Company, International Edition, 1998.

2. Kosko, B, ‘Neural Networks and Fuzzy Systems’, Prentice Hall of India Pvt. Ltd., 1994.

Reference Books:

1. Klir, G.J. and Folger, T.A., ‘Fuzzy Sets, and Information’, Prentice Hall, 1994.

2. James A. Freeman, David M. Skapura, ‘Neural Networks Algorithms’, Applications and programming
Techniques’, Addison Wesley Publishing company 1992.

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EI 1542	SmartSensors	L	T	P	C
		3	0	0	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:

CO1: understand the basics of micromaching techniques, microelectronics and smart sensor.

CO2: design basic amplification circuits, signal conditioning circuits and analog to digital converters.

CO3: understand basics of office, building and home automation techniques.

CO4: acquire the knowledge of Fuzzy Logics and Neural Networks.

CO5: have basic knowledge of Internet of Things.

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓							✓	
CO2			✓	✓					
CO3	✓		✓		✓	✓			✓
CO4		✓							✓

CO5				✓		✓		✓	

SYLLABUS

UNIT – IBASICS OF SMART SENSORS & MICROMACHINING:

Introduction, Mechanical-Electronic transitions in sensing, nature of sensors, overview of smart sensing and control systems, integration of micromachining and microelectronics, introduction to micromachining, bulk micromachining, wafer bonding, surface micromachining, other micromachining techniques.

UNIT – IISENSOR INFORMATION TO MCU:

Introduction, amplification and signal conditioning, separate versus integrated signal conditioning, digital conversion.

UNIT – IIIMCUS AND DSPS TO INCREASE SENSOR IQ:

Introduction, MCU control, MCUs for sensor interface, DSPcontrol, Software, tools and support, sensor integration.

UNIT – IVCOMMUNICATIONS FOR SMART SENSORS :

Introduction, definitions and background, sources and standards, automotive protocols, industrial networks, office & building automation, home automation, protocols in silicon, other aspects of network communications.

UNIT – VCONTROL TECHNIQUES:

Introduction, state machines, fuzzy logic, neural networks, combined fuzzy logic and neural networks, adaptive control, other control areas.

UNIT – VISENSOR COMMUNICATION & MEMS:

Wireless zone sensing, surface acoustical wave devices, intelligent transportation system, RF-ID, Microoptics, micrograppers, microprobes, micromirrors, FEDs.

UNIT – VIIPACKAGING, TESTING AND RELIABILITY OF SMART SENSORS: Introduction, Semiconductor packaging applied to sensors, hybrid packaging, packaging for monolithic sensors, reliability implications, testing smart sensors. Unit Standards for Smart Sensors: Introduction, setting the standards for smart sensors and systems, IEEE 1451.1, IEEE 1451.2, IEEE P1451.3, IEEE 1451.4, extending the systems to network.

UNIT – VIIIIMPLICATIONS OF SMART SENSOR STANDARDS AND RECENT TRENDS: Introduction, sensor plug-and- play, communicating sensor data via existing wiring, automated/remote sensing and web, process control over the internet, alternative standards, HVAC sensor chip, MCU with integrated pressure sensors, alternative views of smart sensing, smart loop.

Suggested Readings:

1. Smart Sensors and Sensing Technology, Daniel E. Suarez, Nova Science Publishers.

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EI 1543	OptimizationTechniques	L	T	P	C
		3	0	0	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:

CO1: Learn efficient computational procedures to solve optimization problems.

CO2: Cast engineering minima/maxima problems into optimization framework.

CO3: Use Matlab to implement important optimization methods.

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓							
CO2		✓		✓		✓			
CO3	✓					✓			✓

SYLLABUS

General:

Engineering applicationof Optimization, Formulationof designproblems as mathematical programming problems, classification of optimization problems, Functions of single and multiple variables-optimalitycriteria, directandindirectsearchmethods.

Linear Programming:
Graphicalmethod,Simplexmethod,revisedsimplex method, Dualityinlinear programming(LP),Sensitivityanalysis,otheralgorithmsfor solvingLPproblems, Transportation, assignmentand other applications.

Non Linear Programming:
Unconstrained optimizationtechniques, Directsearchmethods,Descent methods,Constrainedoptimization, Directandindirect methods,Optimizationwithcalculus,Khun-Tuckerconditions.

Dynamic Programming:
Introduction,Sequential optimization,computationalprocedure,curse of dimensionality,Applications in controlsystemandinstrumentation.
AdvancedTechniques of Optimization:Geneticalgorithmsforoptimizationandsearch.Artificial intelligenceinoptimization.

Suggested Readings:

1. D.BertsimasandJ.N.Tsitsiklis,IntroductiontoLinearOptimization,Athena,Scientific, Belmont,Massachusetts,1999.
2. S.S.Rao,“EngineeringOptimization:TheoryandPractice”,NewAgeInternational(P)Ltd.,NewDelhi,2000.
3. K.Deb,“OptimizationforEngineeringDesign–AlgorithmsandExamples”,Prentice-HallofIndiaPvt.Ltd., NewDelhi, 1995.

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EI 1544	**ArtificialIntelligence**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OUTCOMES:

After successful completion of the course students can be able to:

CO1: The graduate can represent the concept of intelligent agents, search technique, knowledge,
reasoning and planning.

CO2: Capable of giving ideas of intelligent agents and search method.

CO3: Understands knowledge representation

CO4: Graduates can understand about planning and learning methodologies.
CO5: Understands Implementation of plans and method for designing controllers.

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓							
CO2		✓		✓		✓			
CO3	✓					✓			✓
CO4		✓						✓	✓
CO5				✓		✓		✓	

SYLLABUS

UNIT I INTRODUCTION TO ARTIFICIAL INTELLIGENCE

Overview of Al-general concepts-problem spaces and search –search techniques – BFS, DFS-Heuristicsearch techniques.

UNIT II KNOWLEDGE REPRESENTATION

Knowledge –general concepts- predicate logic-representing simple fact- instance and ISA relationships –resolution –natural deduction.

UNIT III KNOWLEDGE ORGANISATION AND MANIPULATION

Procedural Vs declaration knowledge – forward Vs backward reasoning – matching techniques – controlknowledge/strategies – symbol reasoning under uncertainty – introduction to non – monotonic reasoning –logic for monotonic reasoning.

UNIT IV ERCEPTION – COMMUNICATION AND EXPERT SYSTEMS

Natural language processing – pattern recognition – visual image understanding – expert system
Architecture

UNIT V KNOWLEDGE ACQUISITION

Knowledge acquisition – general concepts – learning – learning by induction – explanation based learning

Text Books:

1. Elaine Rich and Kelvin Knight, Artificial Intelligence, Tata McGraw-Hill, New Delhi, 1991.
2. Stuart Russell and Peter Norvig, Artificial Intelligence: A modern approach Prentice Hal, 1995

Reference Books:

1. Nelson N.J. Principles of Artificial Intelligence, Springer Verlag, Berlin, 1980.
2. Patterson, Introduction to Artificial Intelligence and Expert systems, Prentice Hall of India, New delhi,1990.

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EI 1545	Microelectronics and VLSI Design	L	T	P	C
		3	0	0	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:

CO1: Estimate the effort required for verification and formulate a verification plan for complex IC designs.

CO2: Develop HVL based self-checking test benches both directed and random.

CO3: Apply techniques to assess the verification efficiency and identify the methods to improve it.

CO4: Select suitable formal verification methods for exhaustive verification of a design.

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓								✓
CO2		✓		✓			✓		
CO3	✓						✓	✓	
CO4		✓			✓				✓

SYLLABUS

Module 1:

Introduction to functional verification - HDL and HVL languages - Functional verification approachesverification technologies – code coverage – functional coverage - requirements specification and theverification plan – levels of verification – directed testbench – coverage driven random based approach

Module 2:
Introduction to SystemVerilog - data types, arrays, structures and unions – procedural blocks, tasks andfunctions – procedural statements – design hierarchy – interfaces.

Module 3:
High level modeling – data abstraction – OOPS – parallel simulation – race condition – simple andcomplex stimulus and response – bus functional models – response monitors – transaction levelinterface self checking testbenches – reference models – transfer function – scoreboarding – monitors -randomization in SystemVerilog – constrained random verification – random device configuration.

Module 4:
Functional coverage in SystemVerilog – Covergroup/Coverpoint – coverage monitoring – Verificationmethodology - OVM/UVM basics – System on chip verification – system level and block level verification.Introduction to formal verification – basics of equivalence checking and model checking – Booleansatisfiability (SAT) – assertion based verification – SystemVerilog assertions.

References:

1. Sutherland, Stuart, Davidmann, Simon, Flake, Peter, SystemVerilog for Design: A Guide to UsingSystemVerilog for Hardware Design and Modeling", Second Edition, Springer Science & BusinessMedia, 2006.
2. Chris Spear, Greg Tumbush, SystemVerilog for Verification: A Guide to Learning the TestbenchLanguage Features, 3rd Edition, Springer Science & Business Media, 2012.
3. Bergeron, J., Writing Testbenches using SystemVerilog, Springer, USA, 2006.
4. Rashinkar P, Paterson P, Singh L., System-on-a-chip verification: methodology and techniques,Springer Science & Business Media; 2007
5. Erik Seligman, Tom Schubert, M V Achutha Kiran Kumar, Formal Verification: An Essential Toolkitfor Modern VLSI Design, Morgan Kaufmann, 2015

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EI 1546	**Advanced Wireless Communication**	L	T	P	C
		3	0	0	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:

CO1: Develop a comprehensive overview of UWB system design that spans pulse shape,

modulationschemes, multiple access techniques and applications.
CO2: Identify the Capacity and information rates of MIMO channels.
CO3: Describe the concepts of cellular communication.
C04: Classify the mobility and security procedures for LTE communication.

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓							
CO2		✓		✓		✓		✓	
CO3	✓					✓			✓
CO4		✓							✓

SYLLABUS

Unit I:
Introduction to Wireless Systems: Types, History, Modern Wireless Communication system,Cellular Concept: Design issues, cell capacity, reuse, interference, system capacity, coverage.

Unit II:
Beyond 3G: HSPA and LTE, Architecture, Radio interface and channels, Resource mappingSession, mobility and security procedures, LTE Advanced, Heterogeneous Networks, Internetworking, IP based coupling Architecture, Multimode terminals and intersystem handover.

Unit III:
MIMO Wireless communication: Wireless channels, Error/Outage probability over fadingchannels, Diversity techniques, Channel coding as a means of time diversity, Multiple antennas inwireless communications, Capacity and Information rates of noisy, AWGN and fading channels,Capacity of MIMO channels, Capacity of non-coherent MIMO channels, Constrained signaling forMIMO communications.

Unit IV:
Ultrawideband communication: Introduction, Power spectral density, Pulse shape, UWB modulation methods, UWB transmitter/receiver, Multiple access techniques in UWB, Capacity of
UWB systems, Comparison of UWB with other wideband communication systems, Interference andcoexistence of UWB with other systems, Applications of UWB communication systems.

Text Books:

1. Iti Saha Misra, "Wireless Communication and Networks – 3G and Beyond", Mc Graw Hill Education, Second Edition, 2013.
2. Jochen Schiller, "Mobile Communications", Pearson Education, Second Edition, 2012.
3. E.Dahlman et. al., "3G Evolution: HSPA and LTE for Mobile Broadband", Elsevier, Second Edition, 2008.
4. Tolga M. Duman and Ali Ghrayeb, "Coding for MIMO Communication systems", John Wiley& Sons, West Sussex, England, 2007.
5. M. Ghavami, L. B. Michael and R. Kohno, "Ultra Wideband signals and systems in Communication Engineering", 2nd Edition, John Wiley & Sons, NY, USA, 2007.
6. T.S. Rappaport, "Wireless communication, Principles and Practice", Pearson Publications.

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EI 1547	**FibreOpticsandLASERInstrumentation**	**L**	**T**	**P**	**C**
		3	0	0	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:

CO1 : Calculate attenuation constant, numerical aperture, acceptance angle and multipath time dispersion of single and multi mode optical fiber if refractive indices of core, cladding and medium are given.

CO2 : explain the methods of fabrication of optical fibers, LASERs and light emitting diodes

CO3 : calculate quantum efficiency and responsivity of PIN and Avalanche photodiodes if operating wavelength and obtained photocurrent is given.

CO4 : design Laser based systems for measurement of distance and velocity.

CO5 : investigate medical applications of Lasers.

MAPPING OF COs WITH POs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓	✓							
CO2			✓	✓		✓		✓	
CO3						✓			✓
CO4			✓					✓	✓
CO5	✓					✓		✓	

SYLLABUS

OPTICALFIBRES AND THEIRPROPERTIES:

Principles oflightpropagationthrougha fibre-Differenttypes offibres andtheir properties,fibrecharacteristics–Absorptionlosses–Scatteringlosses–Dispersion–Connectors and splicers –Fibretermination–Opticalsources–Opticaldetectors.

INDUSTRIALAPPLICATION OF OPTICALFIBRES:

Fibreopticsensors–Fibreopticinstrumentationsystem–Different typesofmodulators– Interferometricmethodofmeasurementoflength– Moirefringes– Measurementof pressure,temperature,current,voltage,liquidlevel andstrain.

LASERFUNDAMENTALS :

Fundamentalcharacteristics of lasers–Threelevelandfourlevellasers–Propertiesof laser –Laser modes –Resonator configuration–Q-switchingandmodelocking–Cavity damping–Types oflasers – Gas lasers,solidlasers,liquidlasers,semiconductor lasers.

INDUSTRIALAPPLICATIONOF LASERS:

Laserformeasurementofdistance,length,velocity,acceleration,current, voltageandAtmosphericeffect–Materialprocessing–Laserheating,welding, melting andtrimmingofmaterial– Removalandvaporization.

HOLOGRAMANDMEDICALAPPLICATIONS:

Holography–Basic principle-Methods –Holographic interferometryand application,Holographyfor non-destructivetesting–Holographic components– Medicalapplications oflasers,laserandtissueinteractive–Laserinstruments for surgery,removaloftumors ofvocalcards,brainsurgery,plasticsurgery,gynaecologyandoncology.

Text books:

1.J.M.Senior,‘OpticalFibreCommunication–Principles andPractice’,PrenticeHall ofIndia, 1985.

2.J. WilsonandJ.F.B.Hawkes,‘IntroductiontoOpto Electronics’,PrenticeHall ofIndia, 2001.

References:

1.G. Keiser,‘OpticalFibreCommunication’,McGrawHill,1995.

2.M.Arumugam,‘OpticalFibreCommunicationandSensors’,Anuradha Agencies,2002.

3.JohnF.Read, ‘IndustrialApplications ofLasers’,Academic Press,1978.

4.Monte Ross,‘LaserApplications’,McGrawHill,1968

SuggestedReadings:

1. JohnandHarry,**IndustrialLasersandtheirApplications**, McGrawHill, 1974.

2. Senior J.M.,**OpticalFiberCommunicationPrinciplesandPractice**,PrenticeHall,1985.
3. JohnF Read,**IndustrialApplicationsof Lasers**,AcademicPress,1978
4. MonteRoss,**LaserApplications**, McGrawHill,1968
5. KeiserG.,**OpticalFiberCommunication**,McGrawHill, 1991
6. Jasprit Singh,**SemiconductorOptoelectronics**,McGrawHill, 1995
7. GhatakA.KandThiagarajarK, Optical Electronics FoundationBook,TMH, NewDelhi, 1991

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EI 1548	**Testing and Calibration of instruments**	**L**	**T**	**P**	**C**
		3	**0**	**0**	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:

CO1: explain key terms related to testing and calibration.

CO2: illustrate the test measurement instrumentation system.

CO3: explain the testing procedures for industrial instruments.

CO4: prepare calibration data sheet for an instrument of interest.

CO5: carryout the calibration management process based on types of instrument and with relevant standards.

MAPPING OF COs WITH POs

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓	✓							
CO2		✓		✓		✓			
CO3	✓					✓			✓
CO4		✓						✓	✓
CO5				✓		✓		✓	

SYLLABUS

UNIT I INTRODUCTION TO TESTING AND CALIBRATION

The Signal Flow of Electronic Instruments, The Instrument Block Diagram, Measurement Systems, Types of instrument, Traceability, Calibration Types, Calibration Requirements, Calibration Methodology, Instrument Specifications and Calibration Tests, Calibration Standard Requirements.

UNIT II TEST MEASUREMENT INSTRUMENTATION

Test Measurement Instrumentation, Process Instrumentation, Test Objective Requirements and limitations, Test Data - Format and Analysis

UNIT III TESTING OF INSTRUMENTS

Voltage-Voltmeter, Current - Ammeter and Resistance - Ohmmeter, Temperature - Thermocouple, Pressure - Primary pressure sensing elements-Diaphragm, Bourdon tube

UNIT IV CALIBRATION REQUIREMENTS

Calibration procedure, calibration procedure content, calibration datasheet, Instrument Specification Forms, Project Specifications, Manufacturer's Specifications, Calibration Intervals, Safety Considerations, Calibration Status Labels

UNIT V CALIBRATION STANDARDS

National Measurement Standard Laboratories, Commercial Calibration Services, standards in different National Laboratories and Bureaus, calibration management and maintenance.

Text Books

1. Mike Cable, —Calibration - A technician's guide, ISA, 2005.
2. 2. Vaisala Oyj, —Calibration Book, Calibration book project team, 2006.

References

1. Clyde F.Coombs Jr, —Electronic Instrument Handbook, 3rd Edition, 2008.
2. M/s. Beamex OYED, Fram in Vaasa, Finland, 2nd Edition, 2012.
3. http://www.iceweb.com.au/Test&Calibration/Test%20and%20Calibration.htm

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EI 1549	**Industrial Instrumentation**	**L**	**T**	**P**	**C**
		3	**0**	**0**	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:
CO1: illustrate the working principle of instruments involved in level and pressure measurement.
CO2: explain the theory, operation and installation of variable head type and mass flow meters
CO3: describe the construction and principle of operation of electrical type flow meters
CO4: select appropriate method to measure level, pressure and flow for different applications.
CO5: provide customized solution for specific level, pressure and flow measurement problems
CO6: explain the safety precautions / guidelines while being in Industrial area during installation, commissioning and operation

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓							
CO2		✓		✓		✓			
CO3	✓		✓			✓			✓
CO4		✓						✓	✓
CO5			✓	✓		✓		✓	
CO6		✓						✓	✓

SYLLABUS

Level Measurement
Sight Glass, Float, Displacer type and Bubbler system – Electrical level gauge:- Resistance and Capacitance – Nuclear radiation - Ultrasonic level transmitters - Guided Wave Radar Level Transmitters – vibration and microwave level switches- – Boiler drum level measurement. Leading manufacturers of flow and level instruments with specifications. (Non-descriptive).

Pressure Measurement
Units of pressure, Manometers - different types, Elastic type pressure gauges - Bourdon tube, bellows and diaphragms, Electrical methods - Elastic elements with LVDT and strain gauges, Capacitive type pressure gauge, Piezo resistive pressure sensor, Resonator pressure sensor, Measurement of vacuum-McLeod gauge, Thermal conductivity gauge, lonization gauges, Cold cathode type and hot cathode type, calibration of pressure gauges, Dead weight tester.

Flow Measurement
VARIABLE HEAD TYPE FLOW METERS: Variable head type flow meters: Orifice plate, Venturi tube, Flow nozzle and Dall tube – Installation of head flow meters – Conditioning Orifice Plates- Pitot tube.

QUANTITY METERS, AREA FLOW METERS AND MASS FLOW METERS: Positive displacement flow meters: Nutating disc, Reciprocating piston, Oval gear and Helix type flow meters – Inferential meter – Turbine flow meter – Area flow meter: Rotameter – Theory and installation – Mass flow meters: Thermal and Coriolis – Temperature/pressure compensation in mass flow meters - Calibration of flow meters: Dynamic weighing methods.

Principle and constructional details of Electromagnetic flow meter – Ultrasonic flow meters – Laser Doppler anemometer – Vortex shedding flow meter – Target flow meter – Open channel flow measurement – Solid flow rate measurement – guidelines for selection of flow meter.

Industrial Safety and Specifications

Safety: Introduction, electrical hazards, hazardous areas and classification, Non-hazardous areas, enclosures – NEMA types, fuses and circuit breakers, protection methods: purging, explosion proofing and Intrinsic safety. Specification of instruments, preparation of project documentation, process flow sheet, Instrument index sheet, Instrument specification sheet, panel drawing and specifications.

SuggestedReading:

1. Ernest O.Doebelin, "Measurement systems Application and Design", International StudentEdition, IVEdition,McGrawHill BookCompany.
2. R.K.Jain, "MechanicalandIndustrial Measurements",Khanna Publishers,NewDelhi.
3. C. D. Johnson,"ProcessControl InstrumentationTechnology",PHI
4. S.K. Singh, "Industrial Instrumentation andControl",TataMcGrawHillPublishingLtd., NewDelhi
5. D.Patranabis,"PrinciplesofIndustrialInstrumentation",TataMcGrawHillPublishing Ltd.,New Delhi,
6. AndrewW.G,"AppliedInstrumentationinProcessIndustries– Asurvey",Vol.1&Vol.2,GulfPublishingCompany, Houston.
7. James W. Dailly, William F. Riley, Kenneth G. Mc.Connel, ―Instruments for Engineering Measurments, Wiley Edition.
8. A.K.Sawhney, ―A course in Electrical and Electronic Measurement and Instrumentation‖ Dhanpat Rai and Sons, New Delhi, 2014.
9. Liptak B.G., ―Instrumentation Engineers Handbook (Measurement)‖, CRC Press, 2005.
10 Lessons in Industrial Instrumentation: www.ibiblio.org/ kuphaldt/ socratic/ sinst/ book/ liii.pdf
11. Industrial Flow measurement: http://eprints.hud.ac.uk/5098/1/macrabtreefinalthesis.

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ELECTIVE II

EI 1551	Robotics & Automation	L	T	P	C
		3	0	0	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:

- CO1: demonstrate knowledge of the relationship between mechanical structures of industrial robots and their operational workspace characteristics.
- CO2: apply spatial transformation to obtain forward kinematics equation of robot manipulators.
- CO3: solve inverse kinematics of simple robot manipulators.
- CO4: obtain the Jacobian matrix and use it to identify singularities.
- CO5: generate joint trajectory for motion planning.

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓							
CO2		✓		✓	✓			✓	
CO3	✓					✓			✓
CO4		✓			✓			✓	
CO5				✓		✓			✓

SYLLABUS

UNIT – I INTRODUCTION

Robotics – Basic components – Classification – Performance characteristics – Actuators-Electric actuator-DC motor horse power calculation, magnetostrictive hydraulic and pneumatic actuators. Sensors and vision systems: Different types of robot transducers and sensors – Tactile sensors – Proximity and range sensors–ultrasonic sensor-touch sensors-slip sensors-sensor calibration- vision systems – Image processing and analysis – image data reduction – segmentation feature extraction – Object recognition.

UNIT – II : ROBOT CONTROL

Control of robot manipulators- state equations-constant solutions-linear feedback systems-single axis PID control- PD gravity control- computed torque control- variable structure control- Impedance control.

UNIT – III :END EFFECTORS

End effectors and tools– types – Mechanical grippers – Vacuum cups – Magnetic grippers – Robot end effectors interface, work space analysis work envelope-workspace fixtures-pick and place operation-continuous path motion-interpolated motion-straight line motion.

UNIT – IV: ROBOT MOTION ANALYSIS

Robot motion analysis and control: Manipulator kinematics –forward and inverse kinematics- arm equation-link coordinates-Homogeneous transformations and rotations and Robot dynamics .

UNIT – V : ROBOT APPLICATIONS/AUTOMATION

Industrial and Non industrial robots, Robots for welding, painting and assembly – Remote Controlled robots

– Robots for nuclear, thermal and chemical plants – Industrial automation – Typical examples of automated industries.

Text books:

1. Mikel P. Grover,et. Al. "Industrial Robots – Technology Programming and Applications", McGraw Hill.
2. Robert J.Schilling, Fundamentals of Robotics-Analysis and Control, PHI. (Unit-II and Unit-III)

Reference:

1. K.S.Fu,R.C.Gonzalez, CSG. Lee, Robotics,control sensing vision and Intelligence, Tata McGraw-Hill.

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EI 1552	**PCBasedInstrumentation**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OUTCOMES:

After successful completion of the course students can be able to:

CO1: Understand the main functional units in a PC and be able to explain how they interact. They should know different bus types, and on this basis be able to distinguish account for different generations of PCs.

CO2: Understand an operating systems and their importance such as multitasking, privilege levels and drivers.

CO3: Solve simple instrumentation tasks using both PC and microcontroller. They shall also master programming in C and LabVIEW on a level that enables them to solve such tasks.

CO4: reinforce their understanding of the concepts to re-in force their command and over these aspect to implement in projects

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓						✓		
CO2				✓		✓	✓		
CO3		✓						✓	✓
CO4				✓		✓		✓	

SYLLABUS

UNIT I

Introduction,Necessityandfunctionsof computers.Levelof automationand economy ofcomputer control.CentralizedcomputercontrolVsdistributed computercontrol.

UNIT II

Computer architecture,Micro and mini-computer, functional models of I.O. system ,interfacing, Sampling

UNITIII

Multiplexing;A/DandD/A converters,interfacingwithdifferenttypes oftransducers- Analog/Digital, Electricalandnonelectricalselectionof sensors;Microcomputer interfacingstandardbusesSerialbuses; Serial data communicationprotocols.

UNITIV

Studyofautomaticprocesscontrol,Fundamental ofautomaticprocesscontrol,buildingblockof automaticsystem, directanddistributeddigital control system,Programmablecontrollers.

UNITV

Personalcomputerin reallifeenvironment,Introduction,personalcomputer:systemandfacility, PCbus andsignals,interrupts,interfacingPC with outerworld,PCinRTE, RealtimeapplicationofIBM PC ,PC based distributedcontrol system, Programming and application,Modelling and simulation forplantautomation, PLCArchitectureand programming of PLC, industrial control application: cement plant, thermal power plant , water treatmentplant,steelplant,

SuggestedReadings:

1. Computerbased industrial control:KrishanKant,PHI.
2. PC-based Instrumentation:ConceptsAndPractice(Paperback),N.Mathivanan, PHI

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EI 1553	Information and Communication Theory	L	T	P	C
		3	0	0	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:

CO1: Understand the concepts of probability to analyse detection and estimation problem in communication.

CO2: Acquire the knowledge of binary hypothesis testing for control, instrumentation and communication system.

CO3: Design the channel performance using Information theory.

CO4: Apply the concepts of random process in control and communication system.

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓							
CO2		✓		✓		✓			
CO3	✓					✓			✓
CO4		✓						✓	✓

SYLLABUS

Unit 1:

Introduction to detection and estimation problem in communication, The meaningand axioms of probability; Random variables, Examples of commonly used random variablesand their density and distribution functions, Moments and characteristic functions, Bivariatedistributions and functions of two random variables, joint moments and characteristicfunctions, conditional distributions and expected values.

Unit 2:

Binary hypothesis testing: Bayes, Neyman-Pearson, maximum likelihood, MAP andminimum probability of error criteria; Bayes, ML and MAP estimation.

Unit 3:

Information, entropy, source coding theorem, Mutual information, Datacompression, Huffman coding, Markov sources; Channel capacity theorems for discrete andcontinuous ensembles; Introduction to rate distortion function, Shannon Hartley Law,Trade-off between bandwidth and SNR.

Unit 4:
Correlation matrix and characteristic functions of sequences of random variables,jointly normal random variables; Mean square estimation, stochastic convergence and limittheorems, Random number generation.

Unit 5:
Random processes, correlation function and power spectrum, random processthrough linear systems, KLT, ergodicity.

Text Books:

1. Papoulis, A. and Pillai, S.U., "Probability, Random Variables and Stochastic Processes", TataMcGraw-Hill.
2. Cover, T.M. and Thomas, J.A., "Elements of Information Theory", 2nd Ed., Wiley Interscience.
3. Van Trees, H.L., "Detection, Estimation and Modulation Theory", Part I, Wiley Interscience.
4. Bose, R., "Information Theory, Coding and Cryptography", Tata McGraw-Hill.

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EI 1554	Intelligent Instrumentation	L	T	P	C
		3	0	0	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:
CO1: Understand the concept of Intelligent instrumentation
CO2: Identify the optimized protocol selection according to the application area
CO3: Design complete automatic process control system
CO4: Analyze the PLC systems In industry

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1									

CO2									
CO3									
CO4									

SYLLABUS

UNIT I: Introduction:

Intelligence, features characterizing intelligence, intelligent instrumentation system; features of intelligent instrumentation; components of intelligent instrumentation system. Block diagram of an intelligent instrumentation system.

UNIT II: Signal Processing, Manipulation And Transmission

Signal amplification & attenuation (OP-AMP based); Instrumentation Amplifier (circuit diagram, high CMRR& other features); Signal Linearization (different types such as Diode resistor combination, OP-AMP based, etc.(; Bias Removal, Signal filtering (outputs from ideal filters, outputs form constant-k filters, matching of filter sections, active analog filters);OP-AMP based Voltage-to-current converter, Current-to-voltage conversions, Signal integration, Voltage follower (pre amplifier); voltage comparator, Phase –Locked loop, Signal addition, Signal multiplication, Signal Transmission (Signal amplification, Shielding , Current loop transmission, Voltage-to-frequency conversion, Fiber optic transmission).

UNIT III: Smart Sensors

Primary sensors; Excitation; Compensation (Nonlinearity: look up table method, polygon interpolation, polynomial interpolation, cubic spline interpolation, Approximation & regression: Noise & interference; Response time: Drift; Cross-sensitivity); information coding/Processing; Data Communication; Standards for smart sensor interface

UNIT IV: Interfacing Instruments & Computers

Address decoding; Data transfer control; A/D converter; D/A converter; Sample & hold circuit; others interface considerations.

UNIT V: Recent Trends In Sensor Technologies

Introduction; Film sensors (Thick film sensors, this film sensor) Semiconductor IC Technology- Standard methods; Micro electro- mechanical systems (Micro-machining, some application examples); Nono-Sensors.

Suggested Readings:

1. 1. Barney, G.C., Intelligent instruments, Hemel Hempsteao: Prentice Hall.

2. 2. ALAN S. Morris, Principles of Measurement s Instrumentation. New Delhi, PHI Pvt. Ltd.
3. D.Patranabis, Sensors s Transducers, New Delhi, PHI.
4. Roman Kuc, Introduction to Digital Signal Processing, New York: McGraw-Hill Pub. Co.

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EI 1555	Computer ControlledProcesses	L	T	P	C
		3	0	0	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:

CO1: students will be able to analyze control systems using different transforms.

CO2: students will be able to understand various PID Algorithms.

CO3: students will be able model and identify different process control systems.

CO4: students will be able to understand and analyze adaptive control systems.

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓							
CO2		✓		✓		✓			
CO3	✓							✓	✓
CO4		✓		✓					

SYLLABUS

ANALYSIS OF SAMPLEDDATACONTROLSYSTEM:

Continuous anddiscretesystems sample data system- Ztransform–inverseZtransform-selection ofsampling period–mathematicalrepresentation of sampler-transferfunction ofzeroorderholdandfirst orderholddevice-Pulsetransferfunction—open loopandclosedresponse of linearsampledatacontrol systemforstepinput– stabilityanalysis:Jury’s testandbilineartransformation-Statespacerepresentationofsampledatasystems.

DIGITALCONTROLALGORITHMS
DeadbeatAlgorithm– Dahlin's method–ringing–Kalman'sapproach – discrete equivalent to an analog Controller – design for load changes. PID Algorithms – tuning techniques. Selectionofsamplingtime.DeadtimeCompensation–Smith Predictor Algorithm.

SYSTEMMODELINGANDIDENTIFICATION
Mathematicalmodelforprocesses–firstorder.Second orderprocesseswithoutandwithpuredelayhigherordersystems–processmodelingformsteptest data–pulsetestingfor processidentification–time–domainidentification–linearleastsquare algorithm.
RobustControl, IntelligentControllers,Optimal Control

ADAPTIVECONTROL
Introduction-types-MFAcontrol-singleloopMFAcontrol-multivariableMFA control-modelreferenceadaptivecontrol.

MODELPREDICTIVECONTROL
Introduction-optimizationproblems-dynamicmatrixcontrol-DMCfor first orderprocess–quadratic DMC.

Suggested Reading:

1. P.B. Deshpande and RH. Ash, "Elements of Computer Process Control", Instrument Society of America,1981.
2. B.W.Bequette."Process control" ,PrenticeHallInc.2006.
3. C.L. Smith,"DigitalComputer ProcessControl", IntextEducationalPublishers,1972.
4. VanceVandoren"Techniquesfor AdaptiveControl"BH publishers.,2003.

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EI 1556	Biomedical Signal Processing	L	T	P	C
		3	0	0	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:
CO1: Understand DFT and its computation.
CO2: Analyze the design techniques involved for digital filters.
CO3: Identify the bio-signals.
CO4: Understand special techniques like Heart rate variability Analysis

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓							
CO2		✓		✓		✓			
CO3	✓					✓			✓
CO4		✓						✓	✓

SYLLABUS

Module I : DISCRETE – TIME SIGNALS AND SYSTEMS

Sampling of Analogue signals – aliasing – standard discrete time signals – classification – discrete time systems – Linear time invariant stable casual discrete time systems – classification methods – linear and circular convolution – difference equation representation – DFS, DTFT, DFT – FFT computations using DIT and DIF algorithms.

Module II: INFINITE IMPULSE RESPONSE DIGITAL FILTERS

Review of design of analogue Butterworth and Chebyshev Filters, Frequency transformation in analogue domain – Design of IIR digital filters using impulse invariance technique – Design of digital filters using bilinear transform – pre warping – Frequency transformation in digital domain – Realization using direct, cascade and parallel forms.

Module III: FINITE IMPULSE RESPONSE DIGITAL FILTERS

Symmetric and Antisymmetric FIR filters – Linear phase FIR filters – Design using Frequency sampling technique – Window design using Hamming, Hanning and Blackmann Windows – Concept of optimum equiripple approximation – Realisation of FIR filters – Transversal, Linear phase and Polyphase Realization structures.

Module IV: ANALYSIS OF BIO –SIGNALS

Removal of artifacts-ECG ,Event detection –ECG,P wave, QRS Complex, T wave, correlation analysis of ECG signals ,Averaging of signals-PCG,ECG and EMG.

Module V: SPECIAL TOPICS IN BIOMEDICAL SIGNAL PROCESSING

Heart rate variability Analysis .Analysis of PCG signals, Analysis of Time variant systems, Fixed segmentation –STFT, ACF, SEM and GLR.

Text Book:

John G. Proakis and Dimitris G.Manolakis, Digital Signal Processing, Algorithms and Applications, PHI of India Ltd., New Delhi, 3rd Edition, 2000. Rangaraj.M.Rangayyan , Biomedical signal processing,

Reference Book:

Sanjit K.Mitra 'Digital Signal Processing', A Computer Based Approach, Tata McGraw-Hill, New Delhi, 1998.

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EI 1557	IC Technology & Applications	L	T	P	C
		3	0	0	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:
CO1: Understand the rapid advances in CMOS technology.
CO2: Learn the basic terminology of VLSI.
CO3: Know the steps involved in IC fabrication.
CO4: Understand MOSFET device related issues and their impact on circuits.
CO5: Appriciate CMOS Inverter its VTC and the parameters affecting it.

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓		✓						
CO2		✓	✓				✓		
CO3	✓					✓			✓
CO4		✓			✓			✓	✓

CO5				✓		✓		✓	

SYLLABUS

Introduction to IC Technology:

Historical perspective, design methodologies & styles, VLSI Design flow, Design hierarchy Custom Circuit design, Cell based and Array based design implementations.

IC Fabrication:

MOSFET fabrication, CMOS n-well, p-well, twin tub process, layout design rules, full custom mask layout design, Power dissipation, Designing combinational logic circuits.

Device Physics:

Analysis of MOSFET, Calculation of threshold voltage, Static I-V characteristics of MOSFETs, MOSFET capacitances, C-V characteristics, Channel length modulation, body bias effect and short channel effects, MOS switch, MOSFET models for calculation.

CMOS Inverter:

Static and Dynamic Characteristics of CMOS inverter, switching characteristics and interconnect.

Memory Design:

Read-Only Memories, ROM cells, Read-write memories (RAM), dynamic memory design, 4 transistor SRAM cell, 6 transistor SRAM cell, Sense amplifiers.

Text Books:

1. Sung-Mo (Steve) Kang (Author), Yusuf Leblebici "CMOS Digital Integrated Circuits Analysis & Design (3/e)" TMH, 2002.
2. J.Rabey, M. Pedram, "Digital Integrated circuits (2/e)", PHI, 2003.

Reference Book:

1. Pucknell & Eshraghian, "Basic VLSI Design", (3/e), PHI, 1996.

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EI 1559	Data Acquisition and Signal Conditioning	L	T	P	C
		3	0	0	3

COURSE OUTCOMES:

After successful completion of the course students can be able to:

CO1: elucidate the elements of data acquisition techniques.

CO2: design and simulate signal conditioning circuits.
CO3: explain various data transfer techniques
CO4: explain the components of data acquisition system
CO5: differentiate between single and multi-channel

MAPPING OF COs WITH POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	✓	✓							
CO2		✓		✓		✓			
CO3	✓					✓			✓
CO4		✓						✓	✓
CO5				✓		✓		✓	

SYLLABUS

Data Acquisition Techniques:
Analog and digital data acquisition, Sensor/Transducer interfacing, unipolar andbipolar transducers, Sample and hold circuits, Interference, Grounding and Shielding.

Data Acquisition with Op-Amps:
Operational Amplifiers, CMRR, Slew Rate, Gain, Bandwidth. Zero crossingdetector, Peak detector, Window detector. Difference Amplifier, Instrumentation Amplifier AD 620, Interfacingof IA with sensors and transducer, Basic Bridge amplifier and its use with strain gauge and temperature sensors,Filters in instrumentation circuits,

Data Transfer Techniques:
Serial data transmission methods and standards RS 232-C: specificationsconnection and timing, 4-20 mA current loop, GPIB/IEEE-488, LAN, Universal serial bus, HART protocol,Foundation-Fieldbus, ModBus, Zigbee and Bluetooth.

Data Acquisition System (DAS):
Single channel and multichannel, Graphical Interface (GUI) Software forDAS, RTUs, PC-Based data acquisition system.

Laboratory Work:
Op-amp as a comparator and its application, Integrator and differentiator, Active filters,Simulation of the above applications using ORCAD, Instrumentation Amplifier/AD 620, Interfacing of sensorsand transducers using DAQ cards.

Text Books:

1. Coughlin, R.F., Operational Amplifiers and Linear Integrated Circuits, Pearson Education (2006).
2. Kalsi, H.S., Electronic Instrumentation, Tata McGraw Hill (2002).
3. Gayakwad, R.A., Op-Amp and Linear Integrated Circuits, Pearson Education (2002).
4. Mathivanan, N., Microprocessor PC Hardware and Interfacing, Prentice Hall of India Private Limited (2007).

Reference Books:

1. Ananad, M.M.S., Electronic Instruments and Instrumentation Technology, Prentice Hall of India Private Limited (2004).
2. Murthy, D.V.S., Transducers and Instrumentation, Prentice Hall of India Private Limited (2006).

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Department of Mechanical Engineering
M. Tech. CAD-CAM & Automation

1st Semester

Code	Subject Name	L	T	P	Credit
ME 1501	Computer Aided Manufacturing	3	0	0	3
ME 1502	Geometric Modeling for CAD	3	0	0	3
ME 1503	Product Design & Development	3	0	0	3
ME 15xx	Elective I	3	0	0	3
ME xxxx	Elective II	3	0	0	3
ME 1504	CAD-CAM & Automation Lab - I	0	0	3	2
ME 1510	Seminar	0	0	2	1
	Total	15	0	5	18

Electives –I

Code	Subject	L	T	P	Credit
ME 1531	Optimization Technique	3	0	0	3
ME 1532	Virtual Reality	3	0	0	3
ME 1533	Innovation & Product Design	2	1	0	3

Elective –II

Code	Subject	L	T	P	Credit
ME 3501	Advanced Material Science	3	0	0	3
ME 1547	MEMS Technology	3	0	0	3
ME 1548	Ergonomics & Aesthetics	3	0	0	3
ME 1549	Non Traditional Techniques for Optimum Design	3	0	0	3

ME 1501	**Computer Aided Manufacturing** First Semester (Core)	L T P C 3 0 0 3

Introduction to Computer Aided Design (CAD), Computer Aided Process Planning (CAPP), Computer Aided Manufacturing (CAM), Computer Integrated Manufacturing (CIM), product cycle and automation in CAD/CAM, Need of CAD/CAM.

Process Planning: Basic concepts of process planning, computer aided process planning (CAPP), Retrieval or variant and generative approach of CAPP, Implementation consideration of CAPP.

Numerical control of Machine tools: Principles of Numerical control (NC), Computer Numerical control (CNC), Direct Numerical control (DNC), comparison between conventional and CNC systems, Classification of CNC system, NC coordinate system, positional control, system devices; drives, ball screws, transducers, feedback devices, counting devices, signal converters, interpolators, adaptive control system.

NC Part programming: Concept, format, codes, preparatory and miscellaneous coded, manual part programming, APT programming, macros, fixed cycles.

Group Technology (CT): Introduction, needs of GT, part families, classification and coding systems, GT machine cells, benefits of GT.

CIM and FMS: Introduction, hierarchical computer system, components of CIM, types of manufacturing systems, transfer lines, flexible manufacturing system (FMS), The manufacturing cell, tool management and workpiece handling system, benefits of CIM.

Texts/References

1. Groover, “Automation Production systems and computer integrated manufacturing” PHI
2. Groover and Zimmer, “CAD/CAM” PHI
3. Chang, Wysk and Wang, “Computer Aided Manufacturing” PHI
4. Yoram Koren, “Computer control of manufacturing system”McGraw Hill Book Co.
5. B.L. Jones, “Computer Numerical Control” John Wiley and Sons
6. Rao, Tiwari and Kunda, “Computer Aided Manufacturing” Tata McGraw Hill
7. Vajpayee, “Principles of Computer Integrated Manufacturing” PHI
8. Radhakrishna Subramanyan and Raju, “CAD/CAM/CIM” New Age International (P) Ltd.
9. Sharma, “Fundamentals of Computer aided Manufacturing” S.K. Kataria and Sons.

ME 1502	**Geometric Modeling for CAD**	L T P C
	First Semester (Core)	3 0 0 3

Introduction: Historical Development, Explicit and Implicit Equations, Intrinsic Equations, Parametric Equations, Coordinate Systems.

Transformation: Representation of points; Transformation matrix; Transformation of a point; Homogeneous coordinates; General transformation – rotation, reflection, translation, scaling and sharing; Combined transformation; Solid body transformation; Parallel projections – orthographic, axonometric and oblique; Perspective projections – single-point, two-point, three-point and vanishing points.

Plane Curves: Curve representation – parametric and nonparametric curves, like circle, ellipse, parabola and hyperbola; Conic sections.

Space Curves: Fundamental of Curve Design, Parametric Space of a Curve, Reparametrization, Representation of space curves; Cubic splines; parabolic blending; Bezier curves; B-spline curves, Rational Polynomials, NURBS.

Surface Generation: Fundamental of Surface Design, Parametric Space of a Surface, Reparametrization of a Surface patch, Sixteen point form, Four Curve Form, surfaces of revolution; Sweep surfaces; Quadric surfaces; Bilinear surfaces; Ruled and developable surfaces; Coons linear surfaces; Coons bi-cubic surfaces; Bezier surfaces; B-spline surfaces.

Solids: Fundamental of Solid Design, Parametric Space of a Solid; Surface and Curves in a Solid.

Solid Modeling: Topology and Geometry, Set theory, Euler Operators, Regularized Boolean Operators, Construction Criteria, Graph Based Models, Instances and Parameterized Shapes, Cell-decomposition and Spatial Occupancy Enumeration, Sweep representation, CGS, BRep, Wireframe Analytical properties, Relational properties and Intersection. Applications in Mechanical Engineering Design.

CAD Standards: Standardization of graphics, Graphical kernel system (GKS), other graphic standards, data exchange standards for modelling data.

Text books and references:

1. David F. Rogers and J. Alan Adams, "Mathematical Elements for Computer Graphics" Tata McGraw-Hill Edition
2. Mantyla M. Ibrahim Zeid, "An Introduction to Solid Modeling, CAD/CAM Theory and Practice" Tata McGraw-Hill
3. P.N.Rao, "CAD/CAM Principles and Applications" Tata McGraw-Hill

4. Michael E. Mortenson, “Geometric Modeling” John Wiley
5. Anupam Saxena, Birendra Sahay, “Computer Aided Engineering Design” Springer

ME 1503	**Product Design & Development**	L	T	P	C
	First Semester (Core)	3	0	0	3

Introduction to product design and development: Requirement of product development and challenges; Product life-cycle; Product development process and organizations; Product design process; Identifying customer need; concept generation; concept selection and testing; product analysis; challenges in product development.

Introduction to product design tools: quality function deployment (QFD), Computer Aided Design; Industrial Design; Robust design; Design for environment; Design For Excellence (DFX), Design For Manufacturing (DFM), Design for Assembly (DFA), Design for service, Ergonomics in product design, Prototyping

Design for Manufacturing and Assembly (DFMA) guidelines: Design guidelines for products to be manufactured by different processes such as casting, machining, injection moulding etc. Product design for assembly: types of assembly, product design for manual assembly: design guidelines; development of DFA methodology

Application of value engineering in product design and development, Patents and Intellectual Property.

Text books and references:

1. Karl T. Ulrich and Steven D. Eppinger, “Product Design and Development” McGraw Hill
2. Geoffrey Boothroyd, “Assembly Automation and Product Design” Marcel Dekker Inc., NY
3. Otto K, and Wood K, “Product Design” Pearson
4. Dan Cuffaro, Isaac Zaksenberg, Garrett Oliver, “The Industrial Design Reference & Specification Book:” Rockport

ME 1504	**CAD-CAM & Automation Lab - I**	L T P C
	First Semester	0 0 3 2

Introduction to CAD software, 2 D drafting, Dimensioning; 3 D drafting, Geometric modelling of curves, surfaces and solid primitives, Modification of geometric models as per user's requirements. Drawing of complex machine components and assembly.
Introduction to Finite Element Analysis software, Import and FEM analysis of CAD components (stress and deflection analysis).

ME 1531	**Optimization Technique**	L T P C
	First Semester (Elective I)	3 0 0 3

Introduction: Definition of optimization and its importance; Basic terminologies –design variables/vector, cost/objective function, constraints and variable bounds, etc; Different types of optimization problems –based on number of variables, based on nature of variables, based on constraints, based on approaches used, based on number of objectives, etc.

Single variable unconstrained optimization: Global optimum point; Local optimum point; Stationary point; Optimality criteria; Graphical method for optimum point; Direct methods for bracketing the optimum point –exhaustive search method and bounding phase method; Refining the bracketed optimum point through region elimination methods –interval halving method, Fibonacci search method and golden section search method; Gradient based methods – bisection method. Newton-Raphson method and secant method.

Multi-variable unconstrained optimization: Optimality criteria; Undirectional search; Direct methods –simplex search method, Hooke-Jeeves pattern search method and Powell's conjugate direction method; Gradient based methods –Cauchy's steepest descent method, Newton's method, Marquardt's method, conjugate gradient method and variable metric method.

Multi-variable linear and constrained optimization: Definition and formulation of linear programming problem; unrestricted variables; slack variables; artificial variables; feasible design; infeasible design; basic solution; basic feasible solution; Simplex method for less-than-equal type of constraints; Simplex method for equality and greater-than-equal types of constraints.

Multi-variable nonlinear and constrained optimization: Kuhn-Tucker conditions; Sensitivity analysis; Transformation methods –interior penalty function method, exterior penalty function and method of multipliers; Direct methods –variable elimination method, complex search method and random search method; Gradient based methods –cutting plane method, sequential linear programming and feasible direction method.

Integer and mixed optimization: Penalty function method and branch-and-bound method.

Text books and references:

1. Kalyanmoy Deb, "Optimization for Engineering Design – Algorithms and Examples" Prentice Hall of India Pvt. Ltd. .
2. S. Rao, Engineering Optimization: Theory and Practice
3. Ravindran, K. M. Ragsdell, G. V. Reklaitis, Engineering Optimization: Methods and Applications, Second Edition
4. Jasbir S. Arora, "Introduction to Optimum Design" McGraw-Hill International Editions
5. Ashok D. Belegundu and Tirupathi R. Chandrupatla, "Optimization Concepts and Applications in Engineering" Pearson Education

		L	T	P	C
ME 1532	**Virtual Reality**				
	First Semester (Elective I)	3	0	0	3

Introduction to Virtual Reality (VR): Virtual vs Interactive vs Immersive, Virtual Reality (VR) vs Augmented Reality (AR), Real vs Virtual.

Benefits of VR: 3D Visualization, Navigation, Interaction, Physical Simulation, Virtual environments.

3D Computer Graphics: From Computer Graphics to VR, Modelling Objects, Dynamic Objects, Constraints, Collision Detection, Perspective Views, 3D Clipping, Stereoscopic Vision, Rendering the Image, Texture Mapping, Bump Mapping, Environment Mapping, Shadow, Radiosity, Other Computer Graphics Techniques.

Human Factors: Human factor in virtual environments, Vision, Vision and Display Technology, Hearing, Tactile, Equilibrium.

VR Hardware: Computers, Tracking Devices, Input Devices, Output Devices, Glasses, Displays, Audio. Head Mounted Display (HMD), Motion Trackers, BOOM, CAVE, Sensor Glove, Haptic Feedback devices. **VR Software:** VR Software Features, Web-Based VR, Division's dVISE, Blueberry3D, Boston Dynamics, MultiGen.

VR and AR Applications: Industrial, Training Simulators, Entertainment, VR/AR Centres.

Text books and references:

1. John Vince, "Introduction to Virtual Reality" Springer
2. Greg Kipper, Joseph Rampolla, "Augmented Reality: An Emerging Technologies Guide to AR" Syngress Media,U.S.
3. Fan, D. (Ed.), "Virtual Reality for Industrial Applications" Springer

ME 1533	**Innovation & Product Design**	L T P C
	First Semester (Elective I)	2 1 0 3

Introduction: History of design and innovation. Use of technology in day to day life, in agriculture, manufacturing, sanitation, medicine, transportation, information processing, and communications. Comparison of the work of past and current designers across a range of settings.

Fundamentals of Design: Perception of gap and need in user experience. Concepts and ideas. Visualization of ideas through drawing. Computer generated design using auto CAD software.

Optimization in Design: Introduction, Siddal's Classification of Design Approaches, optimization by Differential Calculus, Langrange Multipliers, Linear Programming (Simplex Method), Geometric Programming[3], Johnson's Method of Optimum Design.

Human engineering Consideration in Product Design: Introduction, Human Being as Applicator of Forces, Anthropometry: Man as Occupant of Space, The Design of Controls, The Design of Displays, Man/Machine information Exchange.

Components: Study of basic Electrical, Mechanical, and Electronics components, materials and their properties.

Tools and Manufacturing: Use of basic tools such as milling machine, drill presses, band saws, grinders, Manufacturing processes such as welding techniques and tool making.

Modern Approaches to Product Design: Concurrent Design, Quality Function Deployment (QFD)

Case studies: Constructing prototype and testing.

Text books and references:

1. Bryan Lawson, "What Designers Know" ELSEVIER
2. Karl T. Ulrich, "Design: creation of artifacts in society" University of Pennsylvania
3. Lucienne T.M. Blessing, Amaresh Chakrabarti, "DRM, a Design Research Methodology" SPRINGER

4. John Heskett, “Design: A very short Introduction” OXFORD
5. John Kolko, “Exposing the Magic of Design” OXFORD
6. AK Chitale & RC Gupta, “Product Design & Manufacturing” PHI

ME 3501	**Advanced Material Science**	L	T	P	C
	First Semester (Elective II)	3	0	0	3

Composites: Dispersion strengthened composites, particulate composites, Fiber reinforced composites, characteristics of fiber reinforced composites, Fiber reinforced system and applications, Laminar composites materials, Application of laminar composites.

Polymers: Typical Thermoplastics, structure property relationship in thermoplastics, effect of temperature on thermoplastics, Mechanical properties of thermoplastics.

Micro-electro mechanical systems (MEMS) & NANO Micromachining, Importance of different levels of structure to the material behavior, Technological significance.

Powder metallurgy: Powder metals, P/M process, P/M materials, P/M heat treatment, P/M applications.

Texts/References

1. J.F. Shackesford and MK. Muralidhana, “Introduction to Material Science” Pearson Education.
2. DR. Askeland and PP. Phule, “Essentials of materials Science and Engineering” CENGAGE Learning.
3. 3. Advanced Topics in Material Science and Engineering. J L Lopez, Kluwer Academic.
4. 4. Powder metallurgy. B K Datta, PHI.
5. 5. Materials Science and Engineering, an Introduction, William D. Callister. John Willey and Sons Inc. Singapore.
6. 6. Physical Metallurgy: Principle and Practice, V. Raghavan. Prentice Hall India Pvt Ltd.

ME 1547	**MEMS Technology**	L T P C
	First Semester (Elective II)	3 0 0 3

Overview of MEMS and microsystems, microelectronics, microfabrication, miniaturization, typical MEMS and microsystems products.

Working principles of microsystems: micro sensors, micro actuation, MEMS with micro actuators, microfluidics, micro valves, micro pumps, micro-heat pipes.

Overview of materials for MEMS and microsystems: atomic structure of matter, ions and ionization, doping of semiconductors, diffusion process, electrochemistry.

Microsystem fabrication: photolithography, ion implantation, diffusion, oxidation, chemical vapor deposition, physical vapor deposition, sputtering, etching.

Micro manufacturing: bulk micro manufacturing, surface micro manufacturing, LIGA process.

Assembly, packaging and testing of microsystems: overview of micro assembly, micro assembly processes, major technical problems of micro assembly, microsystem packaging and its levels, essential packaging technologies, reliability and testing in MEMS packaging.

Reference books:

1 Tai-Ran Hsu, “MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering” John Wiley & Sons, Inc.

2 N. P. Mahalik, “Micro manufacturing and Nanotechnology,” Springer

3 Nadim Maluf, Kirt Williams, “An Introduction to Microelectromechanical Systems Engineering,”Artech House, Inc.

4 Mark Ratner, Danier Ratner, “Nanotechnology” Pearson Education Inc.

5 Charles P. Poole Jr. & Frank J. Owens, “Introduction to Nanotechnology ” John Wiley & Sons, Inc.

6 Roger, Pennathur, Adams, “Nanotechnology Understanding Small systems” CRC Press

7. Stephen Beeby, Graham Ensell, Michael Kraft, Neil White, ‘‘MEMS Mechanical Sensors”Artech House, Inc.

8 Mohamed Gad-el-Hak, “MEMS Introduction and Fundamentals” CRC Press

ME 1548	**Ergonomics & Aesthetics**	L T P C
	First Semester (Elective II)	3 0 0 3

Introduction: Ergonomics, Social significance of ergonomics

Posture and Movement: Biomechanical, physiological and anthropometric background, Human biological, ergonomic and psychological capabilities and limitation. Sitting, standing, Hand and arm postures, change of postures; lifting, carrying, pulling and pushing movement.

Information and operation: Visual, Hearing and other senses/information, Controls, types of controls, Relation between operation and operation, Expectation, User friendliness, Different forms of Dialogue.

Environmental Factors: Noise, Vibration, Illumination, Climate, Chemical Substances.

Work Organisation: Analysis and design of job requirements, work place arrangements, materials handling devices systems and machine controls for the improvement of human work place.

The Ergonomics Approach: Project Management, Advances in applied bio-mechanics and ergonomics. **Aesthetics:** Aesthetic judgement, Aesthetic universals, Principles of aesthetics, Aesthetic in Marketing, Information technology, Industrial design.

Text books and references:

1. S. Dalela, "Work Study and Ergonomics" Standard Publishers
2. Wickens Christopher D, "An Introduction to Human Factors Engineering" Prentice Hall
3. ChandlerAllen Phillips "Human Factors Engineering" John Wiley and sons inc.
4. Sanders Mark S "Human Factors in Engineering and Design" McGraw Hill
5. Jan Dul, Bernard A. Weerdmeester "Ergonomics for beginners: A quick reference guide" CRC press

ME 1549	**Non Traditional Techniques for Optimum Design**	L T P C
	First Semester (Elective II)	3 0 0 3

Introduction: Definition and importance of a non-traditional technique. Advantages over a classical technique.

Genetic Algorithm (GA): Introduction; Chromosome representation and initialization- binary and real representation; GA operators – selection, crossover and mutation; Elite preserving mechanism; Schema theory; Constraints handling; GA for combinatorial problems – permutation representation and real-coded representation; Multi-objective optimization – concept of dominance, non-dominated sorting, ranking and crowding distance.

Differential Evolution (DE): Introduction; Chromosome representation; Target, base and trail vectors; Mutation and crossover; DE for combinatorial problems; Differences between DE and other non-traditional techniques.

Particle Swarm Optimization (PSO): Introduction; Chromosome representation; Global, population and local best solutions; Velocity and position of a solution; PSO for combinatorial problems; Differences between PSO and other nontraditional techniques.

Introduction to other non-traditional techniques: Like simulated annealing, tabu search algorithm, artificial neural network, and ant colony optimization.

Text books and references:

1. Kalyanmoy Deb "Optimization for Engineering Design-Algorithms and Examples" Prentice Hall of India Pvt. Ltd.
2. Kalyanmoy Deb "Multi-Objective Optimization using Evolutionary Algorithms" John Wiley & Sons Ltd
3. Kenneth V. Price, Rainer M. Storn and Journi A. Lampinen "Differential Evolution: A Practical" Springer
4. Maurice Clerc "Particle Swarm Optimization" ISTE Publishing Company

Department of Mechanical Engineering

M. Tech. Design and Manufacturing

1st Semester

Code	Subject	L	T	P	Credit
ME 2501	Principles of Industrial Design & Manufacturing	3	0	0	3
ME 2502	Computer Aided Design	3	0	0	3
ME 1501	Computer Aided Manufacturing	3	0	0	3
ME xxxx	Elective-I	3	0	0	3
ME xxxx	Elective-II	3	0	0	3
ME 2510	Seminar	0	0	2	1
ME 2503	Design and Manufacturing Lab-I	0	0	3	2
	Total	15	0	5	18

Electives –I

Code	Subject	L	T	P	Credit
ME 2531	Entrepreneurship & Management	3	0	0	3
ME 2532	Advanced Mechatronics	3	0	0	3
ME 3501	Advanced Material Science	3	0	0	3
ME 3503	Composite Materials	3	0	0	3
ME 2535	Soft Computing	3	0	0	3

Elective –II

Code	Subject	L	T	P	Credit
ME 3502	Structural Property correlation of Engineering Materials	3	0	0	3
ME 2547	Computational Methods & Computer Programming	3	0	0	3
ME 1531	Optimization Technique	3	0	0	3
ME 2549	Principles of Tribology	3	0	0	3
ME 1533	Innovation & Product Design	2	1	0	3

ME 2501	Principles of Industrial Design & Manufacturing First Semester (Core)	L	T	P	C
		3	0	0	3

Introduction: Engineering design process and its structure, Steps in design process, Morphology of design, Mechanical engineering design, Traditional design methods, Design synthesis, Aesthetic and ergonomic considerations in design, Use of standards in design, Selection of preferred sizes, design for Maintenance (DFM), design for manufacture, assembly, shipping, maintenance, use, and recyclability. Design checks for clarity, simplicity, modularity and safety, Design organization and communication, technical reports, drawings, presentations and models.

Materials Selection: Performance characteristics of materials, Materials selection process, Economics of materials, Evaluation methods of materials selection –cost versus performance relation, weighted index, value analysis, Materials in Design:Design for Brittle Fracture, Design for Fatigue Failure, Design for Corrosion Resistance, Design with Plastics, Design with Brittle Materials.

Modeling and Simulation in Design: Linear and Non-linear models, Buckinghum π-theorem, Monte Carlo Simulation, Basics of meta-models, Applications of FDM and FEM in design

Manufacturing Considerations in Design: Role of processing in design, Types of manufacturing processes, Economics of manufacturing, Design for castings, Forgings, Sheet metal forming, Design for machining, Powder metallurgy, Welding, Heat treatment, Assembly, Corrosion resistance, Designing with waste management, Design for manufacturability.

Cost Evaluation: Categories of costs, Methods of developing cost estimates, Cost indexes, Cost capacity factors, Estimating Plant Cost, Design to cost, Manufacturing costs, Value Analysis in Costing, Activity-Based Costing, Learning Curve, Life cycle costing.

Economic Decision Making: Mathematics of time value of money, Cost comparison, Depreciation, Taxes, Profitability of investments, Inflation, Sensitivity and break-even analysis, Uncertainty in economic analysis, Benefit cost analysis,

Failure and Reliability in Design: Probabilistic and Non-probabilistic approach, Cause-effect analysis, Failure modes and analysis, Fault Tree analysis, Robust vs. reliability based design.

Texts/Reference:

1. George Ellwood Dieter: Engineering Design: A Materials and Processing Approach: McGraw-Hill; 4th edition
2. V. B. Bhandari: Design of Machine Elements: TMH, 3/e
3. G.Pahl,W.Beitz, J.Feldhusen, K.H.Grote, Engg. Design: A Systematic Approach, Springer
4. I.M. Pandey, Financial Management, 11th Ed., Vikas Pub. House
4. Linda C. Schmidt, Product Engineering and Manufacturing, 2nd Edition,
5. Shuchen B. Thakore and B.I. Bhatt,Intro.to Process Engineering and Design, McGraw Hill

ME 2502	Computer Aided Design First Semester (Core)	L T P C 3 0 0 3

Introduction: Overview of computer aided engineering design.

Transformation: Representation of points; Transformation matrix; Transformation of a point; Homogeneous coordinates; General transformation –rotation, reflection, translation, sealing and sharing; Combined transformation; Solid body transformation; Parallel projections –orthographic, axonometric and oblique; Perspective projections –single-point, two-point, three-point and vanishing points.

Plane Curves: Curve representation –parametric and non parametric curves, like circle, ellipse, parabola and hyperbola; Conic sections.

Space Curves: Representation of space curves; Cubic splines; Parabolic blending; Bezier curves; B-spline curves.

Surface Generation: Surfaces of revolution; Sweep surfaces; Quadric surfaces; Bilinear surfaces; Ruled and developable surfaces; Coons linear surfaces; Coons bi-cubic surfaces; Bezier surfaces; B-spline surfaces.

Solid Body Modeling: Designing a 3D model, like a machine part; Hidden surface removal.

Texts/References

1. Mathematical Elements for Computer Graphics. David F. Rogers and J. Alan Adams, Tata McGraw-Hill Edition.
2. Computer Graphics. Roy A. Plastock and Gordon Kalley, McGraw-Hill Book Company.
3. Computer Aided Design: A basic and Mathematical Approach. S K Srivastava, IK Publishing House.
4. Introduction to Computer Aided Design. C K maiti, Pan Stanford Publishing Pte. Ltd.
5. Fundamentals of Computer Aided Design. K Goyal, S K Kataria and Sons.

ME 1501	Computer Aided Manufacturing	L	T	P	C
	First Semester (Core)	3	0	0	3

Introduction to Computer Aided Design (CAD), Computer Aided Process Planning (CAPP), Computer Aided Manufacturing (CAM), Computer Integrated Manufacturing (CIM), product cycle and automation in CAD/CAM, Need of CAD/CAM.

Process Planning: Basic concepts of process planning, computer aided process planning (CAPP), Retrieval or variant and generative approach of CAPP, Implementation consideration of CAPP.

Numerical control of Machine tools: Principles of Numerical control (NC), Computer Numerical control (CNC), Direct Numerical control (DNC), comparison between conventional and CNC systems, Classification of CNC system, NC coordinate system, positional control, system devices; drives, ball screws, transducers, feedback devices, counting devices, signal converters, interpolators, adaptive control system.

NC Part programming: Concept, format, codes, preparatory and miscellaneous coded, manual part programming, APT programming, macros, fixed cycles.

Group Technology (CT): Introduction, needs of GT, part families, classification and coding systems, GT machine cells, benefits of GT.

CIM and FMS: Introduction, hierarchical computer system, components of CIM, types of manufacturing systems, transfer lines, flexible manufacturing system (FMS), The manufacturing cell, tool management and workpiece handling system, benefits of CIM.

Texts/References

1. Groover, Automation, Production systems and computer integrated manufacturing, PHI
2. Groover and Zimmer, CAD/CAM, PHI
3. Chang, Wysk and Wang, Computer Aided ManufacturingPHI4.YoramKorenComputer control of manufacturing system, McGraw Hill Book Co.
4. YoramKoren, “Computer control of manufacturing system”McGraw Hill Book Co.
5. B.L. Jones, Computer Numerical Control, John Wiley and Sons
6. Rao, Tiwari and Kunda, Computer Aided Manufacturing, Tata McGraw Hill
7.Vajpayee, Principles of Computer Integrated Manufacturing, PHI
8. RadhakrishnaSubramanyan and Raju, CAD/CAM/CIM, New Age International (P) Ltd.
9. Sharma, Fundamentals of Computer aided Manufacturing, S.K. Kataria and Sons.

ME 2503	Design and Manufacturing Lab-I First Semester	L T P C 0 0 3 2

Heat treatment of ferrous alloys, metallographic investigation of bare and heat treated ferrous alloys, hardness test of bare and heat treated ferrous alloys, tensile testing of bare and heat treated ferrous alloys, micro-hardness testing, fracture testing of metals and polymers, preparation of laminated composites, mechanical and fracture testing of laminated composites, synthesis of nano- particles using planetary ball mill, Sol-Gel method for synthesis of Nano particles, thermal characterization of materials, design of mechanical system (prime mover / non-prime mover/innovative product design)

ME 2531	Entrepreneurship & Management First Semester (Elective I)	L T P C 3 0 0 3

Introduction to Entrepreneurship: Meaning and concept of entrepreneurship, the history of entrepreneurship development, role of entrepreneurship in economic development, agencies in entrepreneurship management and future of entrepreneurship.

The Entrepreneur: Meaning of entrepreneur, the skills required to be an entrepreneur, the entrepreneurial decision process, and role models, mentors and support system.

Business Opportunity Identification: Business ideas, methods of generating ideas, and opportunity recognition.

Preparing a Business Plan: Meaning and significance of a business plan, components of a business plan, and feasibility study.

Financing the New Venture: Importance of new venture financing, types of ownership securities, venture capital, types of debt securities, determining ideal debt-equity mix, and financial institutions and banks.

Launching the New Venture: Choosing the legal form of new venture, protection of intellectual property, and marketing the new venture.

Managing Growth in New Venture: Characteristics of high growth new ventures, strategies for growth, and building the new venture capital.

Harvesting Rewards: Exit strategies for entrepreneurs, bankruptcy, and succession and harvesting strategy.

E-Entrepreneur, Leadership, Motivation& Productivity. Decision Making, Business Plan, S.S.I., System approach, Organization as system, MIS. Quality, TQM, ISO 9000 Standards.

Texts/Reference

1.Entrepreneurship by Hisrich, Peters, Shepherd, Manimala; McGraw Hill Education India Private Limited; 9 edition
2.Entrepreneurship by Rajeev Roy; Oxford University Press India; Second edition
3.Entrepreneurship by AlpanaTrehan; Dreamtech Press
4.Management and Entrepreneurship by N.V.R. Naidu, T. Krishna Rao; I K International Publishing House Pvt. Ltd
5.Shankar: Entrepreneurship: Theory & Practice: McGraw-Hill
6.A.K. Singh: Entrepreneurship Development & Management: Laxmi Publication
7.David H. Holt: Entrepreneurship: -New Venture Creation: Prentice Hall Publication
8.Randolph&Ponker: Effective Project Planning & Management: Longman Higher Education

ME 2532	Advanced Mechatronics	L	T	P	C
	First Semester (Elective I)	3	0	0	3

Introduction: Definition of Mechatronics, Scope, key elements, Conventional Vs Mechatronics Systems; Need of Mechatronics in Mechanical Engineering; Electrical/Electronic systems i.e. conductors, Insulators and Semiconductors, passive components used in electronics, transformers, transistors, integrated circuits, digital circuits.

Sensors: Strain gauge, Potentiometers, Tachometers, Linear variable differential transformer, piezoelectric accelerometer, Hall effect sensors, Optical Encores, Resolver, Induction, Tactile and Force sensors.

Actuators: Pneumatic and Hydraulic Actuators, Electrical actuators, stepper motors, DC motors, AC motors.

Electronics fundaments: Brief review of some semiconductor devices. The operational Amplifier. Binary variable and logic, Boolean Algebra, Logic circuits. Digital-to-analog converters, analog-to-Digital converters.

Control systems: Mathematical modeling of physical systems, sensors and actuators, System equations, controllability, observability, pole placement technique, PID Controller.

Applications: Case studies of control of hydraulic, pneumatic, mechanical and electrical system, Application of CNC machines & Robotics. Applications of Mechatronics in Manufacturing and Automation Case Studies.

Texts/References

1.Analytical Robotics and Machatronics, Wolfram Stadler, McGraw Hill.
2.Robotic engineering, Rlafter, PHI.
3.Machatronics, AMT
4.Automatic Control System, B.C. Kuo, Ogata, PHI
5.Introduction to Digital computer electronics, A.P. Mahind, TMH

6.Measurement Systems, E.O. Doeblin, McGraw Hill
7.Bolton W. "Mechatronics", 2ndEdition, Pearson Education, New Delhi (1999)
8.Necsulelscu Dan, "Mechatronics", Pearson Education, New Delhi (2002)
9.Mechatronics by Mahalik, Spinger.

ME 3501	Advanced Material Science	L	T	P	C
	First Semester (Elective I)	3	0	0	3

Composites: Dispersion strengthened composites, particulate composites, Fiber reinforced composites, characteristics of fiber reinforced composites, Fiber reinforced system and applications, Laminar composites materials, Application of laminar composites.
Polymers: Typical Thermoplastics, structure property relationship in thermoplastics, effect of temperature on thermoplastics, Mechanical properties of thermoplastics.
Micro-electro mechanical systems (MEMS) & NANO Micromachining, Importance of different levels of structure to the material behavior, Technological significance.
Powder metallurgy: Powder metals, P/M process, P/M materials, P/M heat treatment, P/M applications.

Texts/References

1. J.F. Shackesford and MK. Muralidhana, Introduction to Material Science, Pearson Education.
2. DR. Askeland and PP. Phule, Essentials of materials Science and Engineering, CENGAGE Learning.
3. Advanced Topics in Material Science and Engineering. J L Lopez, Kluwer Academic.
4. Powder metallurgy. B K Datta, PHI.
5. Materials Science and Engineering, an Introduction, William D. Callister. John Willey and Sons Inc. Singapore.
6. Physical Metallurgy: Principle and Practice, V. Raghavan. Prentice Hall India Pvt Ltd.

ME 3503	Composite Materials	L	T	P	C
	First Semester (Elective I)	3	0	0	3

Fibre Reinforced Plastics (FRP)
Definition; Types; General properties and characteristics; Reinforcing materials –particles, fibers, whiskers; Properties of reinforcing materials; Matrix materials; Additives; Properties of FRP materials; Applications

Manufacturing Processes
Open mold processes –Hand layup, Spray up, Vacuum bag, Pressure bag & autoclave, Centrifugal casting, Filament winding; Closed mold processes –Compression molding, Resin transfer molding (RTM), Injection molding, Pultrusion; SMC & DMC products, etc.

Designing Fibre Reinforced Plastics
Design variables; Selection of fiber-matrix and manufacturing process; Effects of mechanical, thermal, electrical and environmental properties, Fiber orientation, Symmetric and asymmetric

structure; Effects of unidirectional continuous and short fibers; Lamination theory; Design equations, Design for failure; FEA design packages; Design examples & case studies in FRP.

Engineering Ceramics And Metal Matrix Composites
Reinforcement materials; Matrix; Characteristics and specialized properties like –weibull modulus, high temperature strengths, wear & frictional property improvements; Selection criteria; Advantages and limitations in use of ceramics & MMCs; Fracture mechanics; Applications.

Ceramic & Polymer Metal Composites
CMC & PMC Characteristics, Various types, Advantages & Limitations, Applications. Role of Mixtures Reinforcement –Particles –Fibres. Carbon/Carbon Composites-Advantages, Limitations-Sol-Gel techniques –Chemical Vapor Deposits. Applications.

Texts/References

1.Haslehurst.S.E. "Manufacturing Technology ", ELBS, London, 1990.
2.Krishnan K. Chawle. "Composite Material: Science and Engineering" Second Edition, Springer, 1998
3.T.W.Clyne, P.J. Withers, "An Introduction to metal matrix composites", Cambridge University Press, 1993.
4.F.C. Campbell "Structural Composite Materials", Materials Park,ASM International,2010

		L	T	P	C
ME 2535	Soft Computing First Semester (Elective I)	3	0	0	3

Introduction: Introduction to soft computing, difference between hard computing and soft computing, need for soft computing, applications of soft computing.

Artificial neural network: Neurons and neural network, Neural network types, structure of neural network, basic model of neural network, single layer perceptron, multi layer perceptron, radial basis function network, self organizing map (SOM), recurrent neural network, training of neural network, supervised and unsupervised learning of neural network, applications of neural network.

Fuzzy logic: Concept of fuzzy logic and fuzzy sets, classical sets, fuzzy relations and rule base, fuzzy arithmetic, fuzzy reasoning and clustering, defuzzification, neuro-fuzzy systems, applications of fuzzy systems.

Genetic algorithm: Concept of genetic algorithm (GA), binary GA, real GA, GA operators, selection, crossover and mutation, optimizations through GA – single objective and multi objective, applications of GA.

Soft computing tools: Different tools for soft computing applications – MATLAB, WEKA, FisPro, kappalab, GUAJE Fuzzy.

Uncertainty quantification: Soft computing for uncertainty modeling and quantification.

Texts/Reference

1. D K Pratihar: Soft Computing Fundamentals and Applications, Alpha Science International.
2. Ikvinderpal Singh: Soft Computing, Khanna Publishers.
3. N P Padhy, S P Simon: Soft Computing with MATLAB programming, Oxford University Press, India.
4. S Kaushik, S Tiwari: Soft Computing Fundamentals, Techniques and Applications, McGraw Hill India.
5. T Andrea: Soft Computing, Springer.
6. S N Sivanandam, S N Deepa: Principles of Soft Computing, Willey India.

ME 3502	Structural Property correlation of Engineering Materials	L	T	P	C
	First Semester (Elective II)	3	0	0	3

Introduction

Stiffness, Strength, and Toughness, Types of mechanical behaviour, Relevance, Measurement, data, Macroscopic, continuum behaviour, Physical mechanisms controlling behaviour.

Elasticity

Introduction, Stress, strain, compliance and stiffness tensors, Physical origin of elastic moduli, Generalized Hooke's law and its application to crystals, designing for modulus and Composites.

Continuum Plasticity

True stress-true strain, Necking and Considerer's Criterion, Yield Criteria and yield locus, Normality, Isotropic and kinematic hardening, Plastic stress-strain relations.

Fracture

Importance of Fracture Mechanics, Griffith Fracture Theory, Crack Driving Force & Energy Release Rate, Modes of fracture, Stress intensity factors, Similitude, Role of Crack-tip Plasticity--Plastic Zone Size & Shape, K-dominance, Fracture Toughness-Microstructural Issues.

Fatigue

Total life approaches, Fatigue design approaches, HCF and LCF, Fatigue crack inhibition, Fatigue crack growth, Paris law and models, Threshold, Damage tolerant approach, Striations, Different stages of fatigue crack growth, Examples.

Mechanical Testing Behaviour

Mechanical Characterization: Mechanical Property characterization-Principles & characterization techniques related to tensile, compressive, hardness, fatigue, and fracture toughness properties. Deformation, Super plasticity Stress-strain diagram, Determination of YS, UTS, MoE, %E, %RA, Hardness testing, true stress-strain diagram, stretcher strain characteristics, effects of cold working, & n values, poison's ratio, Deep drawn quality of sheets, Impact test, bend test, shear test, Significances of property evaluation, SN curves and fatigue life, non-destructive testing, residual stress measurements, corrosion testing, wear & tear characteristics, slow strain rate characteristics.

Texts/References

1. GE Dieter, Mechanical Metallurgy, McGraw-Hill
2. RW Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, John Wiley & Sons
3. MF Ashby and DRH Jones, Engineering Materials 1, Butterworth-Heinemann
4. D Hull and DJ Bacon, Introduction to Dislocations, Pergamon
5. Fracture Mechanics –T.L. Anderson, CRC Press.

ME 2547	Computational Methods & Computer Programming	L	T	P	C
	First Semester (Elective II)	3	0	0	3

Introduction to computer Programming: Discussion on at least one programming language, like C, C++ JAVA, MATLAB, etc.

Error analysis in numerical computation: Absolute error; Relative error; Round-off error and Truncation error.

Solution of Single variable nonlinear equations: Bracketing method –graphical method, incremental method, bisection method and false position method; Open methods –fixed point iteration, Newton-Raphson method and Secant method.

Roots of singe variable polynomials: Polynomial deflation; Bairstow's method and Muller method.

Solution of a system of multi-variable equations: Linear system of equations-Gauss elimination method. Gauss-Jordan method, matrix inversion, LU decomposition, Jacobiiteration and Gauss-Seidel iteration; Nonlinear system of equations-fixed point iteration. Newton's method, Jacobian matrix and Seidel iteration.

Curve fitting: Least-square line fitting; Exponential curve fitting; polynomial curve fitting –Lagrange polynomial and Newton's polynomial; Interpolation by piecewise spline function –linear spline, quadric spline and cubic spline.

Eigenvalues and Eigenvectors: Eigenvalues of a homogenous matrix and eigenvalues of a symmetric matrix.

Numerical differentiation: Finite difference methods-forward, backward and centre.

Numerical integration: Newton-Cotes quadrature-trapezoidal rule and Simpson's rules; Romberg integration and Gauss quadrature.

Solution of ordinary differential equations: Initial value problem-Euler's methods and Gunge-Kutta methods; Boundary value problems-shooting method, finite difference methods.

Solution of partial differential equations: Elliptic equations and parabolic equations.

Texts/References

1. Numerical Methods for Engineers, Steven C. Chapra and Raymond P. Canade, Tata McGraw-Hill Publishing Company Ltd.
2. Numerical Methods for Mathematics Science and Engineering. John H. Mathews. Prentice-Hall of India Pvt. Ltd.
3. Applied Numerical Analysis. Curtis F. Gerald and Patrick O. Wheatley, Addison Wesley.
4. Computer Oriented Numerical Methods. V Rajaraman, PHI.

ME 1531	Optimization Technique	L	T	P	C
	First Semester (Elective II)	3	0	0	3

Introduction: Definition of optimization and its importance; Basic terminologies –design variables/vector, cost/objective function, constraints and variable bounds, etc; Different types of optimization problems –based on number of variables, based on nature of variables, based on constraints, based on approaches used, based on number of objectives, etc.

Single variable unconstrained optimization: Global optimum point; Local optimum point; Stationary point; Optimality criteria; Graphical method for optimum point; Direct methods for bracketing the optimum point –exhaustive search method and bounding phase method; Refining the bracketed optimum point through region elimination methods –interval halving method, Fibonacci search method and golden section search method; Gradient based methods –bisection method. Newton-Raphson method and secant method.

Multi-variable unconstrained optimization: Optimality criteria; Undirectional search; Direct methods –simplex search method, Hooke-Jeeves pattern search method and Powell's conjugate direction method; Gradient based methods –Cauchy's steepest descent method, Newton's method, Marquardt's method, conjugate gradient method and variable metric method.

Multi-variable linear and constrained optimization: Definition and formulation of linear programming problem; unrestricted variables; slack variables; artificial variables; feasible design; infeasible design; basic solution; basic feasible solution; Simplex method for less-than-equal type of constraints; Simplex method for equality and greater-than-equal types of constraints.

Multi-variable nonlinear and constrained optimization: Kuhn-Tucker conditions; Sensitivity analysis; Transformation methods –interior penalty function method, exterior penalty function and method of multipliers; Direct methods –variable elimination method, complex search method and random search method; Gradient based methods –cutting plane method, sequential linear programming and feasible direction method.

Integer and mixed optimization: Penalty function method and branch-and-bound method.

Texts/References

1. Kalyanmoy Deb, "Optimization for Engineering Design – Algorithms and Examples" Prentice Hall of India Pvt. Ltd.
2. Jasbir S. Arora, "Introduction to Optimum Design" McGraw-Hill International Editions
3. Ashok D. Belegundu and Tirupathi R. Chandrupatla, "Optimization Concepts and Applications in Engineering" Pearson Education

ME 2549	Principles of Tribology	L	T	P	C
	First Semester (Elective II)	3	0	0	3

Introduction: History, Industrial Importance.

Engineering Surfaces: Properties and Measurement: Measurement Methods, Surface Profilometry, Statistical Description, and Fractal Description.

Surface Contact: Non-conforming Surface Contact Geometry, Stresses in Non-conforming Contacts, Contact of Rough Surfaces, Numerical Surface Contact Models.

Adhesion: Adhesion at Solid-Solid Contact, Basic Models, Factors influencing Adhesion, Adhesion produced by Surface Tension, Stiction, Adhesion at the Contact between Rough Surfaces.

Friction: Measurement Methods, Origin of Friction, Friction Theories, Mechanisms, Friction of Metals, Non-metallic Materials: Ceramics, Polymers, Solid Lubricants.

Wear: Types: Adhesive, Abrasive, Corrosive, Fatigue, Minor Forms: Fretting, Erosion, Percussion, Delamination Theory, Wear Debris Analysis, Wear Testing Methods, Wear of Metals, Ceramics, Polymers, Systems Approach for Wear Reduction.

Thermal Considerations in Sliding Contact: Measurement of Surface Temperature in Sliding: Thermocouples, Thin Film Sensors, Radiation Detectors, Metallographic Observation, Liquid Crystals etc., Theoretical Analyses: Archard's Approach, Multiple Heat Input Considerations.

Surface Engineering: Surface Treatments: Microstructural and Thermochemical Treatments, Surface Coatings: Hard Facing, VapourDeposition Processes: PVD, CVD, PECVD etc., Selection of Surface Treatment / Surface Coatings.

Nanotribology: Measurement Tools: Surface Force Apparatus, Scanning Tunnelling Microscope, Atomic / Friction Force Microscope, Measurements, Fabrication Techniques for MEMS / NEMS, Atomic Scale Simulations.

Texts/References

1. Introduction to Tribology of Bearings. B. C. Majumdar, A. H. Wheeler & Co. Ltd., New Delhi,1999
2. Basic Lubrication Theory. A. Cameron and C. M. McEttles, Wiley Eastern Ltd., New Delhi, 1987.
3. Engineering Tribology. P. Sahoo, PHI Learning, 2005.
4. Principles of Tribology. H Ping, Willey.

ME 1533	Innovation & Product Design	L	T	P	C
	First Semester (Elective II)	2	1	0	3

Introduction: History of design and innovation. Use of technology in day to day life, in agriculture, manufacturing, sanitation, medicine, transportation, information processing, and communications. Comparison of the work of past and current designers across a range of settings.

Fundamentals of Design: Perception of gap and need in user experience. Concepts and ideas. Visualization of ideas through drawing. Computer generated design using auto CAD software.

Optimization in Design: Introduction, Siddal's Classification of Design Approaches, optimization by Differential Calculus, Langrange Multipliers, Linear Programming (Simplex Method), Geometric Programming[3], Johnson's Method of Optimum Design.

Human engineering Consideration in Product Design: Introduction, Human Being as Applicator of Forces, Anthropometry: Man as Occupant of Space, The Design of Controls, The Design of Displays, Man/Machine information Exchange.

Components: Study of basic Electrical, Mechanical, and Electronics components, materials and their properties.

Tools and Manufacturing: Use of basic tools such as milling machine, drill presses, band saws, grinders, Manufacturing processes such as welding techniques and tool making.

Modern Approaches to Product Design: Concurrent Design, Quality Function Deployment (QFD)

Case studies: Constructing prototype and testing.

Texts/References

1. Bryan LawsonWhat Designers Know, ELSEVIER

2. Karl T. Ulrich Design: creation of artifacts in society University of Pennsylvania
3. Lucienne T. M. Blessing, AmareshChakrabarti DRM, a Design Research Methodology, SPRINGER
4. John Heskett Design: A very short Introduction, OXFORD
5. John Kolko Exposing the Magic of Design, OXFORD
6. AK Chitale& RC Gupta Product Design & Manufacturing, PHI.

M.Tech. in Materials & Manufacturing Technology
Department of Mechanical Engineering

Semester-I

CODE	SUBJECT NAME	L	T	P	C
ME 3501	Advanced Material Science	3	0	0	3
ME 3502	Structural Property Correlation of Engineering Materials	3	0	0	3
ME 3503	Composite Materials	3	0	0	3
ME xxxx	Elective I	3	0	0	3
ME 35xx	Elective II	3	0	0	3
ME 3510	Seminar	0	0	3	2
ME 3504	Mini Project-I	0	0	2	1
	Total	15	0	5	18

Electives-I

CODE	SUBJECT NAME	L	T	P	C
ME 1531	Optimization Technique	3	0	0	3
ME 3532	Iron and Steel Manufacturing Process	3	0	0	3
ME 3533	Non-Ferrous Metals and Alloys	3	0	0	3
ME 3534	Physical and Chemical Characterization of Materials	3	0	0	3
ME 3535	Statistical Quality Control and Management	2	1	0	3

Electives-II

CODE	SUBJECT NAME	L	T	P	C
ME 3546	Failure Analysis and Prevention	3	0	0	3
ME 3547	Advances in Polymeric Materials	3	0	0	3
ME 3548	Advanced Ceramics for Strategic Applications	3	0	0	3
ME 3549	Material Selection and Safety	3	0	0	3

ME 3501	**Advanced Material Science**	L T P C
	First Semester (Core)	3 0 0 3

Composites: Dispersion strengthened composites, particulate composites, Fiber reinforced composites, characteristics of fiber reinforced composites, Fiber reinforced system and applications, Laminar composites materials, Application of laminar composites.

Polymers: Typical Thermoplastics, structure property relationship in thermoplastics, effect of temperature on thermoplastics, Mechanical properties of thermoplastics.

Micro-electro mechanical systems (MEMS) & NANO Micromachining, Importance of different levels of structure to the material behavior, Technological significance.

Powder metallurgy: Powder metals, P/M process, P/M materials, P/M heat treatment, P/M applications.

Texts/References

1. J.F. Shackesford and MK. Muralidhana, "Introduction to Material Science" Pearson Education.
2. DR. Askeland and PP. Phule, "Essentials of materials Science and Engineering" CENGAGE Learning.
3. 3. Advanced Topics in Material Science and Engineering. J L Lopez, Kluwer Academic.
4. 4. Powder metallurgy. B K Datta, PHI.
5. 5. Materials Science and Engineering, an Introduction, William D. Callister. John Willey and Sons Inc. Singapore.
6. 6. Physical Metallurgy: Principle and Practice, V. Raghavan. Prentice Hall India Pvt Ltd.

ME 3502	**STRUCTURAL PROPERTY CORRELATION OF ENGINEERING MATERIALS**	**L T P C**
	First Semester (Core)	3 0 0 3

Introduction

Stiffness, Strength, and Toughness, Types of mechanical behaviour, Relevance, Measurement, data, Macroscopic, continuum behaviour, Physical mechanisms controlling behaviour.

Elasticity

Introduction, Stress, strain, compliance and stiffness tensors, Physical origin of elastic moduli, Generalized Hooke's law and its application to crystals, designing for modulus and Composites.

Continuum Plasticity

True stress-true strain, Necking and Considerer's Criterion, Yield Criteria and yield locus, Normality, Isotropic and kinematic hardening, Plastic stress-strain relations.

Fracture

Importance of Fracture Mechanics, Griffith Fracture Theory, Crack Driving Force & Energy Release Rate, Modes of fracture, Stress intensity factors, Similitude, Role of Crack-tip Plasticity--Plastic Zone Size & Shape, K-dominance, Fracture Toughness-Microstructural Issues.

Fatigue

Total life approaches, Fatigue design approaches, HCF and LCF, Fatigue crack inhibition, Fatigue crack growth, Paris law and models, Threshold, Damage tolerant approach, Striations, Different stages of fatigue crack growth, Examples.

Mechanical Testing Behaviour

Mechanical Characterization: Mechanical Property characterization-Principles & characterization techniques related to tensile, compressive, hardness, fatigue, and fracture toughness properties. Deformation, Super plasticity Stress-strain diagram, Determination of YS, UTS, MoE, %E, %RA, Hardness testing, true stress-strain diagram, stretcher strain characteristics, effects of cold working, & n values, poison's ratio, Deep drawn quality of sheets, Impact test, bend test, shear test, Significances of property evaluation, SN curves and fatigue life, non-destructive testing, residual stress measurements, corrosion testing, wear & tear characteristics, slow strain rate characteristics.

Texts/References

1. GE Dieter, Mechanical Metallurgy, McGraw-Hill
2. RW Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, John Wiley & Sons
3. MF Ashby and DRH Jones, Engineering Materials 1, Butterworth-Heinemann
4. D Hull and DJ Bacon, Introduction to Dislocations, Pergamon
5. Fracture Mechanics –T.L. Anderson, CRC Press.

ME 3503	**COMPOSITE MATERIALS**	**L T P C**
	First Semester (Core)	3 0 0 3

Fibre Reinforced Plastics (FRP)

Definition; Types; General properties and characteristics; Reinforcing materials –particles, fibers, whiskers; Properties of reinforcing materials; Matrix materials; Additives; Properties of FRP materials; Applications

Manufacturing Processes

Open mold processes –Hand layup, Spray up, Vacuum bag, Pressure bag & autoclave, Centrifugal casting, Filament winding; Closed mold processes –Compression molding, Resin transfer molding (RTM), Injection molding, Pultrusion; SMC & DMC products, etc.

Designing Fibre Reinforced Plastics

Design variables; Selection of fiber-matrix and manufacturing process; Effects of mechanical, thermal, electrical and environmental properties, Fiber orientation, Symmetric and asymmetric structure; Effects of unidirectional continuous and short fibers; Lamination theory; Design equations, Design for failure; FEA design packages; Design examples & case studies in FRP.

Engineering Ceramics And Metal Matrix Composites

Reinforcement materials; Matrix; Characteristics and specialized properties like –weibull modulus, high temperature strengths, wear & frictional property improvements; Selection criteria; Advantages and limitations in use of ceramics & MMCs; Fracture mechanics; Applications.

Ceramic & Polymer Metal Composites
CMC & PMC Characteristics, Various types, Advantages & Limitations, Applications. Role of Mixtures Reinforcement –Particles –Fibres. Carbon/Carbon Composites-Advantages, Limitations-Sol-Gel techniques –Chemical Vapor Deposits. Applications.

Texts/References
1.Haslehurst.S.E. "Manufacturing Technology ", ELBS, London, 1990.
2.Krishnan K. Chawle. "Composite Material: Science and Engineering" Second Edition, Springer, 1998
3.T.W.Clyne, P.J. Withers, "An Introduction to metal matrix composites", Cambridge University Press, 1993.
4.F.C. Campbell "Structural Composite Materials", Materials Park,ASM International,2010

ME 1531	OPTIMIZATION TECHNIQUE	L T P C
	Elective-I	3 0 0 3

Introduction: Definition of optimization and its importance; Basic terminologies –design variables/vector, cost/objective function, constraints and variable bounds, etc; Different types of optimization problems –based on number of variables, based on nature of variables, based on constraints, based on approaches used, based on number of objectives, etc.

Single variable unconstrained optimization: Global optimum point; Local optimum point; Stationary point; Optimality criteria; Graphical method for optimum point; Direct methods for bracketing the optimum point –exhaustive search method and bounding phase method; Refining the bracketed optimum point through region elimination methods –interval halving method, Fibonacci search method and golden section search method; Gradient based methods –bisection method. Newton-Raphson method and secant method.

Multi-variable unconstrained optimization: Optimality criteria; Undirectional search; Direct methods –simplex search method, Hooke-Jeeves pattern search method and Powell's conjugate direction method; Gradient based methods –Cauchy's steepest descent method, Newton's method, Marquardt's method, conjugate gradient method and variable metric method.

Multi-variable linear and constrained optimization: Definition and formulation of linear programming problem; unrestricted variables; slack variables; artificial variables; feasible design; infeasible design; basic solution; basic feasible solution; Simplex method for less-than-equal type of constraints; Simplex method for equality and greater-than-equal types of constraints.

Multi-variable nonlinear and constrained optimization: Kuhn-Tucker conditions; Sensitivity analysis; Transformation methods –interior penalty function method, exterior penalty function and method of multipliers; Direct methods –variable elimination method, complex search method and random search method; Gradient based methods –cutting plane method, sequential linear programming and feasible direction method.

Integer and mixed optimization: Penalty function method and branch-and-bound method.

Text books and references:

1. Kalyanmoy Deb, "Optimization for Engineering Design – Algorithms and Examples" Prentice Hall of India Pvt. Ltd.
2. Jasbir S. Arora, "Introduction to Optimum Design" McGraw-Hill International Editions
3. Ashok D. Belegundu and Tirupathi R. Chandrupatla, "Optimization Concepts and Applications in Engineering" Pearson Education

ME 3532	**Iron and Steel Manufacturing Process**	**L T P C**
	Elective-I	3 0 0 3

Ferrous Metals: Iron-Carbon equilibrium diagram; effects of alloy additions; types of steel – plain carbon steels, low alloy steels, heat treatable steels, tool steels, die steels, stainless steels, special steels; international systems to classify steel grades – AISI/SAE, DIN, EN series/BS, BIS; automotive grades and compositions; mechanical, thermal, electrical and physical properties of steels, applications.

Steel Making: Principles of steel making, melting practices, development of steel making processes, physiochemical principles and kinetic aspects of steel making, carbon boil, oxygen transport mechanism, desulphurization, dephosphorization, slag-functions, composition control, properties and theories, raw materials for steel making and plant layout, effects of melting practices on end product, principle equipment used and applications of steel making processes.

Cast Iron: Types of Cast irons – grey cast irons, alloy CI, Spheroidal cast irons, white iron, malleable iron, vermicular cast irons; chemical compositions and properties.

TEXT BOOK

1. William D. Callister, Jr., "Materials Science and Engineering an Introduction", John Wiley & Sons, 6th Edition, , Inc., 2004.
2. V.Raghavan, "Materials Science and Engineering", Prentice Hall of India Pvt. Ltd.,5th Edition, 2007
3. Hajra Choudhary, "Elements of Workshop Technology", Asia Publishing House, Vol. I & II; 1996
4. R.K. Jain and S.C. Gupta, "Production Technology", Hanna Publishers, 1997
5. H.M.T. "Production Technology", Tata McGraw Hill, 1990
6. 1. Avner, S. H., "Introduction to Physical Metallurgy", second edition, McGraw Hill, 1985.
7. Henkel & Pense "Structure and Properties of Engineering materials", 2001
8. ASM Handbook, Vol. 2, "Properties and Selection - Nonferrous Alloys and Special-Purpose Materials"
9. ASM Handbook, Vol.3, "Alloy Phase Diagrams.

REFERENCE BOOK

1. Flinn, R.A., and Trojan, P.K., "Engineering Materials and their Applications", Jaico , 4th Edition, 1999.
2. ASM Metals Hand book, "Failure Analysis and Prevention", 10th Edition, Vol.11, ASM 2002.

3. Ashby M.F., “Material Selection in Mechanical Design”, Butter Worth 3rd Edition, 2005. Smithells Metals Reference Book, Eighth Edition
4. ASM Metals Hand Book, Vol.15, “Casting”, ASM International, 10th Edition, 1991

ME 3533 **Non-Ferrous Metals and Alloys** **L T P C**
Elective-I 3 0 0 3

Aluminium and aluminium Base Alloys: enhancing properties of aluminium for auto applications; classification system and grades of alloys; roles of alloy additions on properties; significance of various equilibrium diagrams in designing alloys; solution treatment (age hardening) and microstructural changes; chemical compositions & properties of aluminium alloys; environmental benefits of recycling. aluminium alloy melting practices; component forming processes – castings, extrusions, sheet forming and forgings, material defects and their significances on properties and performances on end product; automotive applications of aluminium alloys and manufacturing processes for body to power train components.

Magnesium And Titanium Base Alloys: Properties and benefits over other traditional metals; classifications of alloys; melting practices; manufacturing processes – casting, extrusion and forging processes; solution treatment and microstructures; alloy compositions and properties; surface coatings; auto applications and limitations.

TEXT BOOK

1. William D. Callister, Jr., “Materials Science and Engineering an Introduction”, John Wiley & Sons, 6th Edition, , Inc., 2004.
2. V.Raghavan, “Materials Science and Engineering”, Prentice Hall of India Pvt. Ltd.,5th Edition, 2007
3. Hajra Choudhary, “Elements of Workshop Technology”, Asia Publishing House, Vol. I & II; 1996
4. R.K. Jain and S.C. Gupta, “Production Technology”, Hanna Publishers, 1997
5. H.M.T. “Production Technology”, Tata McGraw Hill, 1990
6. 1. Avner, S. H., “Introduction to Physical Metallurgy”, second edition, McGraw Hill, 1985.
7. Henkel & Pense “Structure and Properties of Engineering materials”, 2001
8. ASM Handbook, Vol. 2, “Properties and Selection - Nonferrous Alloys and Special-Purpose Materials”
9. ASM Handbook, Vol.3, “Alloy Phase Diagrams.

REFERENCE BOOK

1. Flinn, R.A., and Trojan, P.K., “Engineering Materials and their Applications”, Jaico , 4th Edition, 1999.
2. ASM Metals Hand book, “Failure Analysis and Prevention”, 10th Edition, Vol.11, ASM 2002.
3. Ashby M.F., “Material Selection in Mechanical Design”, Butter Worth 3rd Edition, 2005. Smithells Metals Reference Book, Eighth Edition
4. ASM Metals Hand Book, Vol.15, “Casting”, ASM International, 10th Edition, 1991

ME 3534 **PHYSICAL AND CHEMICAL CHARACTERIZATION OF MATERIALS** **L T P C**
Elective-I 3 0 0 3

UNIT I ANALYSIS AND EVALUATION OF PROPERTIES OF PLASTICS, ELASTOMERS A ND COMPOSITES

Molecular weight distribution, MFI, HDT & VICAT softening point, cold temperature behaviors, Rheological behaviors, hardness and impact properties, identification of polymers, weathering characteristics, cyclic temperature test, flammability, VOC and odor test, scratch resistance test, metal composition analysis, RoHS analysis Electrical properties of Materials – Dielectric constant, electrical resistivity, coefficient of thermal expansion & contraction, wire harness test.

UNIT II INSTRUMENTAL TECHNIQUES 12

FTIR spectrometer, Thermal analyzer, X-ray analyzer, Optical emission spectroscopy, Ion Chromatography, Gas and Liquid Chromatography, High strain rate tester, Non-destructive instruments, etc.New innovations in testing and characterization, X-ray Diffraction, Electron microscope (SEM, TEM), Scanning probe microscopy (SPM, AFM), Spectroscopic methods (EDS, FTIR); Mechanical behaviors, Thermal response, Fire retardancy, Chemical resistance and Electrical-Magnetic-Optical properties of ploymer nanocomposites;

TEXTBOOK

1. Material Characterization: Introduction to Microscopic & Spectroscopic Methods by Yang Leng
2. John Wiley & Sons (Asia) Pte Ltd.
3. ASM Handbook on Metals Handbook: Vol. 8 Mechanical Testing – 1978.
4. Dictionary of Materials and Testing, Second Edition by Joan Tomsic.

ME 3535	**STATISTICAL QUALITY CONTROL AND MANAGEMENT**	**L T P C**
	Elective-I	2 1 0 3

Procurement of various products; evaluation of supplies; capacity verification; development of sources; Procurement procedure; Methods and techniques of manufacture; inspection and control of the product.

Organizational structure and design; quality function; decentralization; designing and fitting; attitude of top management; cooperation of groups; operator's attitude; responsibility; causes of apparatus error and corrective methods.

Philosophy; cost of quality; overview of the works of Juran, Deming, Crosby, Taguchi; PDCA cycle; quality control; quality assurance;total quality management; vendor quality assurance; ISO 9000 and its concept of quality management.

Defect diagnosis and prevention defect study; identification and analysis of defects, correcting measure, the difference between reliability and quality; factors affecting reliability; different measures of reliability; time to failure distributions; MTBF; MTTF; concept of risk analysis.

Inspection by sampling; acceptance sampling; statistical approaches; single, double and multiple sampling plans; statistical design of experiments; control charts; statistical tools; statistical quality control.

ME 3546	**FAILURE ANALYSIS AND PREVENTION**	**L T P C**
	Elective-II	3 0 0 3

UNIT I FUNDAMENTALS OF FAILURE ANALYSIS

Importance of failure analysis for automotive components, Steps in typical failure analysis: Collection of background data (review documentation and speak with appropriate individuals), Selection of failed and unfailed samples for examination, Preliminary examination of the failed part, Non-destructive evaluation, Mechanical testing, Macroscopic examination and analysis, Microscopic examination and analysis, Determination of failure mode, Chemical analysis, Fracture mechanics considerations, Full scale testing under service conditions, Analysis of the evidence, Formulation of conclusions, Recommendations to prevent reoccurrence, Sample preparation methods for failure analysis, Selection of locations/samples for failure analysis.

UNIT II INTRODUCTION TO FAILURE ANALYSIS

Failure mode identification methods, Failure mechanisms: Fatigue failures, fractography, effect of variables: part shape, type of loading, stress concentration, metallurgical factors, etc. Wear failures, adhesive, abrasive, erosive, corrosive wear. Corrosion failures, types of corrosion: uniform, pitting, selective leaching, intergranular, crevice, etc. Elevated temperature failures, creep, thermal fatigue, micro structural instability, and oxidation. Causes of failure in components: Misuse or Abuse, Assembly errors, Manufacturing defects, Improper maintenance, Fastener failure, Design errors, Improper material, Improper heat treatments, Unforeseen operating conditions, Inadequate quality assurance, Inadequate environmental protection/control, Casting discontinuities. Data compilation and identification of root cause.

UNIT III TYPES OF FAILURES IN COMPONENTS

Fatigue failures, Corrosion failures, Stress corrosion cracking, Ductile and brittle fractures, Hydrogen embrittlement, Liquid metal embrittlement, Creep and stress rupture.

UNIT IV METHODS AND EQUIPMENT FOR FA ILURE A NALYSIS

Selection of suitable testing methods for failure analysis Selection of metallurgical equipments for failure analysis SEM-EDAX.

UNIT V PREVENTION OF FAILURE

REFERENCE BOOKS

1. "Understanding How Components Fail" by Donald J. Wulpi; ASM International Publication.
2. "Analysis of Metallurgical Failures: by Vito J. Colangelo; Francis A. Heiser Wiley Publication.
3. ASM Handbook Vol.11 - Failure Analysis and Prevention, ASM International Publication, 1995.
4. "Metallurgy of Failure Analysis" by A K. Das; by McGraw-Hill Professional Publication.
5. Metallurgical Failure Analysis by Charlie R. Brooks; Ashok Choudury; McGraw-Hill Publication.
6. Automotive Component Failures by A. M. Heyes
7. Handbook of Case Histories of Failure Analysis, Vol 2. by A Esaklul Khlefa.
8. Handbook of Case Histories of Failure Analysis, Vol 1 by C.Uhietal Robert.
9. Metallography Principles and Practice by Voort, George F. Vander; ASM International Publication.

ME 3547	**ADVANCES IN POLYMERIC MATERIALS**	**L T P C**
	Elective-II	3 0 0 3

UNIT I POLYMERIC MATERIALS

Polymerization – Thermosets Vs Thermoplastics – Classes and types of polymers; Properties and limitations of plastic material species; Additives; Auto applications – exterior, interior, engine and fuel line, transmission systems, electrical and electronic components.

UNIT II MA NUFA CTURING PROCESSES

Injection molding, Reaction injection molding (RIM), Transfer molding, Extrusion, compression molding, blow molding, scopes and limitations of various manufacturing processes, mold making, safety in handling of materials, hands on training on processes, selection criteria for auto applications, economics.

UNIT III ELASTOMERS

Physics of raw and vulcanized rubbers; Kinetic and thermodynamics theory of rubber elasticity; Stress strain relationships for the vulcanized rubbers; Molecular basis for the material to act as rubber; Study of various additives like peptizers, antioxidants, accelerators, activators, fillers, carbon black, chords and fabrics, blowing agents, colorants, processing aids like – tackifiers, plasticizers, extender oils etc. Characterization of compounds, rheological behaviors, properties influenced by compounding ingredients. Processing of rubbers by - extrusion, calendaring and injection molding. Manufacturing techniques of auto components – tires, belts, hoses, mounts wiper blades, seals, O rings, etc. Study of major synthetic auto rubbers like – NR, SBR, BR, IIR, NBR, SBR, fluorocarbons, silicone, etc – their functional properties and needs of auto industries; uses in fuel systems, chassis and body components, NVH applications.

UNIT IV DESIGN IN PLASTICS A ND ELASTOMERS

Selection of polymers, additives and process; Effects of mechanical, thermal, electrical properties, importance of environmental factors, structural analysis; Mold design; Part geometry; Gating, cooling, ejection, joining and assembling; Geometric tolerances; Safety factor & failure criteria; Machining, finishing and decorating, etc. Designing in rubbers, effects of material, process and environment parameters, life cycle analysis, design software packages, failure mechanics.

UNIT V FOA MS, ADHESIVES, COATINGS A ND PAINTS

PU & Latex foams - Formulations and manufacturing Control of various foam properties – density, modulus of elasticity, compression set, dynamic properties, etc. Adhesives - Condensation polymerization of products like phenol formaldehyde (Phenolic resins), Amino resins, Polyester resins, Alkyl resins, Epoxy resins, Polyurethane resins, Polyamide resins; Additional polymerization products like – Vinyl resins, Vinyl alcohol resins, vinylidine resins, Styrene resins and Acrylic resins. Protective coatings and Paints - Organic paints and coatings, metal coatings, ceramic coatings, Linings, primers, varnishes, enamels, galvanizing, anodizing, black iodizing, electro plating, CVD & PVD surface coatings Other Materials - Seals and Gaskets, Automotive glasses, Refractory materials

REFERENCE BOOKS

1. Kalyan Sehanobish, "Engineering Plastics and Plastic Composites in Automotive Applications", SAE
1. International, April 2009
2. Francis Gardiner and Eleanor Garmson "Plastics and the Environment" Smithers Rapra, 2010
3. Mahendra D Baijal "Plastic Polymer Science and Technology", John Wiley & Sons, 1982
4. Natti S. Rao, Gunter "Design Formulas for Plastic Engineers" Hanser Publishers 2nd Edition, 2004
5. John Moalli "Plastics Failures", Plastics Design Library, William Andrew Inc, 2001

ME 3548	**ADVANCED CERAMICS FOR STRATEGIC APPLICATIONS**	**L T P C**
	Elective-II	3 0 0 3

UNIT I

Introduction: oxide and non-oxide ceramics, their chemical formulae, crystal and defect structures, nonstoichiometry and typical properties.

UNIT II

Powder Preparation: Physical methods (different techniques of grinding), chemical routes - co-precipitation, sol-gel, hydrothermal, combustion synthesis, high temperature reaction (solid state reaction). Basic principles and techniques of consolidation and shaping of ceramics: powder pressing- uniaxial, biaxial and cold isostatic and hot isostatic, injection moulding, slip casting, tape-casting, calendaring, multilayering.

UNIT III

Sintering: different mechanisms and development of microstructure (including microwave sintering). Preparation of single crystal, thick and thin film ceramics. Mechanical behaviour: fracture mechanics and tribology. Engineering applications: at room and high temperatures (including armour application)

UNIT IV

Electrical behaviour: insulating (dielectric, ferroelectric, piezoelectric, pyroelectric) semiconducting, conducting, superconducting and ionically conducting, specific materials and their applications. Magnetic behaviour: basic principles, materials and their applications.

UNIT V

Transparent ceramics, coatings and films: preparation and applications Porous ceramics and ceramic membrane: fabrication techniques and applications in separation technology. Bio-medical applications of ceramic materials Ceramics for energy and environment technologies (fuel cell, lithium battery, gas sensor and catalytic support) Ceramics matrix composites: different types, their preparation and properties (including nano-composites) Exotic ceramics: functionally graded, smart/ Intelligent, bio-mimetic and nanoceramics - basic principles, preparation and applications.

REFERENCES

1. Fundamental of Ceramics by Michel W. Barsoum, McGraw Hill International edition, 1997
2. Modern Ceramic Engineering by David. W. Richerson, Mercel Dekker, NY 1992
3. Ceramic Processing and Sintering by M. N. Rahman, Mercel Dekker, 2003
4. Handbook of Advanced Ceramics by S. Somiya, Academic Press 2003
5. Handbook of Advanced Ceramics, Parts 1 and 2, S. Somiya, Aacdemic Press, 2006

ME 3549	**MATERIAL SELECTION AND SAFETY**	**L T P C**
	Elective-II	3 0 0 3

Introduction: Materials in design, Classes of engineering material, Technologically important material properties. Criteria of selection of materials like properties, cost, manufacturing process, availability, legal and safety factors.

Design Process: Types of design, Design tools and materials data, Function, material, shape and process, Selection of material - Factors of safety in design – fatigue, fracture & creep behaviour of materials, Notch sensitivity - Principles of design optimization - Future trends - CAD - Euler's formula – Theories of failure - Rankine's formula - Tetmajer's formula - Johnson formula - Design of push - rods –eccentricity loaded columns - Reduction of stress concentration.

Materials processing and design: Processes and their influence on design, Process attributes, Systematic process selection, Screening: process selection diagrams, Ranking: process cost.

Materials selection - the basics: The selection strategy, Deriving property limits and material indices, The selection procedure, The structural index.

Selection of material and shape: Shape factors, The efficiency of standard sections, Material limits for shape factors, Material indices which include shape.
Multiple constraints and compound objectives: Selection by successive application of property limits and indices, Systematic methods for multiple constraints, Compound objectives, exchange constants and value-functions
Materials for Corrosion and Wear Resistance: Types of corrosion, Corrosion Prevention Strategies – Design and Coatings materials, Types of wear, materials and coatings for wear resistance.
Materials for High and Low Temperatures: Characteristics of High temperature materials, High temperature steels and super alloys, Refractory materials, ductile to brittle transition, low temperature materials.
Materials, aesthetics and industrial design: Aesthetics and industrial design, Why tolerate ugliness? The market pull: economy versus performance, Materials and the environment: green design
Materials selection - case studies.

TEXTS/REFERENCE:

1. Michael F. Ashby: Materials Selection in Mechanical Design: Butterworth Heinemann, 2nd Edition, London UK, 1999.
2. Mahmoud M. Farag: Materials and Process Selection for Engineering Design, CRC Press, 3rd Edition, 2013.
3. U. C. Jindal: Machine Design, Pearson Education India, 2010.
4. Gladius Lewis: Selection of Engineering Materials: Prentice Hall Inc. New Jersey, USA, 1995.
5. Charles J A and Crane. F A.A.: Selection and Use of Engineering Materials: Butterworth, 3rd Edition, London UK, 1996.

Department of Mechanical Engineering

M. Tech. Thermal Engineering

1st Semester

Sub Code	Subject	L	T	P	Credit
ME 4501	Advanced Thermodynamics	3	0	0	3
ME 4502	Advanced Engineering Fluid Mechanics	3	0	0	3
ME 4503	Conduction and Radiation Heat Transfer	3	0	0	3
ME 4504	Mathematical Methods in Thermal Engineering	3	0	0	3
ME 4505	Thermal Engg. Lab	0	0	3	2
ME 45xx	Elective-I	3	0	0	3
ME 4510	Seminar-I	0	0	2	1
	Total	15	0	5	18

Elective-I

Sub Code	Subject	L	T	P	Credit
ME 4531	Entrepreneurship & Management	3	0	0	3
ME 1531	Optimization Technique	3	0	0	3
ME 4533	Gas Turbines and Jet Propulsions	3	0	0	3
ME 4534	Advanced Internal Combustion Engineering	3	0	0	3
ME 4535	Alternative Energy Sources	3	0	0	3

ME 4501	Advanced Thermodynamics First Semester (Core)	L T P C 3 0 0 3

Review of basic thermodynamics: Laws of thermodynamics, entropy, entropy balance for closed and open systems. Exergy: Concept of reversible work & irreversibility; Second law efficiency; Exergy change of a system: closed & open systems, exergy transfer by heat, work and mass, exergy destruction, exergy balance in closed & open systems; Exergy analysis of industrial systems - power systems and refrigeration systems

Cycle analysis and optimization: Regenerative reheat Rankine cycle and Brayton cycle, combined cycle power plants, multi-stage refrigeration systems.

Thermodynamic optimization of irreversible systems: Finite time thermodynamics principles, optimization studies of various thermal systems, Minimization of entropy generation principle.

Properties of Gas Mixtures: Equation of state and properties of ideal gas mixtures; Change in entropy on mixing; Partial molal properties for non-ideal gas mixtures; Equations of state; Thermodynamics of Reactive System: Conditions of equilibrium of a multiphase - multicomponent system; Second law applied to a reactive system; Condition for reaction equilibrium.

Text & Reference Books:

- R. E. Sonntag, C. Borgnakke & G.J. Van Wylen, Fundamentals of Thermodynamics.
- K. Annamalai, I.K. Puri & M. A. Jog, Advanced Thermodynamics Engineering.
- Bejan, Entropy Generation Minimization.
- Bejan, Entropy Generation through Heat and Fluid Flow.
- M. J. Moran, H. N. Shapiro, D.B.Boettner & M. N. Bailey, Principles of Engineering Thermodynamics.

ME 4502	Advanced Engineering Fluid Mechanics First Semester (Core)	L T P C 3 0 0 3

Concept of continuum and definition of a fluid. Body and surface forces, stress tensor, principle of local stress equilibrium. Scalar and vector fields, Eulerian and Lagrangian description of flow. Motion of fluid element translation, rotation and deformation; vorticity and strain-rate tensors.

Continuity equation, Constitutive Equations-Stokes law of viscosity. Derivation of Navier Stokes equations, Exact solutions of Navier-Stokes equations for incompressible flow: plane Poiseuille flow and Couette flow, Hagen-Poiseuille flow, flow between two concentric rotating cylinders, Stokes first and second problems, Slow viscous flow: Stokes and Oseens approximation, theory of hydrodynamic lubrication.

Boundary layer: derivation, exact solutions, Blasius solution and numerical solutions. Approximate methods: Momentum integral method.

Introduction to hydrodynamic stability, Orr-Sommerfeld equation, neutral curve of linear stability for plane Poiseuille flow.

Description of turbulent flow, velocity correlations, Reynolds stresses. Equations for turbulence kinetic energy and kinetic energy of mean flow. Eddy viscosity models of turbulence: zero equation, one-equation and two-equation models. Prandtls Mixing Length Theory. Empirical laws: law of the wall, velocity defect law, universal velocity.

Text & Reference Books:

- P. K. Kundu & Ira M. Cohen, Fluid Mechanics
- S. K. Som, G. Biswas & S. Chakraborty, Introduction to Fluid Mechanics and Fluid Machines
- G. K. Batchelor, Fluid Dynamics.
- Schlichting, Boundary Layer Theory
- F. M. White, Viscous Fluid Flow

		L	T	P	C
ME 4503	Conduction and Radiation Heat Transfer First Semester (Core)	3	0	0	3

Introduction to Conduction- Recapitulation: Steady and Transient conduction; Fins, Lumped parameter and semi-infinite solid approximations, Heisler and Grober charts; 3-D conduction, isotropic, orthotropic and anisotropic solids.

Analytical Methods- Mathematical formulations, analytical solutions, variation of parameters, integral method, periodic boundary conditions, Duhamels theorem and Greens function

Introduction to Radiation- Recapitulation: Radiative properties of opaque surfaces, Intensity, emissive power, radiosity, Planck’s law, Wien’s displacement law, Black and Gray surfaces, Emissivity, absorptivity, Spectral and directional variations, View factors.

Enclosure with Transparent Medium- Enclosure analysis for diffuse-gray surfaces and nondiffuse, nongray surfaces, net radiation method.

Enclosure with Participating Medium- Radiation in absorbing, emitting and scattering media. Absorption, scattering and extinction coefficients, Radiative transfer equation

Combined Heat Transfer Modes- Combined mode heat transfer and method of their calculation.

Text & Reference Books:

- D. Poulikakos, Conduction Heat Transfer
- G. Meyers, Analytical Methods in Conduction Heat Transfer
- N. Ozisik, Heat Conduction
- R. Siegel and J. Howell, Thermal Radiation Heat Transfer
- M. F. Modest, Radiative Heat Transfer
- E. M. Sparrow and R. D. Cess, Radiation Heat Transfer
- F. P. Incropera and D. P. Dewitt, Fundamental of Heat and Mass Transfer
- N. Ozisik ,Heat Transfer

ME 4504	Mathematical Methods in Thermal Engineering	L	T	P	C
	First Semester (Core)	3	0	0	3

Linear Algebra: Vector space, Norms of vectors and matrices, Condition number of matrices, Singular value decomposition, Backward error analysis, Concept of linear dependence and independence, Characteristics of linear systems, Eigen values and eigenvectors.

Calculus: Functions of single variable, Limit, continuity and differentiability, Mean value theorems, Evaluation of definite and improper integrals, Differentiation under integral sign (Leibnitz rule), Partial derivatives, Total derivative, Maxima and minima,

Differential equations: Concept of order and degree of differential equations, First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Strum Louiville problems, Initial and boundary value problems, Concept of well-posed and ill-posed equations, Classification of PDEs and their characteristics, Parabolic, elliptic and hyperbolic prototype equations

Numerical Methods: Floating point operations and errors, Interpolation, Root finding of linear and non-linear algebraic equations, Numerical differentiation, Numerical integration, Numerical solution of ODEs: initial and boundary value problems; Numerical instability.

Numerical solution of systems of linear algebraic equations: general concepts of elimination and iterative methods, Gaussian elimination, LU decomposition, tridiagonal matrix algorithm, Jacobi and Gauss-Seidel iterations, necessary and sufficient conditions for convergence of iterative schemes, gradient search methods, steepest descent and conjugate gradient methods.

Text & Reference Books:

- G.Strang, Linear Algebra and its Applications.
- K. Hoffman and R. Kunze, Linear Algebra.
- H.Anton, Elementary Linear Algebra with Applications.
- Wilfred Kaplan, Advanced Calculus.

- George B. Thomas, Maurice D. Weir, Joel Hass, Frank R. Giordano, Thomas' Calculus.
- Dennis Zill, Warren Wright, "Advanced Engineering Mathematics.
- K. E. Atkinson, An Introduction to Numerical Analysis.
- Jain, Iyenger, Jain, Numerical Methods Numerical Methods for Scientific & Engineering Computation
- Sheldon M. Ross, Introduction to Probability and Statistics for Engineers and Scientists.
- D. C. Montgomery and G.C. Runger, Applied Statistics and Probability for Engineers.
- Arnold, V., Ordinary Differential Equations.
- King, Billingham, Otto, Differential equations

ME 4510	Seminar-I First Semester (Core)	L	T	P	C
		0	0	2	1

Individual students are required to choose a topic of their interest from thermal engineering related topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 30 minutes. A committee consisting of at least two/three faculty members shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of his / her seminar topic. One copy shall be returned to the student after duly certifying it by the Chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Internal continuous assessment: 100 marks

Evaluation shall be based on the following pattern:
Report = 40 marks
Concept/knowledge in the topic = 30 marks
Presentation = 30 marks
Total marks = 100 marks

ME 4505	Thermal Engg. Lab First Semester	L	T	P	C
		0	0	3	2

Following experiments will be conducted by the Students:

- Performance and emission measurements in Diesel engines
- Performance test on a Hydro-turbine
- Performance evaluation of vapour compression refrigeration system
- Measurement and Analysis of combustion parameters in I.C. engines

		L	T	P	C
ME 4531	**Entrepreneurship & Management** First Semester (Elective I)	3	0	0	3

Entrepreneur & Entrepreneurship. Entrepreneurial Competencies Entrepreneurship and Strategy. E. Entrepreneur, Leadership, Motivation & Productivity. Decision Making, Business Plan, S.S.I., System approach, Organization as system, MIS. Quality, TQM, ISO 9000 Standards

Text & Reference Books:

- V. Desai, Dynamics of Entrepreneurship Development
- Marc J. Dollinger, Entrepreneurship: Strategies and Resources
- David H. Holt, Entrepreneurship: New Venture Creation
- S. Taneja, S.L.Gupta, Entrepreneurship Development New Venture Creation

		L	T	P	C
ME 1531	**Optimization Technique** First Semester (Elective I)	3	0	0	3

Introduction: Definition of optimization and its importance; Basic terminologies – design variables/vector, cost/objective function, constraints and variable bounds, etc; Different types of optimization problems – based on number of variables, based on nature of variables, based on constraints, based on approaches used, based on number of objectives, etc.

Single variable unconstrained optimization: Global optimum point; Local optimum point; Stationary point; Optimality criteria; Graphical method for optimum point; Direct methods for bracketing the optimum point – exhaustive search method and bounding phase method; Refining the bracketed optimum point through region elimination methods – interval halving method, Fibonacci search method and golden section search method; Gradient based methods – bisection method. Newton-Raphson method and secant method.

Multi-variable unconstrained optimization: Optimality criteria; Undirectional search; Direct methods – simplex search method, Hooke-Jeeves pattern search method and Powell's conjugate direction method; Gradient based methods – Cauchy's steepest descent method, Newton's method, Marquardt's method, conjugate gradient method and variable metric method.

Multi-variable linear and constrained optimization: Definition and formulation of linear programming problem; unrestricted variables; slack variables; artificial variables; feasible design; infeasible design; basic solution; basic feasible solution; Simplex method for lessthan-equal type of constraints; Simplex method for equality and greater-than-equal types of constraints.

Multi-variable nonlinear and constrained optimization: Kuhn-Tucker conditions; Sensitivity analysis; Transformation methods – interior penalty function method, exterior penalty function and method of multipliers; Direct methods – variable elimination method, complex search method and random search method; Gradient based methods – cutting plane method, sequential linear programming and feasible direction method.

Integer and mixed optimization: Penalty function method and branch-and-bound method.

Text & Reference Books:

- K. Deb, Optimization for Engineering Design: Algorithms and Examples
- S. S. Rao, Engineering Optimization: Theory and Practice
- Ravindran, K. M. Ragsdell, G. V. Reklaitis, Engineering Optimization: Methods and Applications, Second Edition
- Jasbir S. Arora, Introduction to Optimum Design
- Ashok D. Belegundu and Tirupathi R. Chandrupatla, Optimization Concepts and Applications in Engineering

ME 4533	**Gas Turbines and Jet Propulsion**	L	T	P	C
	First Semester (Elective I)	3	0	0	3

Thermodynamic cycle analysis of gas turbines; open and closed cycles.

Axial flow turbines; blade diagrams and design of blading, performance characteristics. Centrifugal and axial flow compressors, blowers and fans.

Theory and design of impellers and blading. Matching of turbines and compressors.

Fuels and combustion, effect of combustion chamber design and exhaust on performance, Basic principles and methods of heat recovery.

Thermodynamic cycle analysis and efficiencies of propulsive devices, Thrust equation, classification and comparison of ram jets, turbojets, pulse jets and rockets, Performance of turbo-prop, turbo-jet and turbo-fan engines, Augmentation of thrust.

Text & Reference Books:

- HIH Saravanamutto, H. Cohen, GFC Rogers, Gas Turbine Theory
- V. Ganesan, Gas Turbine.
- J. D. Mattingly, Elements of Gas Turbine Propulsion

ME 4534	**Advanced Internal Combustion Engineering**	L	T	P	C
	First Semester (Elective I)	3	0	0	3

Air standard and fuel–air cycle analysis of Otto, Diesel and limited pressure cycles, Effect of design and operating parameters on cycle efficiency, Modified fuel-air cycle considering heat losses and valve timing, Engine dynamics and torque analysis.

Fuels for I.C. Engines and their characteristics, combustion in S.I. Engines, spark knock and other abnormalities, combustion chambers, pollutant formation and control including catalytic converters, combustion in C.I. Engines, Diesel knock, Delay, fuel spray and mixing, Combustion chambers.

Advanced theory of carburetion, Cooling of engine and governing of engine, Ignition system: conventional and electronic, Supercharging, Variable compression ratio engine.

Exhaust emissions, its measurement and control, Fault diagnosis of S.I. Engines, Modelling of I.C. Engine Combustion.

Text & Reference Books:

- V. Ganeshan: I. C. Engines
- Heywood: Internal Combustion Engine Fundamental
- W. W. Pulkrabek: Engineering Fundamentals of I. C. Engines

ME 4535	**Alternative Energy Sources**	L	T	P	C
	First Semester (Elective I)	3	0	0	3

Energy scenario and renewable energy sources: global and Indian situation. Potential of nonconventional energy sources, economics.

Solar energy: radiation, flat-plate and concentrating collectors, fluid flow and heat transfer analysis, estimation of solar radiation, active systems, solar pond, passive space conditioning, power generation, photovoltaics.

Wind energy and principle of its convention. Types of wind machines.

Principles and applications of Wave energy, Tidal energy, Biomass energy, OTEC and Geothermal energy.

Hydrogen energy: Hydrogen as a renewable energy source, Hydrogen Fuel for Vehicles, Production and storage of Hydrogen.

Text & Reference Books:

- J.W. Twidell and A. Weir, Renewable Energy Sources,
- V. V. N. Kishore, Renewable Energy Engineering and Technology
- P. Gevorkian, Sustainable Energy Systems Engineering
- Godfrey Boyle, Renewable Energy, Power for a Sustainable Future.
- B. H. Khan, Non Conventional energy Sources
- P. R. Pryde, Nonconventional Energy Resources
- V. Desai, Nonconventional Energy
- S.P. Sukhatme, Solar Energy
- F. Kreith and J. F. Kreider, Principles of Solar Engineering

National Institute of Technology Silchar
Department of Chemistry

M.Sc. in Applied Chemistry
Course Structure

1. Name of the Department: Chemistry
2. Nam of the Programme: M.Sc. in Applied Chemistry
3. Duration: Two years
4. Total Credit: 70

First Semester

SUBJECT CODE	SUBJECT	L	T	P	CREDIT
CH 1501	ORGANIC CHEMISTRY	4	0	0	4
CH 1502	INORGANIC CHEMISTRY	4	0	0	4
CH 1503	PHYSICAL CHEMISTRY	4	0	0	4
CH 1504	INORGANIC CHEMISTRY LABORATORY	0	0	6	4
CH 1505	ORGANIC CHEMISTRY LABORATORY	0	0	6	4
EAA	EXTRA ACADEMIC ACTIVITIES (YOGA)	0	0	2	0
	Total				20

FIRST SEMESTER

CH 1501 **Organic Chemistry** **4 0 0 4**

REACTION MECHANISM:

A REVIEW OF REACTION MECHANISM INCLUDING METHODS OF DETERMINATION, GENERATION, STRUCTURE, STABILITY AND PROPERTIES OF CARBOCATION, CARBOANION, FREE RADICAL, CARBENE, NITRENE.

NUCLEOPHILIC SUBSTITUTION: THE S_N2, S_N1 MIXED S_N1 AND S_N2 AND SET MECHANISM.

ELECTROPHILIC SUBSTITUTION: BIMOLECULAR MECHANISM SE2 AND SE1.

THERMODYNAMIC AND KINETICS:

ACIDS AND BASES, LABELING AND KINETICS ISOTOPE EFFECTS, HAMMETT EQUATION, SIGMA-RHO RELATIONSHIP, NON-CLASSICAL CARBONIUM ION, NEIGHBORING GROUP PARTICIPATION, KINETICS AND THERMODYNAMICS CONTROL.

STEREOCHEMISTRY:

ELEMENTS OF SYMMETRY, ASYMMETRY AND DISSYMMETRY, CHIRAL CARBON ATOM, CAUSE OF OPTICAL ACTIVITY, ENANTIOMERS, DIASTREOMERS, OPTICAL ISOMERISM IN TARTARIC ACID, ALLENE, BIOPHENYLS, RACEMIZATION, RESOLUTION, METHODS OF RESOLUTION (BIOCHEMICAL AND CHEMICAL METHODS), CONFORMATIONAL ANALYSIS OF SIMPLE CYCLIC AND ACYCLIC SYSTEM. WALDEN INVERSION, ASYMMETRIC SYNTHESIS, STEREOSELECTIVE AND STREOSPECIFIC SYNTHESIS, DESIGNATION OF CIS-TRANS AND E-Z NOTATION

TOPOCITY AND PROSTEREOISOMERISM:

TOPOCITY OF LIGANDS AND FACES AND THEIR NOMENCLATURE, STREOGENICITY, CHIROGENICITY, PSEUDOASYMMETRY, STREOGENIC CENTRE.

HETEROCYCLIC COMPOUNDS:

METHODS OF SYNTHESIS, AROMATIC CHARACTER AND REACTIVITY OF FIVE-MEMBER AND SIX MEMBER HETEROCYCLIC COMPOUNDS

REFERENCE

1. ADVANCE ORGANIC CHEMISTRY BY J. MARCH, JOHN WILEY AND SONS, 1992
2. ORGANIC CHEMISTRY BY S.H.PINE, MC GRAW HILL, 1987
3. A GUIDE BOOK OF MECHANISM IN ORGANIC CHEMISTRY, PETER SYKES LONGMANN
4. PRINCIPLES IN ORGANIC SYNTHESIS, R.O.C NORMAN AND J.M.COXON
5. STEREOCHEMISTRY OF CARBON COMPOUNDS BY E.J.ELIEL, MCGRAW HILL
6. Stereochemistry of Organic Compounds by D. Nasipuri, Wiley, 1994
7. Organic Chemistry by I L Finan 5th edition
8. Organic Chemistry by Marrison & boyd, 5th edition.

FIRSTSEMESTER

CH 1502 **INORGANIC CHEMISTRY** **4 0 0 4**

NON-TRANSITION METAL CHEMISTRY:

SYNTHESIS, PROPERTIES, STRUCTURE AND BONDING OF: NITROGEN, PHOSPHOROUS, SULPHUR, PSEUDOHALOGEN, INTERHALOGEN AND XENON COMPOUNDS; BORANES, CARBORANES, METALLOBORANES, BORAZINES, PHOSPHAZENES, SULPHUR-NITROGEN COMPOUNDS.

TRANSITION METAL CHEMISTRY:

NOMENCLATURE, ISOMERISM, CHELATE-EFFECT, BONDING IN COORDINATION COMPOUNDS: VALENCE BOND THEORY, CRYSTAL FIELD THEORY, D-ORBITAL SPLITTING IN OCTAHEDRAL, TETRAHEDRAL, SQUARE PLANAR COMPLEXES, JAHN-TELLER EFFECT, SPECTROCHEMICAL SERIES, NEPHALAUXETIC SERIES.

ELECTRONIC AND MAGNETIC PROPERTIES OF METAL COMPLEXES:

MAGNETISM: TYPES, DETERMINATION OF MAGNETIC SUSCEPTIBILITY, SPIN-ONLY FORMULA, SPIN-ORBITAL COUPLING, QUENCHING OF ORBITAL ANGULAR MOMENTUM, SPIN CROSSOVER. ELECTRONIC SPECTRA: SPECTROSCOPIC TERMS, D-D TRANSITIONS, CHARGE-TRANSFER TRANSITION, SELECTION RULE AND INTENSITIES, ORGEL DIAGRAM, TANABE-SUGANO DIAGRAM.

ACID-BASE CHEMISTRY:

DIFFERENT CONCEPTS IN ACID-BASE: THE SOLVENT-SYSTEM DEFINITION, BRONSTED-LOWRY DEFINITION, LEWIS CONCEPT, LUX-FLOOD THEORY, USANOVICH DEFINITION. STRENGTHS OF BRONSTED ACID AND BASED, STRENGTHS OF LEWIS ACID AND BASES, LEVELLING EFFECT OF WATER, HARD AND SOFT ACIDS AND BASES, SUPER ACIDS.

OXIDATION REDUCTION CHEMISTRY:

BASIC CONCEPT, ELECTROCHEMICAL CELL, REDOX REACTIONS AND EMF, STANDARD ELECTRODE POTENTIAL AND FORMAL POTENTIAL, FACTORS AFFECTING EMF OF HALF-CELLS: EFFECT OF CONCENTRATION, pH, COMPLEXATION AND PRECIPITATION. REDOX STABILITY IN WATER, REDOX TITRATION

BIO-INORGANIC CHEMISTRY:

CLASSIFICATION OF BIOMOLECULES, METALLOENZYMES, SODIUM/POTASSIUM PUMPS AND SELECTIVITY OF THE PROCESS, DIOXYGEN BINDING, TRANSPORT AND UTILIZATION, HEMOGLOBIN AND MYOGLOBIN FUNCTIONS, BIOLOGICAL ENZYMES.

TEXT BOOKS:

1. INORGANIC CHEMISTRY: PRINCIPLES OF STRUCTURE AND REACTIVITY BY J. E. HUHEEY, E. A. KEITER AND R. L. KEITER, 4TH ED. HARPER COLLINS 1993.
2. GENERAL AND INORGANIC CHEMISTRY PART I BY R. P. SARKAR, 3RD ED., NCBA, 2018.
3. FUNDAMENTAL CONCEPTS OF INORGANIC CHEMISTRY, VOLUME III BY ASIM K. DAS, 2ND ED., 2011.

REFERENCE BOOKS:

1. Advanced Inorganic Chemistry by F. A. Cotton, G. W. Wilkinson, C. A. Murillo and M. Bochamann, JohnWiley& Sons, 6th Ed., 2003.
2. Inorganic Chemistry by D. F. Shriver and P. W. Atkins, 4^{th}Ed., Oxford.
3. Concepts and Models of Inorganic Chemistry by B. E. Douglas, D. H. McDaniel, J. J. Alexander, John Wiley, 1993, 3rd Ed.
4. Inorganic electronic spectroscopy by A.B.P. Lever, Elsevier, 2^{nd} Edition.
5. Introduction to magnetochemistry by A. Earnshaw, Academic Press.

FIRST SEMESTER

CH 1503	**Physical Chemistry**	**4**	**0**	**0**	**4**

CHEMICAL DYNAMICS AND ELECTROCHEMISTRY:

DETERMINATION OF THE ORDER OF REACTION, RATE LAWS, KINETICS OF COMPLEX REACTIONS: PARALLEL, CONSECUTIVE AND REVERSIBLE REACTIONS, STEADY STATE CONCEPT: ARRHENIUS EQUATION, ENERGY OF ACTIVATION AND ITS EXPERIMENTAL DETERMINATION, SIMPLE COLLISION THEORY-MECHANISM OF BIMOLECULAR REACTION, CHAIN REACTIONS, ACTIVATED COMPLEX THEORY OF REACTION RATE, IONIC REACTIONS: SALT EFFECT, PHOTOCHEMICAL REACTIONS, ENERGY KINETICS. MICHAELIS-MENTEN MECHANISM, ACID-BASE CATALYSIS, TYPES OF CATALYSIS, STUDIES OF FAST REACTIONS BY VARIOUS METHODS. ELECTRO CHEMICAL CELLS NERNST EQUATION AND APPLICATIONS OF DABYE-HUCKAL THEORY. ELECTROLYTIC CONDUCTIVITY AND DABYE-HUCKAL TREATMENT, OVER POTENTIAL, CORROSION.

SURFACE CHEMISTRY:

ADSORPTION: CHEMISORPTION AND PHYIOSORPTION, APPLICATION OF ADSORPTION OF GASES ON SOLIDS, FREUNDLICH ADSORPTION ISOTHERM, LANGMUIR ADSORPTION ISOTHERM, BET THEORY OF MULTILAYER-ADSORPTION, ADSORPTION CHROMATOGRAPHY, ELECTRICAL PHENOMENA AT INTERFACES INCLUDING ELECTROKINETICS, COLLOIDS AND ITS APPLICATIONS, MICELLES, REVERSE MICELLES, SOLUBILIZATION, APPLICATION OF PHOTOELECTRON SPECTROSCOPY, ESCA AND AUGER SPECTROSCOPY TO THE STUDY OF SURFACES

CHEMICAL THERMODYNAMICS:

BRIEF REVIEW OF LAWS OF THERMODYNAMIC AND THERMODYNAMICS FUNCTIONS, FREE ENERGY AND ENTROPY CHANGES IN CHEMICAL PROCESSES, GIBBS-HELMHOLTZ EQUATION, FREE ENERGY AND ENTROPY OF MIXING, PARTIAL MOLAR PROPERTIES, CHEMICAL POTENTIAL, GIBBS-DUHEM EQUATION, CHEMICAL EQUILIBRIUM, TEMPERATURE DEPENDENCE OF EQUILIBRIUM CONSTANT, PHASE DIAGRAM OF ONE AND TWO COMPONENT SYSTEMS, PHASE RULE, THERMODYNAMIC DESCRIPTION OF PHASE TRANSITIONS, CLAPEYRON-CLAUSSIUS EQUATION.

PHOTOCHEMISTRY:

PRINCIPLES OF PHOTOCHEMISTRY, LAWS OF PHOTOCHEMISTRY; RATES OF INTERMOLECULAR PROCESSES AND INTERMOLECULAR ENERGY TRANSFER. PHOTOCHEMICAL REACTIONS AND THEIR QUANTUM YIELDS. THE OZONE LAYER IN THE STRATOSPHERES, RADIATION CHEMISTRY, APPLICATION OF PHOTOCHEMISTRY.

THE PROPERTIES OF SOLUTIONS:

LIQUID MIXTURES, COLLIGATIVE PROPERTIES, THE ACTIVITIES OF REGULAR SOLUTION. PARTIAL MOLAR QUANTITIES, THE THERMODYNAMICS OF ACTIVITIES; OSMOSIS; OSMOTIC PRESSURE; MOLECULAR WEIGHT DETERMINATION; ABNORMAL BEHAVIOR OF SOLUTIONS.

THE CHEMICAL EQUILIBRIUM:

THE LAW OF MASS ACTION; EQUILIBRIUM CONSTANTS; THE REACTION ISOTHERM; THE REACTION ISOCHORE; LE CHATELIER'S PRINCIPLE; EQUILIBRIUM CONSTANTS FROM PARTITION FUNCTIONS.

REFERENCES

1. CHEMICAL KINETICS BY KEITH LAIDLER HOPPER AND ROW, 2000
2. CHEMICAL KINETICS, THE STUDY OF REACTION RATES IN SOLUTION BY KENNEA A CONNORS, VCH 1999
3. PHYSICAL CHEMISTRY BY PETER ALKINS- JALIO DE PAULA- 9TH EDITION.
4. PHYSICAL CHEMISTRY BNY SILBAY ALBERTY- 9TH EDITION
5. PHYSICAL CHEMISTRY BYDAVID W.BATH

FIRST SEMESTER

CH 1504 **INORGANIC CHEMISTRY LABORATORY** **0 0 6 4**

LIST OF EXPERIMENTS:

1. Determination of Copper(II) in a given solution
2. Estimation of Zinc(II) in a given solution
3. Determination of Iron(II) in a given solution
4. Determination of Iron(III) in a given solution
5. Estimation of Iron(II) and Iron(III) in a given mixture
6. Estimation of Calcium(II) and magnesium(II) in a given mixture
7. Preparation of tris(acetylacetonato)iron(III)
8. Preparation of tetrabutylammonium octamolybdate(VI)
9. Preparation of pentaamminechlorocobalt(III) chloride
10. Gravimetric estimation of Nickel
11. Gravimetric estimation of Barium

TEXT BOOKS:

4. Vogel's Textbook of Quantitative Chemical Analysis
5. ADVANCED PRACTICAL CHEMISTRY BY S. C. DAS, 5TH EDITION.
6. PRACTICAL INORGANIC CHEMISTRY BY S. GULATI, JL SHARMA, S. MANOCHA, CBS PUBLICATION.

FIRST SEMESTER

CH 1505 **ORGANIC CHEMISTRY LABORATORY** **0 0 6 4**

LIST OF EXPERIMENTS

1. QUALITATIVE ANALYSIS OF BINARY MIXTURE:

(A) SEPARATION OF THE MIXTURE AND SOLUBILITY TEST (WATER, 5% NAOH, 5% $NAHCO_3$, DIL. HCL& CONC. HCL).

(B) DETECTION OF ELEMENTS.

(C) INFERENCE OF SAMPLE BY DETERMINATION OF MELTING POINT.

(D) PREPARATION OF DERIVATIVES.

(E) CONFIRMATION OF THE DERIVATIVES BY DETERMINING ITS MELTING POINT.

2. CHROMATOGRAPHY:

(A) THIN LAYER CHROMATOGRAPHY.

(I). SEPARATION OF MIXTURE OF METHYL ORANGE AND METHYL BLUE BY TLC AND CALCULATION OF RF VALUE.

(II) SEPARATION OF MIXTURE OF 2,4-DINITROPHENYLHYDRAZONES OF ACETALDEHYDE, BENZALDEHYDE, AND VANILLINE(CHLOROFORM) BY TLCIN THE BENZENE: PETROLEUM ETHER (3:1) MIXTURE. DETERMINATION OF R_F VALUES.

(III)SEPARATION OF MIXTURE OF AMINOACIDS.

(B) COLUMN CHROMATOGRAPHY

(I) SEPARATION OF A MIXTURE OF O- AND P-NITRO ANILINES BY USING A COLUMN PACKED WITH ALUMINA IN BENZENE.

(II) SEPARATION OF SYN AND ANTI AZO BENZENE BY USING A COLUMN PACKED WITH ALUMINA IN PETROLEUM ETHER AND METHANOL.

3. ORGANIC PREPARATIONS (MORE THAN ONE STEPS)

(A) PREPARATION OF METHYL ORANGE FROM ANILINE.

(B) PREPARATION OF BENZYLATED DISULFIDE FROM O-CHLORONITROBENZENE BY CONVENTIONAL AS WELL AS MICROWAVE TECHNIQUE.

(C) PREPARATION OF P-AMINOAZOBENZENE FROM ANILINE.

(D) PREPARATION OF ACETANILIDE FROM ACETOPHENONE.

(E) PREPARATION OF N-PHENYL-2, 4-DINITROANILINE FROM CHLOROBENZENE.

Department of Mathematics

NIT SILCHAR

COURSE STRUCTURE of M.Sc. in MATHEMATICS

First Semester			
Sl. No.	**Course Code**	**Name of the Course**	**L T P C**
1	MA 1501	Real Analysis	3 1 0 4
2	MA 1502	Linear Algebra	3 1 0 4
3	MA 1503	Mathematical Methods	3 1 0 4
4	MA 1504	Classical Mechanics	3 1 0 4
5	MA 1505	Computer Programming & Data Structures	3 0 2 4
6	EAA	Extra Academic Activities (Yoga)	0 0 2 0
		Total	20
Second Semester			
Sl. No.	**Course Code**	**Name of the Course**	**L T P C**
1	MA 1516	Abstract Algebra	3 0 0 3
2	MA 1517	Ordinary Differential Equations	3 1 0 4
3	MA 1518	Topology	3 0 0 3
4	MA 1519	Probability and Statistics	3 0 0 3
5	MA 1520	Complex Analysis	3 1 0 4
		Total	15 2 0 17
Third Semester			
Sl. No.	**Course Code**	**Name of the Course**	**L T P C**
1	MA 1601	Functional Analysis	3 1 0 4
2	MA 1602	Partial Differential Equations	3 1 0 4
3	MA 1603	Optimization Techniques	3 1 0 4
4	MA 1604	Numerical Analysis	3 0 2 4
5	MA 1605	Seminar	- - 2 1
		Total	12 3 4 17
Fourth Semester			
Sl. No.	**Course Code**	**Name of the Course**	**L T P C**
1	MA 1616	Discrete Mathematical Structure	3 0 0 3
2	MA 16XX	Elective	3 0 0 3
3	MA 6099	Project &Dissertation	- - - 10
		Total	6 0 0 16
		Total Credit	**70**

List of Elective Courses

Sl. No.	Course Code	Name of the Course	L T P C
1.	MA 1631	Fluid Dynamics	3 0 0 3
2.	MA 1632	Rings and Modulues	3 0 0 3
3.	MA 1633	Measure Theory and Integration	3 0 0 3
4.	MA 1634	Mathematical Modelling	3 0 0 3
5.	MA 1635	Fuzzy Sets Theory	3 0 0 3
6.	MA 1636	Graph Theory and Applications	3 0 0 3
7.	MA 1637	Modelling and Simulation	3 0 0 3
8.	MA 1638	Advanced Operations Research	3 0 0 3
9.	MA 1639	Computational Fluid Dynamics	3 0 0 3
10.	MA 1640	Fuzzy Sets, Fuzzy Logic and Applications	3 0 0 3
11.	MA 1641	Soft Computing Techniques	3 0 0 3
12.	MA 1642	Spectral element method	3 0 0 3
13.	MA 1643	Finite Element Method	3 0 0 3

MA-1501 REAL ANALYSIS

L T P C

Pre-requisite: *None* **3-1-0-4**

Real number system: Ordered sets, Real field, Completeness property, Archimedean property, Denseness of rational and irrationals, Countable and uncountable sets. Metric Spaces: Open sets, Closed sets, Compact sets, Perfect sets, Connected sets, Baire's Category theorem. Numerical sequences and Series: Sequences, Series, Power series, Absolute convergence, Rearrangements. Continuity: Limits of functions, Continuous functions, Continuity and compactness, Continuity and connectedness, Discontinuities, Monotonic functions. Differentiation: Derivative of a real function, Mean Value Theorems, Continuity of Derivatives, L'Hospital's Rule, Taylor's Theorem. Riemann-Stieltjes Integral: Definition and existence of the Integral, Properties of the integral, Differentiation and Integration. Sequences and Series of functions: Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation. Equicontinuity, Ascoli's Theoerm. Functions of several variables: Differentiation, Inverse and Implicit function theorems.

Text Books:

1. Rudin, W.: Principles of Mathematical Analysis, 3rd Ed., Tata McGraw Hill, 1976.

Reference Books:

1. Carothers, N. L.: Real analysis, Cambridge University Press, 2000.
2. Apostol, T.M.: Mathematical Analysis, 2nd Ed., Narosa Book Distributors Pvt. Ltd., 2002.
3. Tao, T.: Analysis I, Vol.1, Hindustan Book Agency, 2006.
4. Tao, T.: Analysis II, Vol. 2, Hindustan Book Agency, 2006.

Course Objectives:

(i) To cover theoretical needs of Measure Theory and Integration, Functional Analysis, Differential equations and other branches of Mathematics.
(ii) To learn the concepts of Metric spaces.
(iii) To understand the concepts of Continuity, Continuity and compactness, Continuity and connectedness.
(iv) To learn the concepts of Sequences and Series of functions.
(v) To learn Riemann-Stieltjes Integration and its properties.
(vi) To learn the concepts of Functions of several variables.

Course Outcomes:

At the end of this course, students will be able to:
(i) Understand the concepts of Continuity, Differentiability, Integration, Sequences and Series of functions, etc.
(ii) Use the concepts of Sequences and Series of functions to the problems arising in ordinary and partial differential equations, Functional Analysis, Fourier analysis, etc.
(iii) Use Metric spaces in order to understand some concepts in Complex Analysis, Functional Analysis and other branches of Mathematics.
(iv) Understand the concepts of Inverse and Implicit function theorems.

MA-1502 LINEAR ALGEBRA **L T P C**
3–1–0–4

Pre-requisite: *Elementary idea of Matrices, Groups, Rings/Fields.*

Vector spaces, Subspaces, Linear sum & Direct sum of subspaces, Quotientspace, Basis & Dimension, Ordered basis & Coordinates.

Linear transformations, Algebra of linear transformations, Isomorphism, Rank & Nullity of a linear transformation, Singular, Non-singular & Invertible linear transformations / operators.

Matrix of a Linear transformation/Linear operator, Change of basis, Rank & nullity of a Matrix, Similar Matrices, System of linear equations& their consistency, Eigen values and Eigen vectors of a Linear operator/ Square matrix, Algebraic & Geometric Multiplicity of Eigen values, Cayley-Hamilton theorem, Diagonilazibility, Minimal polynomial.

Linear functional and Dual space, Dual basis, Second dual space, Annihilators, Transpose of a linear Transformation.
Invariant subspaces, Direct sum decomposition, Invariant direct sums, and Primary decomposition theorem. Bilinear forms and its matrix representation, Quadratic forms, Hermitian forms, Cyclic subspaces, Cyclic decomposition, Rational forms & Jordan canonical forms.

Inner product spaces, Orthonormal basis, Gram-Schmidt Orthogonalization process, Adjoint operators, Orthogonal and Unitary operators / matrices, Normal operator.

Text Books:

1. Hoffman, K. and Kunze R: Linear Algebra, Prentice Hall of India, 2005.
2. Artin, M. : Algebra, Prentice Hall of India, 2005.

Reference Books:

1. Herstein, I.N. : Topics in Algebra, John-Wiley, 1999.
2. Halmos, P. R.: Finite Dimensional Vector Spaces, Springer Verlag, New York, 1987.
3. Lipschutz, S.: Theory and Problems of Linear Algebra, McGraw Hill, New York ,1991.
4. Singh, Surjeet : Linear Algebra, Vikas Publishing House, 1998.
5. Strang, G.: Linear Algebra and Its applications, Nelson Engineering, 4th Edition., 2007.

Course Objectives:

(i) To give sufficient knowledge of the subject, which can be used by students for further applications in their respective domains of interest.
(ii) Students are to be made familiarised with the important properties of matrices including how to use them to solve linear systems of equations and how they are used in linear transformations between vector spaces. (iii) Students are also expected to gain an appreciation for some applications of linear algebra in other branches of science, engineering, and economics etc.

Course Outcomes :
Upon successful completion of this course students will be able to:
(i) Use computational techniques and algebraic skills essential for the study of systems of linear equations, matrix algebra, vector spaces, eigenvalues and eigenvectors, orthogonality and diagonalization.
(ii) Use visualization, spatial reasoning, as well as geometric properties and strategies to model, solve problems, and view solutions, especially in R^2 and R^3 , as well as conceptually extend these results to higher dimensions.
(iii) Apply linear algebra concepts to model, solve, and analyze real-world situations.

MA-1503 MATHEMATICAL METHODS **L T P C**
3–1–0–4

Pre-requisite: *Beta-Gamma functions and Integral calculus.*

Integral Transforms: Laplace Transform, Laplace Transform & Inverse Laplace transform with application to the solution of differential equations.
Fourier Transform: Fourier Integral Transform, Application of Fourier Transform to ordinary and partial differential equations in initial and boundary value problems.
Z-transform: Definition and properties, Z-transform of some standard functions, initial and final value theorems, convolution theorem, Inverse Z-transforms and applications.
Linear Integral Equations: Linear integral equation of the first and second kind of Fredholm and Volterra type, Solutions with separable kernels, Characteristic numbers and Eigen functions, resolvent kernel.
Calculus of Variation:Variation of a functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema, Direct method in variational problems, Rayleigh -Ritz method.

Text Books:

1. Poularikas, A. D.: *The Laplace Transforms and Applications* , CRC Press, 1996.

2. Hildebrand, F.B.: *Methods of Applied Mathematics*, Dover publication, 1972.
3. Krasnov, M.L., Makarenko, G.I. and Kiselev, A.I.: *Problems and Exercises in Calculus of Variations*, Mir Publishers, 1975.
4. Kanwal, R.P.: *Linear Integral Equations*, Academic Press,New York, 1998.
5. Kanwal, R.P. and Sneddon, I.N.: *Fourier Transforms*, Dover publication, 2010.

Reference Books:

1. Gupta, A.S.: *Calculus of variation with applications*, Prentice Hall of India, 2004.
2. Spiegel, M.R.: *Theory and Problems of Laplace transforms*, Schaum's series, 2011.
3. Bender, C. M. and Orszag, S. A.: *Advanced Mathematical Methods for Scientists and Engineers*, McGraw-Hill, 1978.
4. Raisinghania, M. D.: Integral equations and boundary value problems, S. Chand Company Ltd., 2007.

Course Objectives:

(i) To make the students knowledgeable in the area of integral transforms and Z-transform.
(ii) To make the students understand the basic concepts of linear integral equations and variation of functional problems and its applications.

Course Outcomes:

(i) The students will be able to solve initial and boundary value problems in differential and difference equations.
(ii) The students will be capable of solving linear integral equations and variation of functional problems.

MA-1504 CLASSICAL MECHANICS **L T P C**
3–1–0–4

Pre-requisite: *Elementary mechanics, Basic calculus.*

Rigid Body Mechanics : Two-dimensional motion of rigid bodies, equations of motion referred to rotating axes, Euler's dynamical equation of motion, Motion of a rigid body about an axis, theory of small oscillation.

Space Mechanics : Equation of motion of a particle moving in space, path of a particle moving in space, acceleration of a particle in terms of polar coordinates and cylindrical coordinates,

Continuum Mechanics : Molecular diffusion, conservation of mass, material derivatives, equation of continuity, motion, principle of angular momentum, conservation of energy.

Mechanics of Deformation : External forces and internal forces, stress, strain, principal stresses & strains, relation between stress and strain, deformation, stress components, strain components, stress invariant , strain invariant, body force, gravity force, initial stress, incremental stress and incremental strain , equilibrium equations for the stress field in two dimensions and three dimensions.

Lagrangian Mechanics : Generalized coordinates, constraints of motion, degrees of freedom, holonomic system, principle of virtual work, generalized force, Lagrange's equations from D' Alembert's principle, compound pendulum, spherical pendulum.

Hamiltonian Mechanics : Elements of calculus of variations, Euler-Lagrange's equation, generalized momentum, conjugate momentum, Hamilton's canonical equations of motion, Hamilton's principle and principle of least action, Poisson's Brackets, Hamilton-Jacobi theory.

Text / Reference Books :

1. Goldstein, Hardberd, Poole, Charles and Safko, John : Classical Mechanics, Pearson Education,2008.
2. Corben, H. C. and Stehle, Philip : Classical Mechanics, 2nd Ed., Dover Publications, 1977.
3. Malvern, Lawrence E : Introduction to the Mechanics of a Continuous Medium, Prentice Hall, 1977.
4. Loney, S.L : Dynamics of a Particle, Macmillan India Ltd, 1972.
5. Rana,N. C. and Joag, P.S.: Classical Mechanics, Tata McGraw-Hill, 1991.
6. Biot, M.A : Mechanics of Incremental Deformation, John Wiley & Sons, Inc., 1965.

Course Objectives :

(i) To develop familiarity with the physical concepts and facility with the mathematical methods of classical mechanics.
(ii) To develop skills in formulating and solving the problems of mechanics.
(iii) To develop the self-discipline and work habits necessary to succeed in master's program and in the real world.
(iv) To gain an understanding of the history and knowledge of physics and the physics principles that shape our world.
(v) To develop problem solving and critical thinking skills.
(vi) To develop more insight into the scientific process.

Course Outcomes :

Students who have completed this course should

(i) Have a deep understanding of Newton's laws.
(ii) Be able to solve the Newton equations for simple configurations using various methods.
(iii) Learn how to represent the equations of motion for complicated mechanical systems using the Lagrangian and Hamiltonian formulations of classical mechanics.
(iv) Be familiar with topics of current interest in classical mechanics.
(v) Have made progress on a research project in the areas of mechanics.

MA-1505 COMPUTER PROGRAMMING & DATA STRUCTURES

L T P C
3-0-2-4

Pre-requisite: *Programming preliminaries, void algorithms, Numeric variables and constants, Data declaration type, Input and Output statements, Arithmetic operators and expressions in C/C++.*

Computer Programming in C/C++: Control statement and Loops, Functions, Arrays, Subroutines, Character Strings, Structures, Pointer data type and its applications.

Data Structure: Introduction to data types, Data structures, linear and Multi-dimensional Arrays, Pointers, Linked Lists, Stacks, Queues, Complexity algorithms, Singly linked lists, Doubled linked lists, Circular linked lists, Application of Linked Lists, Introduction to complexity of algorithm, Non-linear data Structure, Graphs, Various representation of graphs, Trees: binary trees, red-black trees, AVL tree, B tree, B+ tree, Spanning tree.
Shorting Algorithms: Bubble sort, Selection sort, Insertion sort, Shell sort, Quick sort, Heap sort, Radix sort, Searching Algorithms: Linear Search, Binary Search, Hashing.

Text Books:

1. Balagurusamy, E.: Programming InAnsi C, McGraw Hill Education, 7th Edition, 2016.
2. Hubbard, J.R.: Schaum's Outline of Programming with C++, The McGraw Hill company Inc., 2nd edition, 2000.
3. Kernighan, B. W. and Ritchie, D.M.: The C Programming Language, Pearson, 2nd edition, 2015.
4. Tremblay, J.P. and Sorenson, P. : An Introduction to Data Structures with Applications, McGraw Hill, 1985.
5. Horowitz, E. and Sahni, S.: Fundamentals of data structures, Galgotia Publications, 2008.

Reference Books:

1. Stroustrup, B.: The C++ Programming Language, KindleEdition, 4th Edition, 2013.
2. Kanetkar, Y.: Understanding Pointers in C & C++, 5th edition, BPB Publications, 2018.
3. Sinha, P. K.: Computer Fundamentals concept, 6th edition, BPB Publication, 2003.
4. Kernighan, B. W. and Ritchie, D. M.: The C Programming language, Pearson Education, 2015.
5. Kanetkar, Y., Let us C, 3rd edition, BPB Publication, 2007.
6. Padmanabham, P., C & Data structures, B.S. Publications, 2012.

Course Objectives:

(i) To make the student familiar with the computer programming.
(ii) To enable the students to compare different programming methodologies and define asymptotic notations to analyze performance of algorithms.
(iii) To familiarize the students with appropriate data structures like arrays, linked list, stacks and queues to solve real world problems efficiently.
(iv) To enable the students to illustrate and compare various techniques for searching and sorting.
(v) To prepare the students for writing program in different programing language to implement the concepts of data structure.

Course Outcomes:

At the end of this course, students will be able to:
(i) Describe linear data structures such as stacks, queues and their applications.
(ii) Solve problems involving non-linear data structures such as trees, graphs and their applications.
(iii) Apply various sorting, searching and hashing techniques and their performance comparison.
(iv) Find the numerical solution of the ordinary and partial differential equations.

NATIONAL INSTITUTE OF TECHNOLOGY SILCHAR
Department of Physics
Program: M. Sc in Applied Physics (2019)
Course structure and detailed syllabus
Minimum Credit Requirement: 70
Minimum Duration: 4 semesters Maximum Duration: 6 semesters

Semester	Credit
I	16
II	18
III	17
IV	19

Semester-I

Course Code	Course Name	L	T	P	Credit
PH 1501	Mathematical Physics-I	3	0	0	3
PH 1502	Classical Mechanics	3	0	0	3
PH 1503	Quantum Mechanics-I	3	0	0	3
PH 1504	Electrodynamics-I	3	0	0	3
PH 1505	Physics Lab-I	0	0	6	4
EAA	Extra Academic Activities (Yoga)	0	0	2	0
Total Credits					16

Semester-II

Course Code	Course Name	L	T	P	Credit
PH 1516	Condensed Matter Physics-I	3	0	3	3
PH 1517	Statistical Mechanics	3	0	0	3
PH 1518	Quantum Mechanics-II	3	0	0	3
PH 1519	Mathematical Physics-II	3	0	0	3
PH 1520	Physics Lab-II	0	0	6	4
PH 1521	Computational Physics lab	0	0	3	2
Total Credits					18

Semester-III

Course Code	Course Name	L	T	P	Credit
PH 1601	Condensed matter Physics -II	3	0	0	3
PH 1602	Electrodynamics-II	3	0	0	3
PH 1603	Electronics	3	0	0	3
PH 1604	Atomic and Molecular Physics	3	0	0	3
PH 1605	Physics Lab-III	0	0	6	4
PH 1606	Seminar	0	0	2	1
Total Credits					17

Semester-IV

Course Code	Course Name	L	T	P	Credit
PH 1616	Experimental Techniques	3	0	0	3
PH 1617	Nuclear and Particle Physics	3	0	0	3
PH 1618	Physics of Semiconductor	3	0	0	3
PH 6099	Project	0	0	0	10
Total Credits					19

Detailed syllabus

Semester-I

PH 1501: Mathematical Physics-I L-3, T-0, P-0: CR-3

Matrices, Determinants, Matrix operations, linear combination, Linear function, linear operators, linear dependence and independence. Vector Spaces: Vectors in Function spaces, Operators, self adjoint operators, unitary operators, Transformation of operators, invariance, Gram-Schmidt orthogonalization.

Eigenvalues and eigenvectors of a matrix, Cayley-Hamilton theorem, diagonalization,

Tensor analysis - summation conventions, contra-variant and co-variant tensors and their transformations, classification and fundamental operations with tensors, line element & metric tensor

Special functions – Legendre, Hermite, Laguerre & Bessel functions, Rodrigues formula, Generating function, Recursion relations, Orthogonality relation

Fourier series expansion, Fourier series for arbitrary period, Gibbs phenomenon, Integral transformation – Fourier & Laplace transformation

References:

1. Mathematical Methods in the Physical Sciences by M.P.Boas
2. Advanced Engineering Mathematics by Kreyszig
3. Mathematical methods for physicists by Arfken and Weber
4. A first course on complex analysis by Zill
5. Schaum's outline Complex Variables by Spiegel
6. Methods of Mathematical Physics by Courant and Hilbert
7. Special functions and Polynomials by Gerard ‘t Hooft and Nobbenhuis

PH 1502: Classical Mechanics **L-3, T-0, P-0: CR-3**

Mechanics of a System of Particles, Review of Lagrange's equation: D'Alembert's Priniciple, Lagrange's equations, applications, Variational calculus.

Reduction to the Equivalent one body problem, Equations of motion and first integrals, Classification of orbits, Motion under inverse square law-Kepler problem, Scattering in a central force field

Hamiltonian formulation: Legendre transformations and Hamilton equations of motion, cyclic coordinates and conservative theorems, Derivation of Hamilton's equations a variational principle, principle of least action.

The equations of Canonical transformations, Examples of Canonical transformations. Poisson brackets and other canonical invariants, Equations of motion, Hamilton-Jacobi theory for Hamilton's Principal function, The Harmonic Oscillator problem as an example of the Hamilton-Jacobi method, Hamilton-Jacobi equation for Hamilton's characteristic function Action-angle variables.

Theory of small oscillations, normal coordinates, normal modes, coupled oscillations.

References:

1. H. Goldstein, Classical Mechanics
2. L.O. Landau and E.M. Lifshitz, Mechanics.
3. I.C. Percival and D. Richards, Introduction to Dynamics
4. J.V. Jose and E.J. Saletan, Classical Dynamics: A Contemporary Approach

PH 1503: Quantum Mechanics-I **L-3, T-0, P-0: CR-3**

Postulates of Quantum Mechanics, wavefunction, probability and probability current density, conservation of probability, Operators and their expectations values, Dirac notation.

Schroedinger equation: Simple potential problems, infinite potential well, step and barrier potentials, finite potential well and bound states, linear harmonic oscillator, operator algebra of harmonic oscillator; Three dimensional problems: spherical harmonics, free particle in a spherical cavity, central potential, Three dimensional harmonic oscillator, degeneracy, Hydrogen atom; Angular momentum: Commutation relations, spin angular momentum, Pauli matrices, raising and lowering operators, Total angular momentum, addition of angular momentum, Clebsch-Gordon coefficients.

The variational principle, the ground state of Helium, the hydrogen molecule ion.

References:

1. Introduction to Quantum Mechanics: D. J. Griffiths
2. Quantum Mechanics Concept and Applications: N. Zettili
3. Quantum Physics: S. Gasiorowicz
4. Modern Quantum Mechanics: J.J. Sakurai
5. Quantum Mechanics: L. I. Schiff

PH 1504: Electrodynamics-I **L-3, T-0, P-0: CR-3**

Laplace equation in one, two and three dimensions. Boundary equation and uniqueness theorem, conductor and second uniqueness theorem. The method of Images: The classic Image problem, Induced surface charge, Force and energy and other image problems.

Electric Field in matter: Dielectric, Induced dipoles, Alignment of polar molecules, polarization, bound charges and its physical interpretation, the field inside a dielectric, Gauss law in the presence of dielectric, boundary conditions, Linear dielectric: susceptibility, permittivity dielectric constant boundary value problem with linear dielectric , energy and force in dielectric.

Review of Magnetostatics: magnetic vector potential and magneto static boundary conditions, multipole expansion of the vector potential.

Magnetic field in matter: Diamagnets, paramagnets, ferromagnets and torque and forces on magnetic dipoles, The field of magnetized object and bound currents the magnetic field inside matter, Linear and non-linear media.

Electrodynamics: Maxwell's equations: How Maxwell fixed Ampere's law, Magnetic charge, Maxwell's equation in matter, Boundary conditions, The continuity equation, Poynting's theorem, Momentum: Newton's Third law in Electrodynamics, Maxwell's stress Tensor, Conservation of momentum, angular momentum,.

References:

1. J. D. Jackson, Classical Electrodynamics, Wiley Eastern, 2nd Edition (1975).
2. David J. Griffiths, Introduction to Electrodynamics, Prentice Hall of India, 2nd Edition, (1989).

3. J.R. Reitz., F.J. Milford and R. W. Christy, Foundations of Electromagnetic Theory, 3rd Edition, Narosa Pub. House (1976).
4. P. Lorrain and D. Corson, Electromagnetic Fields and Waves. CBS Publishers and Distributors (1986).
5. B.H. Chirgwin, C. Plumpton and C. W. Kilmister, Elementary Electromagnetic Theory, Vols.1, 2 and 3" Pergamon Press (1972).

PH 1505: Physics-Lab-I

1. To calculate the beam divergence and spot size of the given laser beam
2. Determination of wavelength of unknown lines with help of plane transmission grating.
3. To draw the calibration curve (d vs λ) of a spectrometer with given prism and hence find the wavelength of some unknown lines.
4. To draw the current –voltage (I-V) characteristics of a solar cell.
5. To determine the permittivity of air using parallel plate capacitor.

Department of Management Studies
National Institute of Technology Silchar

Course Structure for MBA Programme (2 Years, 4 Semester Course)
(To be applicable from 2019 entry Batch only)

FIRST SEMESTER			
Subject Code	**Subject Name**	**L-T-P**	**Credits**
MS 1501	Management Practices & Organisation Behaviour	3-0-0	3
MS 1503	Managerial Economics	3-0-0	3
MS 1505	Accounting for Managers & Control	3-0-0	3
MS 1507	Marketing Management	3-0-0	3
MS 1509	Quantitative Techniques	3-0-0	3
MS 1511	Human Resource Management	3-0-0	3
MS 1513	Business Communication-1	0-0-2	1
EAA	Extra Academic Activities (Yoga)	0-0-2	0
			19

MS 1501 **L T P C**
Semester-1st **3 0 0 3**

MANAGEMENT PRACTICES & ORGANISATION BEHAVIOUR

Course Objective:
The purpose of the course is to help students to develop an understanding of the basic management concepts and behavioural processes in organizations.
Course Outcome:
The students will get a thorough knowledge of different management concepts and their relevant applications in day to day organizational commitments.
Course Contents:
Overview of Management: Definition – Management, Role of managers, Evolution of Management thought , Principles of Management, Planning: Nature and purpose of planning, Planning process, Types of plans, Decision Making, Types of decision, Decision Making Process, Rational Decision Making. Organizing: Nature and purpose of organizing, Organization structure, Formal and informal groups in organization, Line and Staff authority, Span of control, Centralization and Decentralization, Delegation of authority, Staffing: Selection and Recruitment, Training, Performance Appraisal, Directing: Creativity and Innovation, Controlling: Process of controlling, Types of control, Budgetary and non-budgetary control.

Organizational Behaviour: Introduction to OB; Foundations of Individual Behaviour; Attitudes and Job Satisfaction; Personality and Emotions; Perception and Individual Decision Making; Motivation & its theories; Understanding Work Teams; Leadership & its theories ; Group Dynamics; Foundations of Group Behaviour; Stress Management; Conflict Management, Organization Culture; Elements and types of culture.
Essential Readings:

- S. P. Robbins and T. A. Judge, Organizational Behaviour, 17/e, Prentice-Hall of India Pvt. Ltd., 2017.
- Charles W.L. Hill, Steven L. Mc Shane, Principles of Management (SIE), Tata Mc Graw- Hill Education pvt. Ltd., 2007

Suggested Readings:

- Udai Pareek, Understanding Organizational Behaviour, 2/e, Oxford University Press, 2008.
- T. S. Bateman and S. A. Snell, Management, 8/e, TMH, 2008.
- K. Aswathappa, Organisational Behaviour, 12/e, Himalya Publishing House, 2016.

MS 1503 **L T P C**
Semester-1st **3 0 0 3**

MANAGERIAL ECONOMICS

Course Objective:
The purpose of the course is to familiarize the students with concepts and techniques used in Micro-Economic Theory and Macro Economic fundamentals and to develop their capability to relate these with their daily life and functioning of an economy.

Course Outcome:
At the end of the course, the student will be equipped with the knowledge of applying the concepts and techniques in making decisions pertaining to the working of the markets, the determination of prices of different business as well as real-life situations. This course will emphasize on application of economic principles to real-world managerial decisions, with reliance on quantitative data analysis.

Course Contents:

Introduction to Managerial Economics: Concept, Goals and Constraints; Firm and Industry, Nature and Importance of Profits, Decision Making of business firms under different objectives.
Demand Analysis: Demand Schedule and Demand Function, Elasticity of Demand, Price Elasticity of Demand, Demand Forecasting, Marginal Utility, Law of Diminishing Marginal Utility.
Supply Analysis: Supply Schedule and Supply Function, Elasticity of Supply. Concept of Market Equilibrium.
Production and Cost Analysis: Production Function, Law of Variable Proportions and the Laws of Returns to Scale, Isoquants, Concept of cost, Cost of Operating an Enterprise, Cost Concepts for Decision Making, Short Run And Long Run Cost Functions; Economies of Scale, Break Even Analysis, Contribution Analysis.
Theory of Market and Pricing: Type of market, Price determination and Profit maximization under different market structures, Managerial Applications.
Macro Economic Fundamentals: Money And Financial Institutions, The Government And Stabilization Policy, National Income, Inflation, Business Cycle, Economic Growth, Monetary Policy, Fiscal Policy, International Trade, Balance Of Payments.

References:

- Salvatore, D. (2007). Managerial Economics (6th ed.). London: Oxford University Press.
- Paul, G., Young, Philip K.Y., Banerjee, S. (2012). Managerial Economics, New Delhi: Pearson.
- Brickley, J. A, Smith, C. W. & Zimmerman, J. L. (2008). Managerial economics & organizational architecture (5th ed.). New Delhi: McGraw Hill.
- Mark, H. (2009). Fundamentals of managerial economics (9th ed.). U.S.A: Cengage Learning.

MS 1505 **L T P C**
Semester-1st **3 0 0 3**

ACCOUNTING FOR MANAGERS & CONTROL

Course Objective:

The course is designed to provide a thorough understanding of the financial and management accounting techniques as an essential part of the decision- making process in the total business information system.

Course Outcome:

After taking this course the students will have a deep understanding of Business Accounting and practices including a basic understanding of Cost Accounting.

Course Contents:

Accounting in Business: Accounting for Decision Making– A Managerial Perspective, Financial Accounting and Management Accounting, Accounting as an information system, Indian Accounting standards, IFRS, Harmonization of Accounting Standards, Analyzing and recording business transactions.

Preparation of financial statements, Corporate Balance sheet.: Key terms, Contents, and Format as per Schedule VI Part I of the Companies Act 1956.

Financial statement analysis: Significance, Techniques, Kinds of ratios, DuPont analysis.

Depreciation Accounting: Meaning and Methods of Depreciation, Management viewpoint, Depreciation methods employed by Indian companies.

Cost Behaviour, Planning and Decision Making: Cost concepts for planning and control, Classification of cost terms used in planning, control and decision making, Components of the total cost.

Cost Volume Profit and Break-even analysis: Importance and assumptions, Contribution margin, Profit planning, Profit volume graph, Limitations.

Relevant costing in managerial decisions: Make or buy, accepting a special order, Dropping a product line, Decision to eliminate unprofitable segments.

Cost Control and Performance Evaluation: Responsibility accounting and Segmental analysis- Types of Responsibility centers: effectiveness and efficiency, Criteria for divisional performance measurement, Return on investment and residual income.

Transfer pricing: Objectives, Transfer pricing methods, Examples Human Resource accounting, and Life cycle accounting.

Analysis of Financial Statements: Statement of Cash flows: Purpose and Importance, Classification of Cash Flows, Preparing a statement of cash flows, Significance of statement of cash flows.

Budgets and Budgetary Control, Zero Based Budgeting; Standard Costing.

Essential Readings:

- Narayanswamy, Financial Accounting - A Managerial Perspective, PHI, New Delhi
- Charles T Homgen, G Foster and S M Datar, Cost Accounting a Managerial Emphasis, 10th Ed, PHI
- Balakrishnan, Shivaramakrishnan, Rinkle – Managerial Accounting, Wiley-2nd Edition.

Suggested Readings:

- Ramachandran & Kakani, Accounting for Management, TMH, New Delhi
- 2. Banerjee, Cost Accounting: Theory and Practice, PHI, New Delhi

MS 1507 **L T P C**
Semester-1st **3 0 0 3**

MARKETING MANAGEMENT

Course Objective:
The purpose of this course is to develop the understanding of the relevant concepts, strategies and issues involved in the marketing of products and services.

Course Outcome:
At the end of this course, the students will have a thorough idea of the processes involved in the planning, designing and implementing marketing strategies to achieve the long-term objectives in a competitive market situation.

Course Contents:
Introduction to marketing; challenges of modern marketing; Customer value and satisfaction; Market-oriented strategic planning; Marketing Information System.
Scanning the marketing environment; Buyer Behaviour; Consumer Behaviour; Market segmentation; Targeting and Positioning (STP).
Marketing Mix; Demand Assessment and Forecasting; Developing new market offerings and global market offerings; developing the product and branding strategy; pricing policy, Internet marketing.
Contemporary Marketing Modes; Green Marketing, Content Marketing, Guerrilla Marketing, Word-to-mouth Marketing, Surrogate Marketing, Umbrella Marketing, Event Marketing, Ambush Marketing, Reverse Marketing-Case Studies.

References:

- Kotler, P., Armstrong, G. & Agnihotri, P., Principles of Marketing (2018) 17th edition, Pearson
- Kotler, P., Keller, K., Marketing Management (2016) 15th Global Edition, Pearson Education.
- Mullins, J., Walker, O., and Harper, B.J, Marketing Management: A Strategic Decision-Making, (2012) 8th edition McGraw-Hill Education.
- Ramaswamy & Namakumari. Marketing Management (2018) 6th Edition, SAGE Publication.
- Boone, L. E., & Kurtz, D. L. (2013). Contemporary Marketing. Cengage learning.

MS 1509 **L T P C**
Semester-1st **3 0 0 3**

QUANTITATIVE TECHNIQUES

Course Objective:
The purpose of the course is to develop the students about understanding the concepts of Basic Statistics and Linear Programming Techniques and to acquaint the student with the basic application of these concepts in the business decision-making process.

Course Outcome:

At the end of the course, the student will be equipped with the knowledge of how actually the decisions are undertaken in real life, along with being exposed to relevant software packages.

Course Contents:

Basic Statistics: Measures of Central Tendency and Dispersion, Bi-Variate Correlation and Regression, Probability Theory, Discrete and Continuous Probability Distribution and its applications in business, Sampling and Sampling Distribution, Estimation and Testing of Hypothesis. Parametric and Nonparametric Statistics.

Linear Programming Problems: Introduction to Operations Research and Decision Theory, Structure of decision strategies. Introduction and use of linear programming; Graphical Method; Simplex method: Minimization and Maximization Cases. Transportation Problems: Introduction and use; North-West Corner Rule; Stepping-Stone Method; Vogel Approximation Method (VAM). Assignment Problems: Introduction and use; Hungarian Method; Balanced and Unbalanced Problems; Maximization Case. Queuing Theory: Introduction to Waiting-line Model; uses of Queuing Model; Queuing Models of different category. Game Theory: Introduction and Use; Problems of Mixed Strategy, PERT; CPM.

References:

- Black, K. (2008). Business statistics for contemporary decision making. New Delhi: Wiley India.
- Spiegel, M. R., Schiller, J., & Srinivasan, R. A. (2004) Probability and Statistics. New Delhi: Tata McGraw Hill.
- Levin, R. I., & Rubin, D. S. (1999). Statistics for management. NewDelhi: Prentice HalI of India.
- Taha, H. A. (2007). Operations Research: An Introduction.Delhi: Pearson Education.
- Sharma, J. K. (2009). Operations research: theory and applications. Delhi: Macmillan.

MS 1511	**L T P C**
Semester-1st	**3 0 0 3**

HUMAN RESOURCE MANAGEMENT

Course Objective:
The course aims at making students understand how to improve the value of an employee by analyzing and preparing him for readiness and willingness to do tasks through the proper direction of the organizational sectors.

Course Outcome:
HRM teaches how to utilize human and non-human resources so that the goals can be achieved.

Course Contents:
Human Resource Management: Concepts and Strategic Importance of HRM, Evolution, and Growth.

Challenges for HR Professionals: HR Department Operations, HR Philosophy, Policies, Procedures and Practices, Functional Areas of HRM.

Designing and Developing HR System: Human Resource Planning, Job Analysis, and Job Design, Job Description, Job Specification,Recruitment and Selection Process, Placement and Induction, Promotion, Transfer and Separations, Career and Succession Planning.

Training and Development: Learning Principles and Theories of Learning, Training vs. Development, Training Need Assessment, Designing and Administering Training Programmes, Executive Development Programmes, Evaluation of T&D Programmes.

Performance Management: Performance Appraisal System, Appraisal Methods, Use of Performance Data, Rating Errors, Performance Feedback and Counseling, Potential Appraisal.

Compensation Management: Compensation Structure, Job Evaluation, Incentives and Benefits Plan, Executive Compensation, Linking Compensation to Performance, Employee Welfare, Employee Relations, Trade Union, Grievence Redressal & Dispute Resolution, Conflict Management, Employee Empowerment.

Emerging Trends in HRM: HRIS, HR Bots, HR Audit, HR Accounting, Outsourcing HR functions, Balance Scorecard, Knowledge Management, Gender issues at the workplace.

Essential Readings:

- Dessler, G. (2008). Human Resource Management (11th ed.). Pearson Education.
- Snell, S., &Bohlander, G. (2007). Managing Human Resources (15th ed.). South-Western/ Cengage.

Suggested Readings:

- Bernardin, H. J. (2007). Human Resource Management: An Experiential Approach (4th ed.). Tata McGraw Hill.
- Rao, V. S. P. (2010).Human Resource Management: Text and Cases (3rd ed.). Excel Books.

MS 1513 **L T P C**
Semester-1st **0 0 2 1**

BUSINESS COMMUNICATION-I

Course Objective:
To acquaint the students with fundamentals of communication, help them honing oral, written and non-verbal communication skills and to transform their communication abilities.

Course Outcome:
This course train students to enhance their skills in writing as well as oral Communication through practical conduct of this course. This course will help students in understanding the principles & techniques of business communication.

Course Contents:
Concept of Communication: Purpose and process of communication; myths and realities of communication; paths of communication; oral communication; noise, barriers to communication; listening process, types of listening, deterrents to listening process, essentials of good listening; telephonic communication. Important Parameters in Communication: The Cross-Cultural Dimensions of Business Communication, Technology, and Communication, Ethical & Legal Issues in Business Communication, Mass Communication: Mass Communication & Promotion Strategies, Advertisements, Publicity, and Press Releases. Media Mix, Public Relations, Newsletters.
Non-verbal communication: Gestures, handshakes, gazes, smiles, hand movements, styles of working, voice modulations, body sport for interviews; business etiquettes; business dining, business manners of people of different cultures, managing customer care.

REFERENCES:

- Scot, O. (2004), Contemporary Business Communication, Biztantra, New Delhi.
- Kaul, Asha, Business Communication, PHI, New Delhi.
- Lesikar, R.V. &Flatley, M.E. (2005), Basic Business Communication Skills for Empowering the Internet Generation, Tata McGraw Hill Publishing Company Ltd. New Delhi.
- Ludlow, R. & Panton, F., The Essence of Effective Communications, PHI.