Course Code	Course Name	Course Category	L-T-P	Credits
20BE2101	Environmental Science	MC	2-0-0	0

Course Learning Objectives:

1. To provide knowledge about multidisciplinary nature of environment, various sources of natural energy.
2. Understanding of ecosystem structure and function etc.
3. Knowledge of biodiversity and conservation
4. Understanding of problems caused by pollution and its impact
5. Understanding about the various social issues related to environment.
6. Awareness for the Environment and human health

Course Content:

UNIT-I: The Multidisciplinary Nature of Environmental Studies and Natural Resources (9 hours)

The Multidisciplinary Nature of Environmental Studies: Definition, scope and importance; Need for public awareness.

Natural Resources: Renewable and Non Renewable Resources Natural resources and associated problems.

a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people. b) Water resources: Use and overutilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies. d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies. e) Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies. f) Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification. Role of an individual in conservation of natural resources. Equitable use of resources for sustainable lifestyles.

UNIT-II: Ecosystems (4 hours)

Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers, Energy flow in the ecosystem, Ecological succession, Food chains, food webs and ecological pyramids, Introduction, types, characteristic features, structure and function of the following ecosystem: -a. Forest ecosystem, b. Grassland ecosystem, c. Desert ecosystem, d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries).

UNIT-III: Biodiversity and It's Conservation (4 hours)

Introduction – Definition: genetic, species and ecosystem diversity, Biogeographical classification of India, Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values, Biodiversity at global, National and local levels, India as a mega diversity nation, Hot-sports of biodiversity, Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts, Endangered and endemic species of India, Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

UNIT-IV: Environmental Pollution (6 hours) Cause, effects and control measures of:-a. Air pollution, b. Water pollution, c. Soil pollution, d. Marine pollution, e. Noise pollution, f. Thermal pollution, g. Nuclear hazards, Solid waste Management: Causes, effects and control measures of urban and industrial wastes, Role of an individual in prevention of pollution, Pollution case studies, Disaster management: floods, earthquake, cyclone and landslides.

UNIT- V: Social Issues and the Environment (4 hours)

From Unsustainable to Sustainable development Urban problems related to energy, Water conservation, rain water harvesting, watershed management, Resettlement and rahabilitation of people;

its problems and concerns. CaseStudies, Environmental ethics: Issues and possible solutions.• Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies. Wasteland reclamation, Consumerism and waste products, Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act, Issues involved in enforcement of environmental legislation, Public awareness.

UNIT-VI: Human Population and the Environment (3 hours)

Population growth, variation among nations, Population explosion – Family Welfare Programme, Environment and human health, Human Rights, Value Education, HIV/AIDS, Women and Child Welfare, Role of Information Technology in Environment and human health, Case Studies.

Learning Resources

Text Book:

1. Erach Bharucha, '*Textbook of Environmental studies*', UGC

Reference Books:

1. Clark RS, '*Marine Pollution*', Clanderson Press, Oxofrd (TB).

2. De AK, '*Environmental Chemistry*', Wiley Eastern Ltd.

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

CO1	Well understanding about their surrounding natural resources and their conservation
CO 2	Able to understand the ecosystem food chain and habitat.
CO 3	Develop the practices for conservation of biodiversity
CO 4	To well understand the pollution courses, impact and prevention from pollution
CO 5	Able to bring about an awareness of a variety of environmental concerns.
CO 6	It attempts to create a pro-environmental attitude and a behavioral pattern in society that is based on creating sustainable lifestyles.

For Theory Courses Only:

I Year B. Tech CE	**SEMESTER - II**	**L**	**T**	**P**	**C**
Code: CE1201	**MECHANICS OF MATERIALS**	**3**	**1**	**0**	**4**

UNIT-I: Stresses and Strains:

Normal stress, shear stress, state of stress at a point, ultimate strength, allowable stress, factor of safety, normal strain, shear strain, Poisson's ratio, Hooke's law, stress-strain characteristics for mild steel. Elastic moduli and the relationship between them, Bars of varying section, temperature stresses, composite bars, Strain energy,Resilience. Normal and tangential stresses on an inclined plane for biaxial stresses, Two perpendicular normal stresses accompanied by a state of simple shear, Mohr's circle of stresses, Principal stresses and strains, Analytical and graphical solutions. Thin seamless cylindrical shells, Derivation of formula for longitudinal and circumferential stresses - hoop, longitudinal and Volumetric strains, Changes in diameter, and volume of thin cylinders, Thin spherical shells.

UNIT-II: Shear ForCEand Bending Moment:

Definition of beam, Types of beams, Concept of shear forCEand bending moment, S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, uniformly distributed load uniformly varying loads and combination of these loads, Point of contra flexure, Relation between S.F., B.M and rate of loading at a section of a beam.

UNIT-III: Flexural Stresses & Shear Stresses

Theory of simple bending, Assumptions, Derivation of bending equation: M/I =f/y = E/R, Neutral axis, Determination of bending stresses, Section modulus of rectangular and circular sections (Solid and Hollow), I,T, Angle and Channel sections. Derivation of formula, Shear stress distribution across various beam sections like rectangular, circular, triangular, I, T angle sections.

UNIT IV: Deflection of Beams:

Bending into a circular arc-slope, deflection and radius of curvature, Differential equation for the elastic line of a beam - Double integration and Macaulay's methods, Determination of slope and deflection for cantilever and simply supported beams subjected to various types of loads, Mohr's theorems, and Moment area method.

UNIT-V: Torsion of Circular Shafts& Springs:

Theory of pure torsion, Torsion equation, Assumptions made in the theory, Theory of pure torsion, Torsional moment of resistance, Polar section modulus, Power transmitted by shafts, Combined bending and torsion and end thrust. **Springs:** Introduction, Types of springs, deflection of close and open coiled helical springs under axial

UNIT – VI: Columns and Struts:

Introduction, Types of columns, Axially loaded compression members, Crushing load, Euler‘s theorem for long columns, assumptions, derivation of Euler’s critical load formulae for various end conditions, Equivalent length of a column, slenderness ratio, Euler’s critical stress, Limitations of Euler’s theory, Long columns subjected to eccentric loading

Text Books:

1. Beer, F.P., and Johnston, JR, E.R., "Mechanics of Materials", (2nd Edition), McGraw Hill, 1992.
2. Hibbeler, R.C., "Mechanics of Materials", Pearson Education, Low PriCEEdition, 2007
3. Bansal, R.K., "Strength of Materials", Laxmi Publications (P) Ltd., 2007

ReferenCEBooks:

1. Popov, E.P., Mechanics of Materials, PrentiCEHall of India Private Limited, 1976.
2. Punmia B C, Mechanics of Materials, Laxmi Publications Ltd, New Delhi

I Year B. Tech CE	Semester - II	L	T	P	C
Code: CE1204	Building Materials And Construction	3	1	0	4

UNIT -I: Introduction To Building Materials: Functions of buildings – Types of building materials – Sustainable materials in construction - Regulations & Standards – Fundamental properties and selection.

UNIT –II: Masonry Products & Concrete:

Building stones – classification, processing, characteristics, durability aspects, tests, application and selection, preservation etc.

Bricks – classification, manufacturing, characteristics, durability aspects, tests, application and selection, sustainability aspects, laying etc.

Limes – Cementing action, manufacturing, slaking, storage, properties, classification, tests, applications etc.

Mortars – Classification, preparation, strength, tests, applications etc.

Concrete – Constituent materials, properties, characteristics, tests, production, properties, masonry units etc.

UNIT –III: Timber, Glass, Ceramics, Plastics & Metals and other special materials.

Introduction – characteristics - manufacturing – classification, applications etc.

Paints, Distempers, Varnishes, Asphalt, Bitumen & Tar, Thermal & Sound insulating materials

UNIT –IV: Elements of Building Construction -I

Foundations, Masonry walls, Framed Buildings Vs. Load bearing wall construction,

Lintels & Arches- Definition, function and classification of lintels, Balconies, chejja and canopy. Arches; Elements and Stability of an Arch.

Flooring & Roofing – Floors; Requirement of good floor, Components of ground floor, Selection of flooring material, Laying of Concrete, Mosaic, Marble, Granite, Tile flooring, Cladding of tiles. Roof;-

Requirement of good roof, Types of roof, Elements of a pitched roof, Trussed roof, King post Truss, Queen Post Truss, Steel Truss, Different roofing materials, R.C.C.Roof.

UNIT –V: Elements of Building Construction -I I

Doors, Windows & Ventilators: Location of doors and windows, technical terms, Materials for doors and windows, Paneled door, Flush door, Collapsible door, Rolling shutter, PVC Door, Paneled and glazed Window, Bay Window, French window. Ventilators. Sizes as per IS recommendations

Stairs: Definitions, technical terms and types of stairs, Requirements of good stairs. Geometrical design of RCC doglegged and open-well stairs.

UNIT –V: Plastering & Pointing, Damp proof course, Water proofing, Scaffolding, Centering and Form work for concrete structures.

Text books:

1. Building Materials by M.L. Gambhir. – Tata Mc. GrawHillPublishers, New Delhi.
2. Building materials by Rangwala
3. Building Construction by Dr. B.C.Punmia – Laxmi Publications (P) Ltd., New Delhi.

Video Reference

Title	Expert Name	Affiliation	Weblink
Lecture series on Building materials and construction (Lecture No.01,02 & 28 to 40)	Prof. B Battacharjee	IIT Delhi	http://nptel.ac.in/courses/105102088/

II Year B. Tech CE	**SEMESTER - I**	**L**	**T**	**P**	**C**
Code: CE2101	**STRUCTURAL ANALYSIS**	**3**	**1**	**0**	**4**

UNIT –I: Indeterminate Structural Analysis:

Indeterminate Structural Analysis –Determination of static and kinematic indeterminacies –Solution of trusses with up to two degrees of internal and external indeterminacies – Castigliano's theorem

UNIT – I: Propped Cantilevers & Fixed Beams:

Analysis of propped cantilevers-shear forCEand bending moment diagrams-Deflection of propped cantilevers. Introduction to statically indeterminate beams with U.D. load central point load, eccentric point load. Number of point loads, uniformly varying load, couple and combination of loads shear forCEand Bending moment diagrams, Deflection of fixed beams effect of sinking of support, effect of rotation of a support.

UNIT – III: Continuous Beams:

Introduction-Clapeyron's theorem of three moments- Analysis of continuous beams with constant moment of inertia with one or both ends fixed-continuous beams with overhang, continuous beams with different moment of inertia for different spansEffects of sinking of supports-shear forCEand Bending moment diagrams.

UNIT – IV: Energy Theorems:

Introduction-Strain energy in linear elastic system, expression of strain energy due to axial load, bending moment and shear forces - Castigliano's first theorem-Deflections of simple beams and pin jointed trusses.

UNIT – V: Moving Loads:

Introduction maximum SF and BM at a given section and absolute maximum S.F. and B.M due to single concentrated load U.D load longer than the span, U.D load shorter than the span, two point loads with fixed distanCEbetween them and several point loads-Equivalent uniformly distributed load-Focal length.

UNIT – VI: InfluenCELines:

Definition of influenCEline for SF, InfluenCEline for BM- load position for maximum SF at a sectionLoad position for maximum BM at a section single point load, U.D.load longer than the span, U.D.load shorter than the span, InfluenCElines for forces in members of Pratt and Warren trusses.

Text Books:

1. Sructural Analysis by R C Hibbler, 6th edition, Person India Publication
2. Elementary Structural Analysis - Norris, Wilbur and Utku, McGraw Hill.

3. Basic Structural Analysis - C.S. Reddy, Tata McGraw Hill.

References:

Intermediate Structural Analysis - C. K. Wang, McGraw-Hill

Theory of Structures - Volumes 1 and 2,

S P Gupta and G S Pandit, Tata McGraw Hill.

Video Reference

Title	**Expert Name**	**Affiliation**	**Weblink**
Lecture series on Structural Analysis-I	Prof.SradhdhaGhosh	IIT Bombay	http://nptel.ac.in/courses/105101085/

II Year B. Tech CE	**SEMESTER - I**	**L**	**T**	**P**	**C**
Code: CE2102	**HYDRAULICS ENGINEERING**	**3**	**1**	**0**	**4**

UNIT-I:Free Surface Flows

-Introduction, Channels and their Geometric properties, Pipe flow and free surface flow, continuity equation, energy in free surface flow. Velocity measurement and distribution, discharge measurement by velocity-area method. Continuity and Momentum equation

UNIT-II:Uniform Flow

Resistance flow formula, Velocity distribution, Equivalent roughness coefficient, Velocity coefficients, Uniform flow in rigid boundary channel, Uniform flow in mobile boundary channel, normal and critical slopes

Energy and Momentum Principle - Concept of Specific Energy, Critical Depth, Alternate depth, Specific Force, Sequent depth.

UNIT-III:Non-Uniform Flow

Gradually Varied Flow – basic assumptions – dynamic equation for Gradually Varied Flow, characteristics of flow profiles in prismatic channels. Computation of length of back water curve - standard step method, direct step method Computation of back water profile using spread sheet.

UNIT-IV: Rapidly Varied flow

Characteristics of the flow – hydraulic jump – initial and sequent depths; Non-dimensional equation, practical applications of hydraulic jump; types of jump in horizontal floor, basic characteristics of the jump – energy loss, efficiency and jump as energy dissipater, stilling basins **Unsteady Flow**:- Rapidly Varied Unsteady flow – Introduction to surges and types of shallow water waves

UNIT-V:Canal Design

Design of a lined canal – Design of best economic channel section – Rectangular and Trapeziodal channel; Design of unlined canal on Non-alluvial and Alluvial soils – Kennedy's regime theory and Lacey's regime theory.

UNIT-VI:Hydraulic machines

Fundamentals of hydraulic turbine theory; Turbine performance characteristics and selection of turbines; Design of radial flow and axial flow turbines and Pelton turbines; Draft tube theory, specific speed; Fundamentals of Rotodynamic pumps – types, advantages, working, volute and whirl pool chambers, velocity triangles for pumps, NPSH and specific speed

Texts/Reference Books:

1. K.Subramanya, Flow in Open Channels, Tata McGraw Hill Publication co. Ltd. New Delhi, 1992
2. V.T. Chow, Open Channel Hydraulics, McGraw Hill, 1975
3. P.N. Modi and S.M. Seth, *Hydraulics and Fluid Mechanics*, Standard Book House, 1998
4. K.G. Rangaraju, flow in Open Channels, Tata McGraw Hill Publication Co. Ltd., New Delhi, 1993
5. R.H. French, Open Channel Hydraulics, McGraw Hill Book Co., New York 1986
6. S.K. Garg, Irrigation Engineering and Hydraulic Structures, Khanna Publishers, 1992

Video Reference

Title	**Expert Name**	**Affiliation**	**Web link**
HYDRAULICS ENGINEERING	Dr. Arup Kumar Sarma	IIT Guwahati	http://nptel.ac.in/courses/105103096/

II Year B. Tech CE	**SEMESTER - I**	**L**	**T**	**P**	**C**

Code: CE2103	WATER RESOURCES ENGINEERING	3	1	0	4

UNIT – I:

Introduction to Engineering Hydrology and its applications

Hydrological cycle, precipitation and its measurement, recording and non-recording rain gauges, estimating missing rainfall data, rain gauge net works, mean depth of over a drainage area, mass rainfall curves, intensity-duration curves, depth-area duration curves. Infiltration and infiltration indices, evaporation stream gauging, run off and its estimation.

Unit-II:

Abstractions from Precipitation: Factors affecting evaporation, measurement of evaporation, evapotranspiration, Infiltration, factors affecting infiltration, measurement of infiltration, infiltration indices. Runoff, Components of runoff, factors affecting runoff, stream gauging, effective rainfall, separation of base flow

UNIT – III:

Hydrograph Analysis: hydrograph analysis, components, peaks flows, unit hydrograph and its derivation from isolated and complex storms, S-curve hydrograph, synthetic unit hydrograph, IUH, SCS triangular unit hydrograph.

UNIT – IV:

Floods: Types of floods and their estimation by different methods, probability and frequency analysis, flood routing through reservoirs and channels, flood control measures, economics of flood control

UNIT – V:

Ground Water: Occurrence, confined and unconfined aquifers, aquifer properties, hydraulics of wells under steady flow conditions. Groundwater quality, Ground water recharge-necessity and methods of improving ground water storage.Darcy's law and its limitations.Formulation of governing equations for groundwater movement.Hydraulics of flow towards wells.

UNIT - V

Introduction to Irrigation: advantages and ill effects of Irrigation, types of Irrigation, methods of application of Irrigation water, Indian agricultural soils, methods of improving soil fertility, preparation of land for Irrigation, Soil-water-plant relationship: vertical distribution of soil moisture, soil moisture constants, soil moisture tension, consumptive use, estimation of consumptive use, Duty and delta, factors affecting duty, irrigation efficiencies.

Text/Reference Books:

1. K.Subramanya, Engineering Hydrology, Tata McGraw Hill Publication co. Ltd. New Delhi, 1992
2. R.K. Linsley and J.L.H. Paulhus: Water Resources Engineering, McGraw Hill Book Co., 1992
3. V.P. Singh, *Elementary Hydrology*, Prentice Hall, 1993
4. P.N. Modi, Irrigation water Resources and Water Power Engineering, Standard Book House, New Delhi, 1990
5. K.C. Patra, "Hydrology Water Resources Engineering

Video Reference

Title	Expert Name	Affiliation	Web link
Water Resources Engineering	Prof. Rajesh Srivastava	IIT Kanpur	http://nptel.ac.in/courses/105104103/

II Year B. Tech CE	SEMESTER - I	L	T	P	C
Code: CE2104	SOIL MECHANICS	3	1	0	4

Unit-1:

Origin and Characteristics of soil:Introduction, Engineering geology and formation of soil, Weight ratios (Water content, Density, Unit weights, Specific Gravity); Volume ratios (void ratio, porosity, degree of saturation, relative density); Interrelationships, Laboratory tests for determination of Index properties, Atterberg limits. Classification and Identification of soils for general and engineering purposes as per IS: 1498-1970, Soil structure and Clay minerals.

Unit-II:

Permeability: Darcy"s law- permeability – Factors affecting – laboratory determination of coefficient of permeability –Permeability of layered systems.

Seepage through soils: Total, neutral and effective stresses –quick sand condition – Seepage through soils – Flow nets: Characteristics and Uses.

Stress analysis:In-Situ Stresses, Effective stresses, Pore water pressure, Capillary rise, piping,quicksand condition – critical hydraulic gradient.

Unit-III:

Compaction: Mechanism of compaction – factors affecting – effects of compaction on soil properties. – Field compaction Equipment - compaction control.

Consolidation: stress history of clay; e-p and e-log p curves – magnitude and rate of 1-D consolidation – Terzaghi"s Theory. Determination of coefficient of consolidation, heights of solids method, void ratio method, pre consolidation pressure, causes of pre consolidation pressure

Unit-VI:

Shear strength of soils: Mohr – Coulomb Failure theories – Types of laboratory strength tests – strength tests based on drainage conditions – Shear strength of sands – Critical Void Ratio – Liquefaction- shear strength of clays. Tri axial test, vane shear test, unconfined compression strength test

Unit-V:

Stability of slopes: Definition and classification of slopes, types of slope failure, Factor of safety with respect to cohesion, Analysis of slope stability for finite and infinite slopes - limit equilibrium method, Swedish slip circle method, Taylor's stability number, method of slices and simplifiedBishop method.

Text Books:

1. Principals of Geotechnical Engineering, By: Braja M. Das., Fifth edition, First reprint 2002, low price edition, Thomson learning Inc.
2. Basic & Applied Soil Mechanics, By: GopalRanjan / Rao A.S.R. 2003 print, New Age International Pvt Ltd.
3. Murthy, V.N.S.,“ Soil Mechanics & Foundation Engineering”.DhanpatRai&Sons' 2006.
4. Arora, K.R., “Soil Mechanics and Foundation Engineering”, Standard publishers Distributors, revised and enlarged sixth edition,2007.

Relevant IS Codes.

Video Reference

Title	**Expert Name**	**Affiliation**	**Web link**
Soil Mechanics	Prof. M.R Madhav	IIT Kanpur	RGUKT-Intranet

II Year B. Tech CE	SEMESTER - I	L	T	P	C
Code: CE2105	Concrete Technology	1	0	3	4

UNIT I: Concrete Big Picture
History and significance of concrete as a construction material. Advantages and Disadvantages of concrete. Role of concrete in "Sustainable Infrastructure Development".
UNIT II: Concrete Constituent Materials
Cement- Manufacturing –Basic Cement Chemistry – Hydration – Classification – Tests – Relevant IS Codes
Aggregatea – Classification – Characteristics – Properties of aggregates – Tests on aggregates and their significance – Grading – Fineness Modulus - Relevant IS Codes
Water – Mixing water, Curing Water – Tests of water - Relevant IS Codes
Admixtures – Functions – Classifications – Types - Relevant IS Codes
UNIT III: Fresh Concrete
Workability – definition, tests and interpretation, Rheology of fresh concrete, Effect of constituent materials on workability, Relevant IS Standards.
UNIT IV: Hardened Concrete
Strength criterion, Stress-strain characteristics of concrete , fracture mechanics approach, tensile strength considerations, behavior under compressive strength.
Factors affecting strength of hardened concrete: porosity, gel-space ratio, total voids in concrete, w/c ratio, degree of compaction, age etc.
Dimensional Stability- Elasticity, Shrinkage and creep
Permeability & Durability: Permeability, Sulphate attack, attack by sea water, Acid attack, Alkali-aggregate reaction, corrosion of reinforcement.
UNIT V: Production of concrete and quality contol.
Batching of materials, Mixing of concrete materials, transpiration, RMC, placing, compaction, finishing and curing, form work.
Factors causing variations in concrete quality, field control, advantages of quality control, statistical quality control.
UNIT VI: Proportioning of concrete mixes
Basic considerations, factors influencing choice of mix design proportions, methods of concrete mix designing – IS method, ACI method, British DoE method
Text Books:
1.M.L. Gambhir "Concrete Technology Theory and Practice" Mc Grah Hill Education (India) Private Limited, 5th Edition.
2. A.M. Niveli & JJ Brooks "Concrete Technology" Pearson Education, 9th Edition.
Video Reference

Title	Expert Name	Affiliation	Weblink
Lecture series on Building materials and construction	**Prof. B Battacharjee**	**IIT Delhi**	**http://nptel.ac.in/courses/105102088/**

II Year B. Tech CE	SEMESTER - I	L	T	P	C
Code: CE2701	Concrete Technology Lab	0	0	3	2

Cement Testing:

1. Normal Consistency

2. Initial and Final Setting Time
3. Soundness
4. Fineness of Cement
5. Compressive Strength of Cement

Aggregate Properties:
6. Grade analysis of Fine and Coarse aggregates
7. Loose and Bulk density of Coarse and Fine aggregates
8. Water absorption of coarse aggregates and Angularity number
9. Specific gravity of Fine and coarse aggregate

Tests on Fresh concrete:
9. Workability (Slump Test)
10. Workability (Compaction factor Test)

Tests on Hardened Concrete:
11. Compressive strength of Concrete
12. Split tensile strength of concrete

II Year B. Tech CE	**SEMESTER - I**	**L**	**T**	**P**	**C**
Code: CE2702	**SOIL MECHANICS LABORATORY**	**0**	**0**	**3**	**2**

LIST OF EXPERIMENTS IN SOIL MECHANICS LABORATORY:

1) Soil Moisture Content
2) Soil Specific Gravity
3) Grain size Analysis – Mechanical Method
4) Hydrometer Analysis
5) Atterberg Limits (Liquid limit, Plastic limit and Shrinkage limit)
6) Vane shear test
7) Compaction test (Standard Proctor test & Modified proctor test)
8) Consolidation Test
9) Sand replacement method
10) Core cutter Method
11) Direct Shear Test
12) Tri-axial test apparatus
13) Falling head permeability test
14) Constant head permeability test

II Year B. Tech CE	**SEMESTER - II**	**L**	**T**	**P**	**C**
Code: CE2202	**DESIGN OF STEEL STRUCTURES**	**3**	**1**	**0**	**4**

UNIT – I: Bolted and Welded connections:
Introduction, Advantages and disadvantages of welding- Strength of welds-Butt and fillet welds: Permissible stresses – IS Code requirements. Design of welds fillet weld subjected to moment acting in the plane and at right angles to the plane of the joints, beam to beam and beam to Column connections.
UNIT – II: Beams:
Allowable stresses, design requirements as per IS Code-Design of simple and compound beams-Curtailment of flange plates, Beam to beam connection, check for deflection, shear, buckling, check for bearing, laterally unsupported beams.

UNIT –III: Tension Members And Compression Members:
General Design of members subjected to direct tension and bending – effective length of columns. Slenderness ratio – permissible stresses. Design of compression members, struts etc.

UNIT – IV:Design Of Built Up Compression Members
– Design of lacings and battern. Design Principles of Eccentrically loaded columns splicing of columns. Design of Column Foundations: Design of sign of slab base and gusseted bases. Column bases subjected moment.

UNIT - V :Roof Trusses:
Different types of trusses – Design loads – Load combinations IS Code recommendations, structural details – Design of simple roof trusses involving the design of purlins, members and joints – tubular trusses.

UNIT – VI: Plate Girder & Gantry Girder:
Design consideration – I S Code recommendations Design of plate girder Welded – Curtailment of flange plates stiffeners – splicing and connections. Gantry girder impact factors - longitudinal forces, Design of Gantry girders.

Text Books:
1. Design of Steel Structures- Limit State Method by N Subramanian, Oxford Press, New Delhi
2. Design of steel structures by S.K. Duggal, Tata Mcgraw Hill, New Delhi

References :
1. Design of steel structures by P Dayaraththam, S Chand Publication, New Delhi
2. Comprehensive Design of Steel structures, by B.C. Punmia, Ashok Kumar Jain and Arun Kumar Jain, Laxmi Publications, New Delhi.
3. Design of Steel Structures by M.Raghupathi, Tata Mc. Graw-Hill

Video Reference

Title	Expert Name	Affiliation	Web link
Lecture series on Design of steel structures	Prof. S R Satish Kumar	IIT Kanpur	http://nptel.ac.in/courses/105106112/

Course code	Course name	Course Category	L-T-P	Credits
23CH3203	Transport Phenomena	PCC	3-1-0	4

Course Learning Objectives:
1. To analyze and characterize fluid flow phenomena of various types of fluids under different conditions.
2. To analyze shell momentum balance in different systems.
3. To develop and solve the equations of change for isothermal systems.
4. To analyze mechanism of Energy Transport.
5. To develop and solve the equations of change for non-isothermal unsteady systems.
6. To analyze mechanism of Mass Transport

Course Content:

Unit I (12 Contact hours)
Viscosity and Mechanism of Momentum Transport: Newton's law of viscosity, pressure and temperature dependence of viscosity, Molecular theory of the viscosity of gases at low density, molecular theory of the viscosity of liquids, Velocity Distributions in Laminar Flow using Shell momentum balances and boundary conditions–flow of a falling film–flow through a circular tube–flow through annulus–flow of two adjacent immiscible fluids

Unit II **(10Contact hours)**

Shell momentum balances and boundary conditions: Laminar flow in a narrow slit - laminar slit flow with a moving wall ("plane Couette flow") - Interrelation of slit and annulus formula, Flow of a film on the outside of a circular tube - Annular flow with inner cylinder moving axially.

Equation of change for Isothermal Systems**:** Equation of continuity and equation of motion, Navier stokes equations.

Unit III **(8 Contact hours)**

Equation of change for Isothermal Systems**:** Navier stokes equations, applications: steady state in a long circular tube-falling film with variable viscosity – operation of coquette viscometer, Shape of surface of a rotating liquid.Velocity Distributions with more than one independent variable- Time dependent flow of Newtonian fluids- flow near a wall suddenly set in motion.

Unit IV **(8Contact hours)**

Thermal Conductivity and Mechanism of Energy Transport: Fourier's law of heat conduction thermal conductivity and diffusivity- Shell energy balances and boundary conditions–heat conduction with electrical heat source–heat conduction with nuclear heat source–heat conduction with viscous heat source–heat conduction through composite walls–heat conduction in a cooling fin.

Unit V **(10Contact hours)**

Equations of change for Non-Isothermal Systems: The equations of energy–Special forms of energy equations- steady state forced convection heat transfer in laminar flow in a circular pipe- tangential flow in an annulus with viscous heat generation-steady flow in a Non-isothermal film – Transpiration cooling-
Temperature Distributions with more than One Independent Variable: unsteady state heat conduction in solids - heat of semi infinite slab- heating of finite slab.

Unit VI **(12Contact hours)**

Diffusivity and the mechanism of mass transport : Fick's law of binary diffusion, Theory of diffusion in gases at low density, Concentration Distribution in solids and in Laminar Flow, Shell mass balances–boundary conditions–diffusion through a stagnant gas film–diffusion with a heterogeneous chemical reaction–diffusion with a homogeneous chemical reaction–diffusion into a falling liquid film (gas absorption)

Learning Resources:

Text book:

1. Bird R.B., Stewart W.E. and Light Foot E.N. '*Transport Phenomena'* – John Wiley International – 2nd Edition, New York, 2002

Reference Books:

1. Christie J. Geankoplis – '*Transport Processes and Unit Operations'* – 3rd Ed., Prentice Hall of India Pvt. Ltd., New Delhi, 1997

Web Resources:

1. https://nptel.ac.in/courses/103102024/

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

CO 1	Analyze and characterize fluid flow phenomena of various types of fluids under different conditions.
CO 2	Develop the shell momentum balance.
CO 3	Solve the equations of change for isothermal systems.
CO 4	Analyze mechanism of Energy Transport.
CO 5	Compute the equations of change for non-isothermal systems..
CO 6	Analyze mechanism of Mass Transport

Course code	Course name	Course Category	L-T-P	Credits
23CH3281	Chemical Process Dynamics and Control Lab	PCC	0-0-3	1.5

Course Learning Objectives:

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

1. To understand the dynamic behavior of the systems
2. To evaluate response of first and higher order characteristics.
3. Study the installed characteristics of the valve.
4. Study if there is a hysteresis in the control valve and sensor.
5. Evaluate the tuning of a PID control via manual and automatic tuning.
6. Evaluate the effect of controller on the control system.

List of Experiments: (any 10 of the following experiments)

1. Differential Pressure Transmitter
   a) To measure pressure/differential pressure from Differential Pressure Transmitter.
   b) To calibrate given Differential Pressure Transmitter.
2. Thermocouple
   a)To calibrate the different Type of Thermocouples.
   b) To plot the Calibration Curve.
3. Interacting-Non interacting systems
   a)To study the dynamic response of liquid level single tank two tank interacting and non-interacting system.
   b)To calculate valve resistance of single tank liquid level system, two tank interacting system, two tank non-interacting system.
   c)To calculate Time constant of single tank liquid level system, two tank interacting system, two tank non-interacting system
   d)To calculate step response of single tank liquid level system, two tank interacting system, two tank non-interacting system to step change in input flow and compare it with the theoretical response
4. Flapper Nozzle System

a) To determine the output characteristics of Flapper Nozzle Trainer System.

5. I/P and P/I converter
   a)To study the working Principle and calibration procedure of I/P converter.
   b) To study the working Principle and calibration procedure of P/I converter.
6. Control Valves
   a)To study the control valve characteristics.
   b)To determine the flow co-efficient C_v of the linear, equal%, open control valves.
   c)To study the inherent characteristics of the linear, equal%, quick open control valves.
   d)To study the installed characteristics of the linear, equal%, quick open control valves.
   e)To study the Hysteresis of the linear, equal%, quick open control valves.
   f)To Calculate range ability of the linear, equal%, quick open control valves.
7. Study of response of Temperature controller with proportional integral derivative controller mode
8. Study of response of Level controller with proportional integral controller mode
9. (i) Study of response of pressure controller with proportional integral derivative controller
   ii) Study the tuning of controller(Open loop method) using Zeigler-Nichols method
10. Study of response of Flow controller with proportional controller mode
11. PCI SKID
    To study the single loop feedback control system.
    A) Level Control Loop
    B) Flow Control Loop
    C) Cascade Control Loop
    D) Ratio Control Loop
    E) Level Control Loop with Feed Forward Input
    F) On/Off Level Control Loop

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

CO 1	Estimate the dynamic behavior of the control systems
CO 2	Compute the controllability, speed of response of the control systems.
CO 3	Select proper control valve to meet process needs.
CO 4	Design direct digital control systems handling and operation.
CO 5	Tuning of a PID control via manual and automatic tuning.
CO 6	Choose PID modes that effect controllability, speed of response of the control systems

Course code	Course name	Course Category	L-T-P	Credits
23CH2101	Thermodynamics-I	ESC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Learn the basic concepts and first law of thermodynamics and its applications.
2. Understand the concepts of Volumetric &Thermodynamic Properties Of Pure Fluids
3. Provide the knowledge on Heat effects
4. Provide the knowledge on applications of second law of thermodynamics.
5. Provide the knowledge of Thermodynamic properties of Real fluids
6. Provide the knowledge on applications of thermodynamics in flow processes.

Course Content:

Unit I **(7 Contact hours)**

Introduction: The first Law and other basic concepts Joule's Experiments - Internal Energy - Formulation of the first law of the thermodynamics - the thermodynamic state and state functions – Equilibrium- The phase rule - The Reversible process-Constant Volume and Constant Pressure processes- Enthalpy- Heat Capacity.- Mass and Energy Balances for Open Systems

Unit II **(8 Contact hours)**

Volumetric &Thermodynamic Properties of Pure Fluids: The PVT behavior of pure substances, virial equations, the ideal gas, the applications of the virial equations, Cubic equations of state, generalized correlations for gases-Thermodynamic properties of pure fluids: Property relations for homogeneous phases, residual properties, Applications of the equation of state-Relationship between Peng-Robinson, Redlich-Kwong and Soave-Redlich-Kwong equation of state

Unit III **(7 Contact hours)**

Heat Effects: Sensible Heat effects:– Latent Heats of pure substances - Standard Heat Reaction- Standard Heat of Formation- Standard Heat of Combustion_ Temperature dependence of ΔH^o, Heat Effects of Industrial Reactions

Unit IV **(8 Contact hours)**

The Second Law of Thermodynamics:- Statements of second law- Heat engines Thermodynamic temperature scales- Entropy- Entropy changes of an ideal gas- Mathematical Statement of the Second Law, Entropy Balance for Open Systems, Calculation of Ideal Work, Lost Work- The Third Law of thermodynamics- Entropy from Microscopic Viewpoint

Unit – V **(8 Contact hours)**

Thermodynamic Properties of Real Fluids: Property Relations for Homogeneous Phases- Residual properties- The Two phase systems. Thermodynamic diagrams- Tables of Thermodynamic Properties- Generalized Property Correlations for Gases; Estimation of Auxiliary Physical Properties- properties of pure substances and mixture: - densities, molecular weights, boiling points, vapor pressures, critical pressure, critical volume and critical compressibility factor, acentric factor combining and mixing rules

Unit – VI **(7 Contact hours)**

Applications of Thermodynamics to Flow Processes:- Duct flow of Compressible Fluids, Turbines (Expanders), Compression Processes; Production of Power from Heat:- The Steam Power Plant- Internal Combustion Engines- Otto cycles and Diesel cycle; Jet Engines, Rocket Engines; Refrigeration and liquefaction:- The Carnot Refrigerator- The Vapor-Compression Cycle- The Choice of Refrigerant- Absorption Refrigeration- The Heat Pump- The various processes for liquefaction.

Learning Resources:

Text Books:

1. J.M.Smith, H.C Van Ness and M. M. Abbott, '*Introduction to Chemical Engineering Thermodynamics*', Sixth Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2003

Reference Books:

1. Halder G, '*Introduction to Chemical Engineering Thermodynamics*', 4th edition, Prentice Hall India, 2014.
2. J.Richard Elliott and Carl T. Lira, '*Introductory Chemical Engineering Thermodynamics*', Second Edition, Prentice Hall, 2012
3. Thomas E Daubert, Chemical Engineering Thermodynamics, McGraw Hill International Editions, 1986
4. K. V. Narayanan, '*Text Book of Chemical Engineering Thermodynamics*', PHI Learning Limited, 2004,
5. Y. V. C. Rao, '*Chemical Engineering Thermodynamics*', University Press (India) Private Limited, 2004

Web resources:

1. https://nptel.ac.in/courses/103101004/
2. http://www.msubbu.in/lecture/thermodynamics.html

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

CO 1	Evaluating the concepts of first law of thermodynamics to find heat, work & changes in internal energy and enthalpy during the analysis of any system undergoing reversible &irreversible processes.
CO 2	Design equation of state for gases and liquids to evaluate the changes in PVT behavior of pure fluids.
CO 3	Importance the calculations enthalpy changes
CO 4	Apply the second law of thermodynamics & concept of entropy while analyzing ideal & real systems.
CO 5	Analyzing the PVT behavior of Real Fluids.
CO 6	Able to apply Thermodynamic laws to flow processes.

Course code	Course name	Course Category	L-T-P	Credits
23CH2102	Heat Transfer	PCC	3-1-0	4

Course Learning

Objectives: The objective of this course is to impart in-depth knowledge on

1. Basics concepts related to different modes of heat Transfer.
2. Steady and unsteady state heat conduction in solids with and without internal heat source.
3. Types of convection mode of heat transfer and parameters effecting rate of heat transfer.
4. Heat transfer with phase change in boilers, condensers etc.
5. Concepts related to design of heat transfer equipment.
6. Radiation mode of heat transfer.

Course Content:

Unit–I **(8 Contact hours)**

Introduction: Nature of heat flow, conduction, convection, natural and forced convection, radiation.

Heat transfer by conduction in Solids: Fourier's law, thermal conductivity, steady state conduction in plane wall & composite walls, compound resistances in series, heat flow through a cylinder, conduction in spheres, thermal contact resistance, critical radius of insulation.

Unit – II **(10 Contact hours)**

Heat transfer in fins: Heat transfer from a rectangular fin, fin effectiveness and efficiency.

Unsteady state heat conduction: negligible internal heat resistance and lumped heat analysis, response time of a temperature measuring instrument, unsteady state heat conduction through a semi-infinite slab, three dimensional heat conduction equations in Cartesian, two dimensional heat conduction equations in cylindrical and one dimensional heat conduction equations in spherical coordinates with heat generation term

Unit – III **(12 Contact hours)**

Heat Transfer to Fluids without Phase change: Regimes of heat transfer in fluids, thermal boundary layer.

Forced Convection: Heat transfer by forced convection in laminar flow, heat transfer by forced convection in turbulent flow, the transfer of heat by turbulent eddies and analogy between transfer of momentum and heat, heat transfer to liquid metals, heating and cooling of fluids in forced convection outside tubes.

Unit - IV **(10 Contact hours)**

Natural convection: Natural convection to air from vertical shapes and horizontal planes, effect of natural convection in laminar flow heat transfer, free convection in enclosed spaces, mixed free & forced convection.

Heat transfer to fluids with phase change: Heat transfer from condensing vapors, heat transfer to boiling liquids.

Unit - V **(12 Contact hours)**

Heat exchange equipment: General design of heat exchange equipment, heat exchangers, condensers, boilers and calendrias, extended surface equipment, heat transfer in agitated vessels, scraped surface heat exchangers, heat transfer in packed beds, heat exchanger effectiveness (NTU method).

Evaporators: Evaporators, performance of tubular evaporators, capacity and economy, multiple effect evaporators, vapour recompression.

Introduction to advanced heat transfer equipment: Corrugated tube heat exchanger

Unit – VI **(8 Contact hours)**

Radiation: Introduction, properties and definitions, black body radiation, real surfaces and the gray body, absorption of radiation by opaque solids, radiation between surfaces, radiation shielding, radiation to semitransparent materials, combined heat transfer by conduction, convection and radiation.

Learning Resources:

Text book:

1. W.L.McCabe, J.C.Smith& Peter Harriot, '*Unit Operations of Chemical Engineering*', McGraw- Hill, 6th Edition, 2001.

Reference Books:

1. D. Q. Kern, '*Process heat transfer'*, McGraw-Hill, 2001.
2. Christie J. Geankoplis, '*Transport processes and Unit operations*', 3rd edition, PHI, 1993.
3. Frank P. Incropera, David P. De Witt, '*Fundamentals of Heat and Mass Transfer*", Wiley International,7th edition,2011
4. Binay K Dutta, '*Heat Trasfer- Principles and Applications*', PHI,2000

Web resources:

1. https://nptel.ac.in/courses/103103032
2. https://nptel.ac.in/courses/112101097/

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

CO1	Describe different modes of heat transfer. Explore material properties related to

	heat transfer.
CO2	Determine temperature distributions in solids and rate of heat transfer using fouriers law of conduction.
CO3	Develop convection mode of heat transfer; Apply Newton's law of cooling; Determine heat transfer coefficients using correlations.
CO4	Importanceof heat transfer process with phase change and determine coefficients in different boiling regimes.
CO5	Explore different heat transfer equipment's and describe their applications in chemical industries.
CO6	Analyzing various parameters affecting rate of heat transfer by radiation over different material surfaces.

Course code	Course name	Course Category	L-T-P	Credits
CH2201	Chemical Reaction Engineering – I	PCC	3-1-0	4

Course Learning Objectives:

The objective of this course is to impart in-depth knowledge about

1. Classification of chemical reactions, their speed and kinetics
2. Temperature dependency of rate equation and interpretation of batch reactor data for Constant volume batch reactor
3. Interpretation of batch reactor data for variable volume batch reactor and methods of Analysis of rate data for single and multiple reactions
4. Formulation of performance equations for ideal reactors
5. Reactors for single reactions and multiple reactions; product distribution
6. Temperature and Pressure effects on the progression of a chemical reaction.
7. To understand the purpose of Residence time distribution.

Course Content:

Unit I: **(10Contact hours)**

Introduction: Overview, Classification of chemical reactions, variables affecting the rate of reaction, definition of reaction rate, Speed of chemical reactions, overall plan.

Kinetics of homogeneous reactions:: The rate equation; Concentration dependency; Single and multiple reactions, elementary and non-elementary reactions, Order and molecularity of chemical reactions, rate constant. Representation of elementary and non-elementary reactions.

Temperature dependency: Temperature dependent term of rate equation from Arrhenius law and comparison of collision and transition theories.

Unit II: **(10 Contact hours)**

Interpretation of Batch reactor data: Constant volume Batch reactor: Integral method of analysis of data-Irreversible first order, second order, third order , n^{th} order and zero order reactions; Half-life method; Fractional life method;

Series reactions, parallel reactions, Catalyzed reactions; First order reversible reactions, reactions of shifting order; Variable volume batch reactor; reaction rate; rate constant; collection and interpretation of kinetic data; parallel and series reactions. Differential method of analysis; varying volume Batch reactor: Analysis of data using differential and integral methods –Irreversible zero order, first order, second order and nth order reactions; Temperature and reaction rate.

Unit III: **(10 Contact hours)**

Introduction to reactor design: General Discussion, symbols and relationship between concentration and conversion;

Ideal reactors for single reactions: Ideal batch reactor, steady state mixed flow and plug flow reactors design with and without recycle. Design for single reactions: Size comparison of single reactors, variation of reactant ratio, Graphical comparison;
Multiple reactor systems- MFRs and PFRs in series and parallel, best arrangement of set of ideal reactors, Recycle reactor, autocatalytic reactions, reactor combinations.

Unit IV: **(10 Contact hours)**

Design for Parallel reactions: Introduction, Qualitative discussion about product distribution, quantitative treatment of product distribution and of reactor size, the side entry reactor.
Design for single reactions: Size comparison of single reactors, variation of reactant ratio, Graphical comparison.
Potpourri of multiple reactions: Irreversible first order reactions in series- Qualitative discussion about product distribution and quantitative treatment of product distribution-mixed flow reactor.
Combination of first order and zero order reactions in series, two step irreversible series- parallel reaction, The Denbigh reactions.

Unit V: **(8 Contact hours)**

Temperature and Pressure effects: single reactions- Heats of reactions, equilibrium constants from thermodynamics, general graphical design procedure, optimum temperature progression, Adiabatic and Non-adiabatic operations; multiple reactions- Product distribution and temperature.

Unit VI: **(8 Contact hours)**

Basics of non-ideal flow: The Residence time distribution (RTD), State of aggregation of the flowing stream , Earliness of mixing and their role in determining reactor behavior; E-the age distribution of fluid, the RTD, Measurement of the RTD- The pulse and the Step experiments relation between E and F curves.

Learning Resources:

Text book:

1. Octave levenspiel, 'Chemical Reaction Engineering', Wiley-India, 3rd edition, 2012.

Reference Books:

1. H S Fogler, 'Elements of Chemical Reaction Engineering', PHI, 4th Edition, 2008.

Web resources:

1. https://nptel.ac.in/courses/103108097/

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

CO1	Build a knowledge on different classification of reactions, mechanisms and their kinetics
CO2	Analyzing the procedure of interpretation of batch reactor data for different types of reactions
CO3	Evaluating the performance equations for all ideal reactors
CO4	Find the design parameters such as volume of the chemical reactor for the given duty
CO5	Organize the ideal reactors for best conversions in single reactors and multiple reactions
CO6	Identify the optimum temperature progression for the maximum performance of the reactor

Course code	Course name	Course Category	L-T-P	Credits
23CH2202	Mass Transfer Operations-I	PCC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. To deduce adequate knowledge in principles of mass transfer and problem-solving techniques.

2. Explore concepts of mass transfer processes such as; absorption, humidification and drying and its applications
3. To recognize the effective usage of mass transfer equipments according to separation process.
4. To able to get an idea of industrial separation equipments.
5. To design the equipments needed for separation processes.
6. To understand the drying operations.

Course Content:

UNIT –I **(8 Contact hours)**

Introduction: Mass transfer operations & their applications. Concepts of molecular diffusion and mass transfer coefficients.

Molecular Diffusion in Fluids: Molecular Diffusion, Fick's first law, Equation of Continuity, binary solutions, Steady State Molecular Diffusion in Fluids at Rest and in Laminar Flow, estimation of diffusivity of gases and liquids. Diffusion in Solids, Fick's Diffusion, Unsteady State Diffusion, types of Solid Diffusion.

UNIT – II **(8 Contact hours)**

Mass Transfer Coefficients and various theories, Correlation's for mass transfer coefficient, Heat and Mass Transfer Analogies

Inter phase Mass Transfer: overall mass transfer coefficients – Two resistance theory – Gas phase & liquid – phase controlled situations

UNIT-III **(7 Contact hours)**

Equipment for Gas Liquid Operations – Stages, Cascades, Description of continuous and stage wise contact equipment Material balances in steady state co-current and counter current stage processes, packing for packed columns, Liquid distribution -Mass transfer coefficients in packed columns, Flooding in packed and plate columns – Ideal -plate – Murphree, point, plate and column efficiency – Comparison of packed and plate

UNIT-IV **(7 Contact hours)**

Absorption and Stripping: Absorption equilibrium, ideal and non-ideal solutions selection of a solvent for absorption, counter current and co-current isothermal absorption and stripping of single component – Operating Lines – Minimum flow rates – Determination of number of transfer units and height of a continuous contact absorbers. Multistage absorption and determination of number plates – absorption factor – Kremser – Brown equation.

UNIT-V **(8 Contact hours)**

Vapor - gas mixtures – Humidity and relative saturation. Dew point adiabatic saturation and wet bulb temperatures – psychometric charts – Enthalpy of gas vapor mixtures – Humidification and dehumidification – Operating lines and design of packed humidifiers, dehumidifiers and cooling towers, Spray chambers.

UNIT-VI **(7 Contact hours)**

Drying: Moisture contents of solids, equilibrium content, bound and unbound moisture, Drying conditions – Rate of batch drying and under constant drying conditions, Mechanism of batch drying, Drying time of batch drying- through circulation drying, Description of batch and continuous dryers.

Text books:

1. R.E. Treybal, *'Mass transfer operations'*, McGraw Hill,1981, 3rd Edition
2. B.K. Dutta, *'Principles of mass transfer and separation processes'*, PHI Learning Private Limited, Eastern Economy Edition

Reference Books:

1. Warren, L., McCabe, Julian C.Smith and Peter Harriot, *'Unit Operations of Chemical Engineering'*, McGraw Hill, 7th Edition
2. Christie John Geankoplis, *'Transport process and separation process principles'*, PHI of India, 4th edition
3. J D Seader and E J Henly, *'Separation Process Principles'*, John Wiley & sons, NY 1998.

Web resources:

1. https://nptel.ac.in/courses/103103034/

2. https://nptel.ac.in/courses/103103035/

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

CO 1	Build a basic knowledge of mass transfer operations and separation processes carried out in chemical industries.
CO 2	Evaluate the applications of different mass transfer processes.
CO 3	Identify technological methods in problem solving of mass transfer operations in industries.
CO 4	Designing of mass transfer equipments used in the chemical industries.
CO 5	Utilize the technological methods in problem solving of mass transfer operations in industries.
CO 6	Recognize the selection criteria for mass transfer process and equipments required by the industries.

Course Code	Course Name	Course category	L-T-P	Credits
23CH2203	Thermodynamics - II	PCC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Understand the concepts of solution thermodynamics
2. Understand ideal solution models to reflect behavior of real mixtures based on the concepts of excess free energy.
3. Understand the models to reflect VLE in ideal and non-ideal solutions
4. Understand phase equilibrium and bubble and dew point.
5. Understand Phase equilibria among phases.
6. Understand Equilibrium constant.

Course Content:

Unit I **(7 Contact hours)**

Properties of Solutions: Partial molar properties, definition, physical significance, determination, Chemical potential definition, effect of temperature and pressure, fugacity in solution, ideal solution, Lewis-Randall rule, Raoult's law, Henry's law, activity and activity coefficients in solutions, effect of temperature and pressure on activity coefficients, Gibbs-Duhem equations, applications

Unit II **(13 Contact hours)**

Property changes on mixing, heat effects of mixing processes, enthalpy composition diagrams, excess properties, relation between excess Gibbs free energy and activity coefficient, Applications of fugacity–fugacity coefficient–Activity–Activity Coefficient

Phase Equilibria: Criterion of phase equilibria, criterion of stability, Duhem's theorem, vapour-liquid equilibrium, phase diagram for binary solutions

Unit III **(10 Contact hours)**

VLE in ideal solutions, non-ideal solutions, positive and negative deviation, azeotropes, VLE at low pressures, Wohl's equation vanlaar equation, Margules equation, Wilson equation, application of activity coefficient equations in equilibrium calculations :basic idea on NRTL,UNIQUAC and UNIFAC methods, Applications of vapor–liquid-Equilibria–minimum boiling Azeotrope–maximum boiling Azeotrope

Unit IV **(10 Contact hours)**

Phase Equilibrium: Vapour-liquid equilibrium at high pressures, vaporization equilibrium Constants: bubble point, dew point and flash calculations in multi component systems, Retrograde condensation, vapour-liquid equilibrium in partially miscible and immiscible systems, phase diagrams
Applications of Bubble Point–Dew Point calculations in separation process–Applications of retrograde condensation

Unit V **10 Contact hours)**

Physical Equilibria Among the Phases: The Gamma/ Phi Formulations of VLE, VLE from Cubic Equations of State, Equilibrium and Stability, Liquid-Liquid Equilibrium (LLE), Vapour- Liquid- Liquid Equilibrium (VLLE), Solid- Liquid Equilibrium (SLE), Solid- Vapour Equilibrium (SVE), Equilibrium Adsorption of Gases on Solids and Osmotic Equilibrium and Osmotic Pressure.; Heat Effects& Chemical Reaction Equilibria: Sensible & latent heat effects of pure substances, Standard heat of reaction, formation, combustion, Temperature dependence of ΔH^0-Reaction stoichiometry, criteria of chemical equilibrium

Unit VI **(10 Contact hours)**

Equilibrium Constant, standard free energy change, standard state, feasibility of reaction, effect of temperature on equilibrium constant, presentation of free energy data, evaluation of K, factors effecting on equilibrium conversion. Effect of pressure and other parameters on conversion, phase-rule for reacting systems, Heat Effect Studies and Equilibrium Constant Calculations in Various Industries.

Learning Resources:

Text Books:

1. J.M.Smith, H.C Van Ness and M. M. Abbott, '*Introduction to Chemical Engineering Thermodynamics'*, Sixth Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2003

Reference Books:

1. Halder G, *'Introduction to Chemical Engineering Thermodynamics'*, 4th edition, Prentice Hall India, 2014.
2. J.Richard Elliott and Carl T. Lira, *'Introductory Chemical Engineering Thermodynamics'*, Second Edition, Prentice Hall, 2012
3. Thomas E Daubert, Chemical Engineering Thermodynamics, McGraw Hill International Editions, 1986
4. K. V. Narayanan, *'Text Book of Chemical Engineering Thermodynamics'*, PHI Learning Limited, 2004,
5. Y. V. C. Rao, '*Chemical Engineering Thermodynamics'*, University Press (India) Private Limited, 2004

Web resources:

1. https://nptel.ac.in/courses/103101004/
2. http://www.msubbu.in/lecture/thermodynamics.html

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

CO 1	Differentiate solution thermodynamics to gases
CO 2	Inspectthe property changes due to mixing and determine the fugacity & activity coefficients of a pure component, mixture & solution
CO 3	Identify the models to evaluate VLE
CO 4	Estimate bubble point, dew-point calculations using Raoult's law & modified Raoult's law.
CO 5	Compute heat effects associated with physical and chemical processes. Apply thermodynamic principles to calculations related to chemical reaction equilibrium
CO 6	Compare equilibrium constants for various pressure and temperature conditions.

Course code	Course name	Course Category	L-T-P	Credits
23CH3102	Chemical Technology	PCC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Understand the schematic representation of important unit operation/ unit processes involved in plant operations. Develop skills in preparing /presenting a neat Engineering drawing for Chemical Process Industries such as Chloro-alkali industries, glass.
2. Develop skills in preparing /presenting a neat Engineering drawing for Chemical Process Industries such as urea, fertilizer.
3. Impart clear description of one latest process along with its Chemistry, Process parameters, Engineering Problems and Optimum Conditions.
4. Demonstrate the importance of updating the latest technological developments in producing products economically and environment friendly.
5. Appreciate the usage of other engineering principles such as Thermodynamics, Heat, mass and momentum transfer in operation and maintain the productivity.
6. Understand the concepts of petroleum industry.

Course Content

UNIT –I **(8 Contact hours)**

Introduction: Chemical industries-facts and figures, Unit operation and unit process concepts, chemical processing and role of chemical engineers.

Chlor-Alkali Industries: Sodium Carbonate, Chlorine-Caustic soda production industries.

UNIT – II **(7 Contact hours)**

Nitrogen Industries: Nitrogen industries: synthetic ammonia, urea. Phosphorus Industries: Phosphorus, phosphorous pent oxide, phosphoric acid, SSP and TSP. Potassium Industries, Sulphur and Sulphuric acid production industries.

UNIT-III **(8 Contact hours)**

Cement manufacture, special cements.

Oils: Definition, constitution, extraction and expression of vegetable oils, refining and hydrogenation of oils.

UNIT-IV **(7 Contact hours)**

Synthetic fibers: Classification, manufacture of Nylon 66, polyester fiber and viscose rayonfiber.

Soaps and detergents: Definitions, continuous process for the production of fatty acids, glycerin and soap, production of detergents.

UNIT-V **(8 contact hours)**

Pulp and paper industry: methods of pulping, production of sulphate and sulphite pulp, production of paper – wet process

Sugar and Starch Industries: Sucrose, Extraction of sugar cane to produce crystalline white sugar, Extraction of sugar cane to produce sugar.

UNIT-VI **(7 contact hours)**

Petroleum Industry: Origin, occurrence and characteristics of crude oil, crude oil distillation. Petrochemical industries: Manufacturing processes of formaldehyde, acetaldehyde, acetic acid, acetic anhydride, nitrobenzene, ethylene oxide, and ethylene glycol. Polymerization industries: polyethylene, polypropylene, PVC and polyester synthetic fibers production industries.

Text books:

1. M.Gopal Rao and M.Sittig, Dryden's outlines of Chemical Technology, 3rd Edition, East-West Press, 1997.

2. Austin, Shreve's chemical process industries , 5th ed., M.C.Graw-Hill,1985

Reference Books:

1. Industrial Chemistry by B.K. Sharma,
2. Hand book of industrial chemistry Vol 1& II K.H.Davis& F.S. Berner Edited by S.C. Bhatia, CBS publishers
3. Chemical Technology: G.N. Panday, Vol 1&Vol II

Web resources:

1. https://nptel.ac.in/courses/103107082/
2. https://nptel.ac.in/courses/103103029/

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

CO1	Draw the plant process flow sheet.
CO2	Learn in maintaining all safety norms during their job
CO3	Solve Engineering problems to keep up the productivity
CO4	Propose alternative manufacturing process
CO5	List chemical reactions and their mechanism involved.
CO6	Identify the key in terms of economic viability of the product.

Course code	Course name	Course Category	L-T-P	Credits
23CH3104	Mass Transfer Operations-II	PCC	3-0-0	0

Course Learning Objectives:

The course content enables the students to:

1. To deduce adequate knowledge in principles of mass transfer and problem-solving techniques.
2. Explore concepts of mass transfer processes such as; distillation, liquid- liquid extraction, leaching, adsorption and crystallization and its applications
3. To recognize the effective usage of mass transfer equipments according to separationprocess.
4. To able to get an idea of industrial separation equipments.
5. To design the equipments needed for separation processes.
6. To design the equipment for crystallization operations.

Course Content:

UNIT – I **(8 Contact hours)**

Distillation-I: Principles of VLE for binary systems–phase diagrams, relative volatility, azeotropes, enthalpy concentration diagrams, flash vaporization, partial condensation, differential distillation, steam distillation, Batch distillation with reflux for binary mixtures.

UNIT – II **(8 Contact hours)**

Distillation-II : Continuous fractionation of binary mixtures, Ponchon – Savrit method and McCabe – Thiele method of determination of ideal plates for binary mixtures – Optimum reflux ratio – Use of total and partial condensers. Use of open steam. Types of Condensers and Reboilers. Packed bed distillation. Principals of azeotropic and extractive distillation, Introduction to Multicomponent distillation

.

UNIT – II **(7 Contact hours)**

Liquid – Liquid Extraction :Solubilities of ternary liquid systems. Triangular and solvent free coordinate systems. Choice of solvent. Extraction with insoluble and partially soluble systems – single stage, multistage cross current and multistage counter current extraction without reflux and with reflux. Continuous contact extraction (packed beds). Equipment's for liquid – liquid extraction operation.

UNIT – IV **(7 Contact hours)**

Leaching: Preparation of solid, unsteady state operation, in-place leaching, heap leaching, percolation leaching, Shanks system, agitated vessels, percolation in closed vessels, Percolation vs Agitation. Steady state continuous operation – equipment's - methods of calculation, stage efficiency and practical equilibrium. Single stage leaching, multistage cross current leaching, multistage counter current leaching

UNIT- V **(8 Contact hours)**

Adsorption: Principles of adsorption and their applications – Types of adsorption – Adsorbents – Adsorption equilibrium – Adsorption Isotherms for vapor and dilute solutions. Single stage and multistage adsorption – unsteady state adsorption, adsorption wave and breakthrough curve and fixed bed adsorption.

UNIT-VI **(7 Contact hours)**

Crystallization: Crystal Geometry, Equilibrium and yields, principles of crystallization, Crystallization equipment

Ion-Exchange: Principles of Ion-Exchange, techniques and applications, rate of Ion-Exchange

Introduction to membrane separation processes

Text books:

1. R.E. Treybal, *'Mass transfer operations'*, McGraw Hill,1981, 3rd Edition
2. B.K. Dutta, *'Principles of mass transfer and separation processes'*, PHI Learning Private Limited, Eastern Economy Edition

Reference Books:

1. Warren, L., McCabe, Julian C.Smith and Peter Harriot, *'Unit Operations of Chemical Engineering'*, McGraw Hill, 7th Edition
2. Christie John Geankoplis, *'Transport process and separation process principles'*, PHI of India, 4th edition
3. J D Seader and E J Henly, *'Separation Process Principles'*, John Wiley & sons, NY 1998.

Web resources:

1. https://nptel.ac.in/courses/103104046/

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

CO1	Build a basic knowledge of mass transfer operations and separation processes carried out in chemical industries.
CO2	Importance and applications of different mass transfer processes.
CO3	Identify technological methods in problem solving of mass transfer operations in industries.
CO4	Design of mass transfer equipments used in the chemical industries.
CO5	Utilize the technological methods in problem solving of mass transfer operations in industries and ability to Select appropriate separation technique for intended problem
CO6	Evaluate the selection criteria for mass transfer process and equipments required by the industries.

Course code	Course name	Course Category	L-T-P	Credits
23CH3181	Chemical Reaction Engineering Lab	PCC	0-0-3	1.5

Course Learning Objectives:

The objective of this Lab is to train the student how to operate the experimental setups and generate the required results from them using basics concepts learned in chemical reaction engineering-I & II courses.

List of Experiments

1. **RTD In tubular Reactor**
   i. To plot the Residence time distribution Curve for the given Plug Flow Reactor using a pulse tracer.
   ii. To determine the dispersion number in PFR
2. **RTD in CSTR**
   i. To plot the Residence time distribution Curve for the given Continuous stirred tank Reactor using a pulse tracer.
   ii. To determine the dispersion number in CSTR
3. **Isothermal Batch Reactor**
   i. To study the progress of a given chemical reaction and determine its rate constant using kinetic data obtained.
   ii. To study the effect of temperature on reaction rate constant.
4. **Isothermal CSTR**
   i. To study the progress of a given chemical reaction and determine its rate constant.
   ii. To study the effect of temperature on reaction rate constant.
5. **CSTRs in series**
   i. To study the progress of given chemical reaction and determine rate constant using all the tanks in series.
   ii. Plot residence time distribution curves for one tank, two tanks and three tanks using pulse tracer.
   iii. Determination of the influence of flow rate on a three tank system following a step change in input concentration.
   iv. Determination of the response to a step change in input concentration of a system comprising one stirred vessel and a "dead time" module
6. **Batch Reactor**
   i. To find the reaction rate constant in a stirred batch reactor using kinetic data measured using conductivity probe.
   ii. To demonstrate the temperature dependence of the reaction and the rate constant.
7. **Tubular Reactor**
   i. To determine the rate constant for a given reaction using tubular reactor.
   ii. To investigate the effect of throughput on conversion
   iii. To demonstrate the temperature dependence of the reaction and the rate constant.
8. **CSTR**
   i. To determine the rate constant for a given reaction using CSTR.
   ii. Determination of the RTD using tracer techniques.

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

CO1	Identify the application of theoretical concepts discussed in chemical reaction engineering course practically and checks their validity.
CO2	Determine chemical kinetics of homogenous reactions.
CO3	Estimate the effect of process conditions on reaction rate, product yield practically.
CO4	Predict the behaviour of a reactor and factors effecting the performance of a reactor using RTD analysis.

Course code	Course name	Course Category	L-T-P	Credits
23CH3201	Process Equipment Design	PCC	3-0-1	3.5

Course Objectives:

The course content enables the students to:

1. understand the development of flow diagrams and design of pipe
2. understand the pressure vessel design
3. understand the design of heads of pressure vessels
4. understand the design of double pipe and shell and tube heat exchangers
5. understand the design of evaporators and reboilers
6. understand the design of continuous distillation column

Unit I **(6 Contact hours)**

Introduction; development of flow diagrams from process description, Introduction to flow sheeting, P and I diagrams, material and energy balances, sizing of equipment, design preliminaries, design codes, MOC selection procedure;

Unit II
(6 Contact hours)

Pipe design: Pump selection, pressure drop in pipe lines, power requirements for pumping liquids, characteristic curves for centrifugal pumps, NPSH, mechanical design of piping system, wall thickness and pipe schedule, pipe support, pipe fittings, pipe size selection.

Unit III **(8 Contact hours)**

Design of Pressure Vessels and Vessel components: General design considerations of pressure vessels, design of thin-walled vessels for internal pressure and external pressure, design principles of tall columns. Types of flanges, design of loose type non-standard flanges, compensation requirements for openings and branches. Impellers stuffing box and design of shaft. Types and selection of equipment supports.

Unit IV **(8 Contact hours)**

Design of heat transfer equipment: Double pipe heat exchangers, Shell and tube exchanger's construction details, TEMA standards and general design considerations. Kern`s methods of Process design of exchangers for sensible heat transfer.

Unit V **(8 Contact hours)**

Design of shell & tube condensers (excluding multi – component condensers). & Design of 1-2 shell and Tube Exchangers in series.

Evaporators: types of chemical evaporators, boiling point elevation, types of feeding in multiple effect evaporators, design of multiple effect evaporators;
Reboiler: types, design of kettle reboiler.

Unit VI **(9 Contact hours)**

Continuous stage wise distillation column (Binary systems), design variables – Mc Cabethiele Method – Low product concentration – smoker equations – prediction of plate efficiency - column sizing. Distillation with side streams and multiple feeds. Choice of plate verses packed columns. Selection of column pressure. Plate contactors – selection of plate type – plate constructions - sieve plate hydraulics design. Design of sieve plates - Down Comer design.

Text Books:

1. R. K. Sinnot, Coulson and Richardson's *'Chemical Engineering Design'* Vol. 6, 4th Ed., Butterworth–Heinemann, 2005

Reference Books:

1. M. V. Joshi, V. V.Mahajani, *'Process Equipment Design'* 3rd Ed., Macmillan Publishers, 2009
2. B. C. Bhattacharya,*' Introduction to Chemical Equipment Design'*, CBS Publisher, 2003

Web resources:

1. http://www.msubbu.in/lecture/processequipment.html
2. https://nptel.ac.in/downloads/103103027/

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

CO1	Gain Knowledge of basics of process equipment design and important parameters of equipment design and pipe design
CO2	Construct pressure vessels
CO3	Create heads of pressure vessels
CO4	Design double and shell and tube heat exchangers
CO5	Make up evaporators and Reboiler
CO6	Design continuous distillation column

Course code	Course name	Course Category	L-T-P	Credits
23CH4121	Advanced Mathematical Techniques in Chemical Engineering	PEC	3-0-0	3

Course Learning Objectives:

The objective of this course is to

1. Introduce model formulation for various chemical processes and associated equations and to have knowledge on vector spaces
2. Have an adequate knowledge on matrices, operators and transformations to solve the associated equations in chemical engineering systems
3. Understand the methods of solution of partial differential modeling equations in chemical engineering systems
4. Have a knowledge on applications of Fourier series, Laplace and Fourier transforms to solve ODE's and PDE's in chemical Engineering
5. Introduce formulation of process models and necessary numerical techniques for solving the model equations arising in chemical engineering systems
6. Learn sensitivity and data analysis, and experimental design essential for modern engineers.

Course Content:

Unit I: [7 hours]

Models in chemical engineering: Linear equations and non- linear equations. Vector and vector spaces, metrics, norms and inner products, linear dependence and dimension, Gram-Schmidt ortho-normalization.

Unit II: [8 hours]

Matrices, operators and transformations: Eigen values and Eigen vectors, Fredholm alternative solvability conditions, Rayleigh's quotient. Application to chemical engineering systems, Geometric basis method, self adjoint and non-self adjoint systems.

Unit III: [7 hours]

Partial differential equations and their applications in chemical engineering, classification of second order partial differential equations, linearity and superposition, Strum - Louiville theory, and Eigen value problems.

Unit IV: **[7 hours]**
Separation of variables and Fourier transforms: Rectangular, cylindrical and spherical coordinate systems, Fourier series and Fourier transforms unbounded domains, Laplace transforms and their applications for solution of ODE and PDEs in chemical engineering.

Unit V: **[8 hours]**
Introduction to numerical methods: Linear algebraic equations, nonlinear algebraic equations, curve fitting and least square methods, function evaluation and regression techniques and applications for solving chemical engineering problems.

Unit VI: **[7 hours]**
Numerical methods for evaluating definite integrals, solving ordinary differential equations - initial and boundary value problems, solutions of partial differential equations and their applications to solve chemical engineering problems.

Learning Resources:

Text book:

7. S. Pushpavanam, *'Mathematical Methods in Chemical Engineering',* Printice-Hall of India, New Delhi, 2001.

Reference Books:

1. R. G. Rice & D. D. Do, Wiley, '*Applied Mathematics and Modeling for Chemical Engineers'*.
2. A. Varma& M. Morbidelli, '*Mathematical Method in Chemical Engineering'*, Oxford University Press.

Web resources:

1. https://nptel.ac.in/courses/103105106

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

CO1	Formulation of various chemical processes
CO2	Apply the concepts of vector spaces, matrices and their transformations to solve equations associated in Chemical Engineering systems
CO3	Identify different advanced methods to tackle the kinds of problems that appear in Chemical Engineering domain.
CO4	The student will enable to develop a deeper understanding and appreciation of the fundamental concepts behind the mathematics associated with a problem in Chemical Engineering
CO5	Solve the model equations arising in Chemical engineering systems using advanced numerical techniques
CO6	Analyze the behavior of complex systems in chemical engineering research

Course code	Course name	Course Category	L-T-P	Credits
23CH4255	Waste to Energy Conversion	OEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1.Learn the characterization of wastes

2.Learn the concepts of production of energy from different types of wastes through thermal, biological and chemical routes

3.Know the concepts the pyrolysis, gasification and syngas utilization

4.Learn how to improve the efficiency of power plant and energy production from waste.
5.Learn the concepts of anaerobic digestion and fermentation and microbial fuel cells.
6.Keep their knowledge upgraded with the current thoughts and newer technology options along with their advances in the field of the utilization of different types of wastes for energy production.

Course Content:

Unit I **(6 Contact hours)**

Introduction, characterization of wastes

Unit II **(6 Contact hours)**

Energy production form wastes through incineration, energy production through gasification of wastes.

Unit III **(8 Contact hours)**

Energy production through pyrolysis, gasification of wastes and syngas utilization.

Unit IV **(7 Contact hours)**

Densification of solids, efficiency improvement of power plant and energy production from waste plastics, and gas cleanup.

Unit V **(8 Contact hours)**

Energy production from organic wastes through anaerobic digestion and fermentation, and introduction to microbial fuel cells.

Unit VI **(10 Contact hours)**

Energy production from wastes through fermentation and trans esterification Cultivation of algal biomass from wastewater and energy production from algae.

Learning Resources:

Text Books:

1. Rogoff, M.J. and Screve, F., '*Waste-to-Energy: Technologies and Project, Implementation'*, Elsevier Store.
2. Young G.C., '*Municipal Solid Waste to Energy Conversion processes'*, JohnWiley and Sons.

Reference Books:

1. Harker, J.H. and Backhusrt, J.R., '*Fuel and Energy'*, Academic Press Inc.
2. EL-Halwagi, M.M., '*Biogas Technology- Transfer and Diffusion'*, Elsevier applied Science.
3. Hall, D.O. and Overeed, R.P., '*Biomass - Renewable Energy'*, John Willy and Sons.

Web resources:

1. http://nptel.ac.in/courses/103107125/#video

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

CO1	Analyzing the characterization of wastes
CO2	Learn the concepts of production of energy from different types of wastes through thermal, biological and chemical routes
CO3	Evaluate concepts the pyrolysis, gasification and syngas utilization
CO4	Methods to improve the efficiency of power plant and energy production from waste.
CO5	Get the concepts of anaerobic digestion and fermentation and microbial fuel cells.
CO6	Explore knowledge upgraded with the current thoughts and newer technology options along with their advances in the field of the utilization of different types of wastes for energy production.

Coursecode	Coursename	Coursecategory	L-T-P	Credits
20CS2101	Design & Analysis ofAlgorithms	PCC	3-1-0	4

CourseLearningObjectives:

Interpretthe fundamentalneedsofalgorithmsinproblemsolving
Classifythedifferentalgorithmdesigntechniquesforproblemsolving
Developalgorithms forvarious computingproblems
Analyzethetimeandspacecomplexity ofvariousalgorithms
CourseContent
UnitI (8ContactHours)
Algorithm, Pseudo code for expressing algorithms, Performance Analysis-Space complexity, Timecomplexity, Asymptotic Notation- Big oh notation, Omega notation, Theta notation and Little ohnotation,Probabilistic analysis,Amortizedanalysis.Analysis ofInsertionSort & Heap Sort.
UnitII (10ContactHours)
Divide and conquer: General Method,solving of recurrence relations– Substitution Method,RecursionTreeMethod,MastersMethod,applications-Binarysearch,Quicksort,Mergesort,Strassen'smatrix multiplication,

UnitIII (10 ContactHours)
Greedymethod:Generalmethod,applications-Jobsequencingwithdeadlines,0/1knapsackproblem,Minimumcostspanningtrees,DisjointSets-disjointsetoperations,unionandfindalgorithms, spanning trees, connected components and bi-connected components, Single sourceshortestpath problem.

UnitIV (10ContactHours)
DynamicProgramming:Generalmethod,applications-Matrixchainmultiplication,Optimalbinary search trees, 0/1 knapsack problem, All pairs shortest path problem, Travelling sales personproblem,Reliability design.

UnitV (12 ContactHours)
Backtracking:Generalmethod,applications-n-queenproblem,sumofsubsetsproblem,graphcoloring,Hamiltonian cycles.Branch and Bound: General method, applications - Travelling sales person problem, 0/1 knapsackproblem-LC BranchandBound solution, FIFOBranch and Bound solution.

UnitVI (10ContactHours)
StringMatching:Naivestringmatching,Tries,RabinKarpAlgorithm,KMPalgorithm,BoyermooreAlgorithm.
NP-HardandNP-Completeproblems:Basicconcepts,nondeterministicalgorithms,NP-HardandNPComplete classes, Reducibility.
Learning resources Text Books:
ThomasH.Cormen,CharlesE.Leiserson,RonaldL.Rivest,CliffordStein,"IntroductiontoAlgorithms".
ReferenceBooks:
SatrajSahniandRajasekharam,*"FundamentalsofComputerAlgorithms",* Galgotiapublicationspvt.Ltd.
ParagHimanshu Dave, HimanshuBhalchandraDave,*"Designand Analysisalgorithms",*Publisher:Pearson.
R.C.T.Lee,S.S.Tseng,R.C.ChangandT.Tsai,McGrawHill"*IntroductiontoDesignandAnalysisofAlgorithmsAstrategicapproach"*
AllenWeiss"*DatastructuresandAlgorithmAnalysisinC++",*Secondedition, Pearsoneducation.
Aho,UllmanandHopcroft"*DesignandAnalysis ofalgorithms*"Pearsoneducation.

WebResources

https://www.oreilly.com/library/view/design-and-analysis/9788177585957/2.https://www.tutorialspoint.com/design_and_analysis_of_algorithms3.https://www.amazon.in/Design-Analysis-Algorithms-V-Muniswamy/dp/9380026730

Courseoutcomes: Attheend ofthecourse, thestudent willbe able to

CO1	Synthesizeefficientalgorithmsincommonengineeringdesignsituations.
CO2	Major techniques for algorithm design and analysis are introduced through thestudyof various algorithms.
CO3	Applydesignprinciplesandconceptstoalgorithmdesign
CO4	Havethemathematicalfoundation inanalysisofalgorithms
CO5	Understanddifferentalgorithmicdesignstrategies
CO6	Analyzethe efficiencyof algorithmsusingtimeandspacecomplexitytheory

Coursecode	**Coursename**	**CourseCategory**	**L-T-P**	**Credits**
20CS2202	**DataSciencewith Python**	**PCC**	**3-0-0**	**3**

Unit–I :Python BasicsforData Science
IntroductiontoPython,Types,Expressions&Variables,StringOperations,Lists&Tuples,Sets,Dictionaries,Conditions & Branching, Loops,Functions, Objects & Classes
Unit–II:WorkingwithDatainPython
FileOperations,RegularExpressions,Pandas,NumPys,WebScraping
Unit–III:DataProcessing
ImportingDataSets;Cleaning&PreparingData–HandlingMissingValues,DataFormatting,Binning;SummarizingtheDataFrame–DescriptiveStatistics,Grouping,ANOVA,Correlation
Unit– IV: DataAnalysis
Model Development : Simple & Multiple Linear Regression, Model Evaluation using Visualization,PolynomialRegression;ModelEvaluation–Overfitting,Underfitting,ModelSelection,RidgeRegression,Model Refinement
Unit–V:DataVisualization
IntroductiontoVisualizationTools–Matplotlib,LinePlots,AreaPlots,Histograms,BarCharts,PieCharts, Box Plots, Scatter Plots, Bubble Plots; Advance Visualization Tools – Waffle Charts, WordClouds, Seaborn and Regression Plots; Creating Maps & Visualizing Geospatial Data – Folium,Mapswith Markers, Choropleth Maps
Unit–VI:MachineLearningusing Python
IntroductiontoMachineLearning–SupervisedvsUnsupervisedLearning,PythonLibrariesforMachine Learning; Regression; Classification; Unsupervised Learning; Recommender Systems**Learningresources:**
TextBook:
JakeVanderPlas, PythonDataScienceHandbook-EssentialToolsforWorkingwithData,o'reillypublications.
OnlineCourseReference:
https://www.edx.org/professional-certificate/python-data-science

Coursecode	Coursename	CourseC ategory	L-T-P	Credits
20CS2282	**DataScienceusing PythonLab**		**0-0-3**	**1.5**

Lab:

Experiment1:

a) **PythonBasics:**Yourfirstprogram,TypesExpressionsandVariablesStringOperations

b) **PythonDataStructures:**ListsandTuplesSets,andDictionaries

c) **PythonProgrammingFundamentals:**ConditionsandBranchingLoops,Functions,ObjectsandClasses

d) **WorkingwithDatainPython:**Readingfileswithopen,Writingfileswithopen, LoadingdatawithPandas,WorkingwithandSavingdatawithPandas

e) **WorkingwithNumpyArrays:**Numpy 1dArrays,Numpy 2dArrays

Experimen2:

a) **atasets:**Learning Objectives, Understanding the Domain,Understandingthe Dataset, Python package for data science, Importing and Exporting Data in Python, BasicInsightsfrom Datasets

b) **CleaningandPreparingtheData:**IdentifyandHandleMissingValues,DataFor matting,Data Normalization Sets, Binning, Indicatorvariables

c) **ModelDevelopment:**SimpleandMultipleLinearRegression,ModelEvaluatio nUsingVisualization,PolynomialRegressionandPipelines,R-squaredandMSEforIn-SampleEvaluation,PredictionandDecisionMaking

d) **SummarizingtheDataFrame:**DescriptiveStatistics,BasicofGrouping,ANOVA, Correlation,MoreonCorrelation

e) **Model Evaluation:** Model Evaluation, Over-fitting, Under-fitting and Model Selection,RidgeRegression, Grid Search, Model Refinement

Experiment3:

a) **Introduction to Visualization Tools:** Introduction to Data Visualization,Introduction toMatplotlib,BasicPlotting withMatplotlib,Dataset onImmigrationto Canada,LinePlots

b) **BasicVisualizationTools:**AreaPlots,Histograms,BarCharts

c) **SpecializedVisualizationTools:**PieCharts,BoxPlots,ScatterPlots,BubblePlots

d) **Advanced Visualization Tools:** Waffle Charts, Word Clouds,Seaborn and RegressionPlots

Expeiment4:

a) **IntroductiontoMachineLearning:**ApplicationsofMachineLearning,Supervis edvsUnsupervisedLearning,Python libraries suitableforMachineLearning

b) **Regression:**LinearRegression,Non-linearRegression,Modelevaluationmethods

c) **Classification:**K-NearestNeighbour,DecisionTrees,LogisticRegression,SupportVectorMachines,ModelEv aluation

d) **UnsupervisedLearning:**K-MeansClustering,HierarchicalClusterin,Density-BasedClustering

CourseCode	CourseName	CourseType	L-T-P	Credits
20CS3103	**SoftwareEngineering**	**PCC**	**3-0-0**	**3**

CourseLearningObjectives:

1. Torecognizethe emergenceandimportanceofSoftwareengineering
2. ToidentifythedifferentphasesinSoftwareDevelopmentLifeCycle
3. TopreparetheSRS(SoftwareRequirementSpecifications)Documentforsuitableproduct
4. Todiscuss thecharacteristics of goodsoftwaredesign
5. Todraw theUML Pattern designsforsuitabledesign
6. Tovalidatetheproductusingvarioustestingmethodsforproducingqualitysoftwareproduct.

CourseContent:

Unit-I (7 ContactHours)

Introduction: IntroductiontoSoftwareEngineering,Exploratorystyle Vs.Modernstyleofdevelopment;Software Development LifeCycle; ProcessModels.

Unit-II (8ContactHours)

SoftwareProjectmanagement:projectPlanning,estimation,**Softwarerequirementsandspecification**:gathering,analysis, specification,characteristics, organization.

Unit–III(9ContactHours)

Softwaredesign:overview,characteristicsofgooddesign,function-orientedsoftwaredesign,objectoriented design, UML, design patterns.

Unit–IV(7ContactHours)

Coding: Implementation,CodingStandard and Guidelines, review, UnitTesting;Verification andvalidation.

Unit– V(7 ContactHours)

Testing: Integrationandsystemstesting,Blackbox&WhiteBoxTesting,debuggingtechniques.

Unit–VI(7ContactHours)

SoftwareReliabilityAndQualityManagement: Softwarequality,SEICMMandISO-9001,Reliability,Safety, RiskAnalysis, computer-aidedsoftware engineering (CASE).

LearningResources:

TextBook:

8. 1.RajibMall,*'FundamentalsofSoftwareEngineering'*,PHI; Fourthedition (2014)
9. 2.Pressman,R.S.,*'SoftwareEngineering:APractitioner'sApproach'*,McGrawHill,seventhedition, 2010.
10. PankajJalote.*'AnIntegratedApproachtoSoftwareEngineering'*,2ndedition,Narosa Publishing House

ReferenceBooks:

4. Pressman,R.S.,*'SoftwareEngineering:APractitioner'sApproach'*,McGrawHill,seventhedition, 2010.
5. PankajJalote.*'AnIntegratedApproachtoSoftwareEngineering'*,2ndedition,Narosa Publishing House
6. BennettS.,McRobbS.&FarmerR.,*'ObjectOrientedSystemsAnalysisandDesignusingUML'*,Tata McGraw-Hill, second edition, 2004.
7. SummervilleIan,*'SoftwareEngineering'*,Addison-Wesley,fifthedition,2000
8. K.K.Agarwal,*'SoftwareEngineering'*

VideoResources :

7.Primary Producer: NPTEL: *Prof. Sarda*, IIT Bombay, Publication Date: October 8, 2008,*'Introduction to Software Engineering'*

coursecode	Coursename	CourseCategory	L-T-P	Credits
20CS3201	CryptographyandNetworkSecurity	PCC	3-1-0	4

https://onlinecourses.nptel.ac.in/noc18_cs43

CourseOutcomes: At theend ofthe coursethe studentswill beable to

CO1	Describethesoftwareengineeringlifecyclebydemonstratingcompetence incommunication, planning,analysis,design,construction,and deployment
CO2	Anabilityto workin oneormoresignificantapplicationdomain
CO3	To develop and deliver quality software by working as an individual and as partofamultidisciplinaryteam

CourseLearningObjectives:

1. Tounderstandbasics of Cryptographyand NetworkSecurity.
2. Tobeable tosecure amessageover insecurechannelby various means.
3. Tolearnabouthow tomaintaintheConfidentiality,IntegrityandAvailability ofadata.
4. Tounderstandvariousprotocolsfornetworksecuritytoprotectagainstthethreatsinthe networks.

CourseContent:

Unit1: **(10Contacthours)**

Introductiontosecurityattacks,servicesandmechanism,introductiontocryptography-ConventionalEncryption:Conventionalencryptionmodel,classicalencryptiontechniques-substitution ciphers and transposition ciphers, cryptanalysis, stream and block ciphers ,ModernBlockCiphers:Blockciphersprincipals,Shannon'stheoryofconfusionanddiffusion, fiestalstructure, data encryption standard(DES), strength of DES, differential and linear crypt analysis ofDES,block ciphermodesof operations, tripleDES, AES.

UnitII:(8Contacthours)

Confidentialityusingconventionalencryption,trafficconfidentiality,keydistribution,randomnumbergeneration,Introductiontograph,ringandfield,primeandrelativeprimenumbers,modular arithmetic, Fermat's and Euler's theorem, primality testing, Euclid's Algorithm, ChineseRemainder theorem, discrete algorithms.

UnitIII:(7Contacthours)

Principles of public key crypto systems, RSA algorithm, security of RSA, key management, Diffle-Hellmankeyexchangealgorithm,introductoryideaofEllipticcurvecryptography,Elgamelencryption,MessageAuthenticationandHashFunction:Authenticationrequirements,authentication functions, message authentication code, hash functions, birthday attacks, security ofhashfunctions and MACS.

UnitIV:(7Contacthours)

MD5messagedigestalgorithm,Securehashalgorithm(SHA),DigitalSignatures:DigitalSignatures - authentication protocols - digital signature standards (DSS) - proof of digital signaturealgorithm,AuthenticationApplications:KerberosandX.509,directoryauthenticationservice,electronicmail security,pretty good privacy (PGP),S/MIME.

UnitV:(7Contacthours)

IPSecurity:Architecture,Authenticationheader,Encapsulatingsecuritypayloads,combiningsecurityassociations, keymanagement.

UnitVI:(7Contacthours)

WebSecurity:Securesocketlayerandtransportlayersecurity,secureelectronictransaction(SET),SystemSecurity: Intruders-Virusesandrelated threats,IDS.

1. WilliamStallings,"CrpyptographyandNetworksecurityPrinciplesand Practices",Pearson/PHI.
2. Wade Trappe, Lawrence C Washington, " Introduction to Cryptography with codingtheory",Pearson.

ReferenceBooks:

6. W.Mao,"ModernCryptography –TheoryandPractice",PearsonEducation.
7. Charles P. Pfleeger, Shari Lawrence Pfleeger – Security in computing –PrenticeHall ofIndia.

Webresources:

1. http://nptel.ac.in/courses/106105031/**lecture by**Dr.DebdeepMukhopadhyay**IITKharagpur**

2. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-033-computer-system-engineering-spring-2009/video-lectures/**lecture by Prof. Robert Morris andProf.Samuel MaddenMIT.**

CourseOutcomes:At theend ofthecourse,thestudentwill beableto

CO1	Implementsecurity ofthedata overthenetwork.
CO2	Exploreemergingareasofcryptographyandnetworksecurity.
CO3	Implementvariousnetworkingprotocols.
CO4	Demonstratehowtoprotectanynetwork fromthethreatsintheworld.

Course code	Coursename	Course Category	L-T-P	Credits
20CS3202	ArtificialIntelligence	PEC	3-1-0	4

CourseLearningObjectives:

1. DefinitionsofArtificialIntelligence,Different Perspectives, Historicalbackground
2. Tounderstandthoseelementsconstitutingproblemsandlearntosolveitbyva rioussearchingtechniques
3. Tounderstandthoseformalmethodsforrepresentingtheknowledgeandtheproc essofinferenceto derivenew representations of theknowledgeto deducewhattodo
4. To understand the notion of planning in AI and some techniques in the classical planningsystem
5. Tounderstandthenotionofuncertaintyandsomeofprobabilisticreasoning methodstodeduceinferences underuncertainty
6. To understand some of those mechanisms by which an AI system can improve it's behaviorthroughits experience

UNITI:

IntroductiontoAIProblems:AItechnique,Criteriaforsuccess.Problems;ProblemSpac eandSearch: Defining the problem as a state space search, Production as a systems, Problemcharacteristics,Productionsystemcharacteristics (6Hours)

UnitII: (6Hours)

HeuristicSearchTechniques:GenerateandTest,Hillclimbing,Bestfirstsearch,Problemreduc tion,Constraintsatisfaction, Means ends analysis.

UNITIII *(12 Hours)*

KnowledgeRepresentation:Representationandmappings,Approachestoknowledgerepresentation; Issues in knowledge representation. Using Predicate Logic: Representing simplefacts in logic, Representing instance and IS-A relationships, Computable functions and predicates,Resolution,Natural deduction, Forward vs. Backwardreasoning.

UNITIV: (6Hours)

DifferentKnowledgeRepresentationSchemes:Semanticnets,Frames,Conceptualdependency,Scripts

UNITV: (9Hours)

Natural Language Processing: Overview of linguistics, Grammars and languages, Basic parsingtechniques, Transitional networks, Semantic analysis and representation structures, Briefintroductionon discourse and pragmatic processing;

UNITVI: *(6 Hours)*

Expert System Architecture: Characteristic features of expert systems, History, Applications, Rulebased system architecture. General Concepts in Knowledge Acquisition: Types of learning, Generallearningmodel, Performancemeasures.

TextBooks:

- ElaineRich,KevinKnight,"ArtificialIntelligence",3rdEdition,TataMcGraw-Hill,2009.
- DanW.Patterson,"IntroductiontoArtificialIntelligence &Expert Systems",PHI,1990.

References:

1.StuartRusselandPeterNorvid,“ArtificialIntelligence:AModernApproach”,PearsonEducation,3rd Edition

WebReferences

1. BerkleyUniversity, “ArtificialIntelligence”,https://courses.edx.org/courses/BerkeleyX/CS188.1x-4/1T2015/course/
2. MIT,“ArtificialIntelligence”,FALL2010https://www.youtube.com/playlist?list=PLUl4u3cNGP63gFHB6xb-kVBiQHYe_4hSi
3. “IntroductiontoArtificialIntelligence”,https://classroom.udacity.com/courses/cs271

CourseOutcomes: Attheendofthis course,the studentshould beable to

CO1	Identifyproblemsthat areamendabletosolution byAImethods
CO2	IdentifyappropriateAImethodsto solveagivenproblem
CO3	Formaliseagivenprobleminthelanguage/frameworkofdifferentAImethods
CO4	ImplementbasicAIalgorithms
CO5	Design and carry out an empirical evaluation of different algorithms on aproblemformalization,andstatetheconclusionsthattheevaluationsupports.

Coursecode	Coursename	CourseCategory	L-T-P	Credits
20CS3203	Career DevelopmentCourse	MC	2: 0:0	0

CourseLearningObjectives:

1. Toenablethestudentsfortheircompetitiveexams
2. Toenhancetheircapabilityinaptitudeandreasoning&programming.
3. Todeveloptheirreasoningskill.
4. Topreparethemforalltypeofcompetitiveexams

CourseContents:

UnitI: **(1.5 hours)**

Numbersystem: BaseSystem,Exponents,Factorials,LCM&HCF,PropertiesofNumbers,Remainders,SuccessiveDivisions

Sequence&Series: ArithmeticProgression,HarmonicProgression,GeometricProgressionProgrammingin C

UnitII: *(8hours)*

Arithmetic: Averages,Clocks & Calendars,Simple Interest & Compoud Interest,Mixture &Alligations,Percentages,Profit, Loss & Discounts,Ratio & Proportion,Speed, Time & Distance,Time&Work

ProgramminginJAVA

Algebra: BinomialTheorem,ComplexNumbers,Functions,HigherDegreeEquations,Inequalities, Linear Equations, Logarithm,QuadraticEquations

ProgramminginPhython

UnitIII: *(6 hours)*

Geometry: Mensuration,Lines & Angles,Circles,Polygons,Triangles,Co-ordinate Geometry,Trigonometry

Probability & Statistics: Mean, Median & Mode,Permutation & Combination,Probability SetTheory&VennDiagram
Programmingin C++

UnitIV: *(7 hours)*

Logical Reasoning: Logical Sequence,Premise, Assumption & Conclusion,Binary Logic,BloodRelations,Linear & Matrix Arrangement,Seating Arrangement,Coding & Decoding,Statements&AssumptionsPuzzles
AnalyticalReasoning:CourseofActionFact,Inference&Judgement,LogicalDeduction,Statement&Assumption,Strong&WeakArguments,Syllogism

UnitV: *(4.5 hours)*

DataInterpretation: Charts(Column,Pie&Bar),TablesGraphs(Line&Area),VennDiagram,DataSufficiency. ReadingComprehension

UnitVI: *(3 hours)*

VerbalAbility: ClozeTestErrorSpotting,Fillintheblanks,SentenceCorrection,WordUsage,Parajumbles, ParagraphCompletion, ParagraphSummary

Learning resourcesTextbook:

1. SarveshKVerma,*'QuantitativeAptitudeQuantumCAT'*,arihantpublications
2. ArunSharma,MeenakshiUpadhyay,*'VerbalAbilityandReadingComprehension'*,McGraw Hill publications
3. ArunSharma,*'DataInterpretation'*,McGrawHillpublications
4. ArunSharma,*'LogicalReasoning'*,McGrawHill publications

Referencebooks:

1. NishitKSinha,'LogicalReasoningandData Interpretation',Pearsonpublications
2. ArunSharma,*'QuantitativeAptitude'*, McGrawHillpublications

Webresources:

1. https://unacademy.com/

Courseoutcomes: Attheend ofthecourse, thestudent willbe able to

CO1	Improveaptitude,problemsolvingskillsandreasoningabilities
CO2	ImproveVerbalabilityskills,Datainterpretationskills
CO3	UnderstandthebasictechniquesrequiredforsolvingReadingComprehension
CO4	Familiarizewiththewrittentestsofcompetitiveexams,campusplacementsandPSUs
CO5	Collectivelysolveproblemsinteamsandgroup
CO6	Adoptandacquirenewtechniques insolving problem

AssessmentMethod

Assessment Tool	Weeklytests	Monthlytests	EndSemesterTest	Total
Weightage(%)	Nil	Nil	100	100

Course Code	CourseName	CourseCategory	L-T-P	Credits

20CS4101	**MACHINELEARNING**	PEC	**3-1-0**	**4**

Objectives:

- Tounderstandthebasictheoryunderlyingmachinelearning.
- Tobeabletoformulatemachinelearningproblemscorrespondingtodifferentapplications.
- Tounderstandarangeofmachinelearningalgorithmsalongwiththeirstrengthsandw
- eaknesses.Tobeabletoapplymachinelearningalgorithmstosolveproblemsofmode ratecomplexity.

CourseOutcomes:

- Abilitytounderstandwhatislearningandwhyitisessentialtothedesignofintelligent machines.
- Abilitytodesignandimplementvariousmachinelearningalgorithmsinawiderangeofreal-worldapplications.

UNITI:INTRODUCTION

Learning Problems–PerspectivesandIssues- A briefintroduction to MachineLearnin`g, SupervisedLearning,UnsupervisedLearning,ReinforcementLearning–ConceptLearning–VersionSpacesandCandidateEliminations–Inductivebias–DecisionTree learning

UNITII:NEURALNETWORKSAND GENETICALGORITHMS

Neural Network Representation – Problems – Perceptrons – Multilayer Networks and Back PropagationAlgorithms – Advanced Topics – Genetic Algorithms – Hypothesis Space Search – Genetic Programming –Modelsof Evalutionand Learning.

UNITIII:BAYESIANLEARNING

Bayes Theorem – Concept Learning – Maximum Likelihood – Minimum Description Length Principle –Bayes Optimal Classifier – Gibbs Algorithm – Naïve Bayes Classifier – Bayesian Belief Network – EMAlgorithm – Probability Learning – Sample Complexity – Finite and Infinite Hypothesis Spaces – MistakeBound Model.

UNITIV :COMPUTATIONALLEARNING

Probability Learning – Sample Complexity – Finite and Infinite Hypothesis Spaces – Mistake Bound Model.Learning Sets of Rules – Sequential Covering Algorithm – Learning Rule Set – First Order Rules – Sets ofFirst OrderRules.

UNITV: INSTANCE BASEDLEARNING

K- Nearest Neighbour Learning – Locally weighted Regression – Radial Bases Functions – Case BasedLearning.

UNITVI:ADVANCEDLEARNING

SVM – Formulation, SVM – Interpretation & Analysis, SVMs for Linearly Non-Separable Data, SVMKernels.Reinforcement Learning –Task–Q-Learning–Temporal DifferenceLearning

TEXTBOOKS:

1. MachineLearning–TomM.Mitchell,-MGH
2. Machine Learning: An Algorithmic Perspective, Stephen Marsland, Taylor & FrancisREFERENCEBOOKS

1. GarethJames,DanielaWitten,TrevorHastie,RobertTibshirani,TrevorHastie,"*AnIntroductiontoStatistical Learning:withApplications inR",*Springer,First Edition.
2. KevinMurphy,"*Machinelearning:aprobabilisticperspective"*,MITPress,FirstEdition.
3. ChristopherBishop,"*patternrecognitionandmachinelearning",*Springer,FirstEdition.

CO4	Demonstrate an understanding of and apply current theories, models, andtechniquesthat provideabasis forthe softwarelifecycle
CO5	Deliverqualitysoftwareproductsbypossessingtheleadershipskillsasanindividual or contributing to the team development and demonstrating effectiveandmodern working strategies by applying both communication and negotiation managementskill.
CO6	Applynewsoftwaremodels,techniquesandtechnologiestobringoutinnovativeandnovelisticsolutionsforthegrowthofthesocietyinallaspects andevolvingintotheircontinuousprofessionaldevelopment.

ForTheorycoursesonly:

CourseNature		**Theory**		
AssessmentMethod				
AssessmentTool	Weeklytests	Monthlytests	EndSemesterTest	Total
Weightage(%)	10%	30%	60%	100%

EC2101	**AnalogElectronicCircuits**	**PCC**	**3L: 1T: 0P**	**4credits**

CourseLearning Objective

TomakethestudentsunderstandtheconceptofamplifierdesignsusingBJTsandMOSFETs and comparison between similardesigns

Coursecontent

Unit-I **(10hours)**

MOSFETBiasingandItsSmallSignalAnalysis

RegionsofoperationofMOSFET,Biasing,LargesignalandSmallsignalmodels,Channel length modulation, Design of MOSFET amplifier in Common Source, CommonGate and Common Drain configurations. Calculating small signal resistances of differentMOSFETcircuits.

Unit-II **(12hours)**

Multi-StageAmplifiers&DifferentialAmplifiersofMOSFET

Cascade Amplifiers, Millers theorem,and Cascode amplifiers,Frequency Analysis ofMultiStageAmplifiers, Calculation oflower&highercutofffrequencies.

Operationof DifferentialAmplifier, Transfercharacteristicsof Differentialamplifier,Biasing of Differential amplifiers, MOSFET differential amplifiers using resistive loads,Calculations of Differential gain, Common mode gain and CMRR. Step response of aDifferentialamplifier.

Unit-III **(8hours)**

CurrentmirrorsinMOSFETs

Design of various configurations MOSFET (CS,CG,CD) amplifiers using current mirrors.Design of a differential amplifier withMOSFET using active load using current mirrors.Designof Single stageand two stageopamp.

Unit-IV

CMOScircuits **(12hours)**

NMOS and PMOS inverter, NMOS inverter using active load; CMOS inverter, Pull upnetworkandPulldownnetwork(PUNandPDN),logicgatesusingCMOS,staticpower and dynamic power, noise margin. Pass Transistor Logic, Transmission gates. Bistabilityprinciple, Latches,Flip flops.

Unit-V (8hours)

BJT-ConfigurationsandMultistageamplifiers

BJT -small signal analysis, Comparison between Large signal models and small signalmodels. and amplification and small signal resistances in different configurations (CE,CBandCC) and multi stageamplifiers.

Unit-VI (10hours)

BJT-DifferentialamplifiersandCurrentmirrors

Design of various configurations BJT (CE,CB and CC) amplifiers using current mirrors.Design of a differential amplifier withBJT using active load usingcurrent mirrors.Designof Single stageand two stageopamp.

Learning ResourcesTextbooks

1. BehzadRazavi,'*FundamentalsofMicroelectronics',*WileyPublications
2. SedraandSmith,*'MicroelectronicsCircuits',*OxfordPublications,6thEdition.

ReferenceBooks

1. Boylestad R. L. and L. Nashelsky, *'Electronic Devices and Circuit Theory'*, 10/e or11/e,Pearson, 2009.
2. MillmanJ. andC.Halkias,*'IntegratedElectronics'*, 2/e,TMH, 2010.
3. NeamenD.,*'ElectronicCircuitAnalysis andDesign'*, 3/e,TMH, 2006
4. SpencerR.R.andM.S.Ghausi,*'IntroductiontoElectronicCircuitDesign'*,Pearson, 2003

WebResources

1. Prof.K.RadhakrishnaRao,NPTEL-IITMadras,*'ElectronicsforAnalogsignalprocessing-I'*,URL:http://nptel.ac.in/courses/117106087/

Courseoutcomes: Attheend ofthecourse, thestudent willbe able to

CO1	Understandthesmall-signalanalysisandlarge-signalmodelforBJT circuits
CO2	DesignofBJTandMOSFETamplifiersindifferentconfigurations
CO3	Design andanalyzeofmulti-stage amplifiers
CO4	Design andanalyzedifferentialamplifierswithactiveandpassiveloads

CO5	Design andanalyzefeedbackamplifiersindifferentconfigurations
CO6	Usetheseengineeringabstractionstoanalyzeanddesignsimpleelectronic circuitsusingEDAtools

AssessmentMethod

Assessment Tool	Weeklytests (Insemester)	Monthlytests (Insemester)	EndSemesterTest	Total
Weightage(%)	10%	30%	60%	100%

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EC2102	**DigitalLogicDesign**	**PCC**	**3L: 1T: 0P**	**4credits**

CourseLearning Objective

1. TodiscusstheconceptsofNumbersystemsandrepresentationsusedinthecomputer s,combinational design, sequential designs and complete system designatgate-level abstraction
2. Todiscusstheimportantfeaturesof ICdesignlike area,poweranddelay.
3. Todesignasimpledigitalsystemat gate-levelas perthedesignspecifications.

CourseContent

Unit-I **(6hours)**

Numbersystems-Representations-Conversions,Booleanconstantsandvariables,basicgates: operation and truth tables, describing logic gates algebraically, evaluating logiccircuit outputs, implementing circuits from Boolean expressions, universality of gates,Boolean theorems, Demorgan‘s theorems, alternate logic gate representations, IEEE/ANSIstandardlogic symbols.

Unit-II (12hours)

Combinational circuit minimization using Boolean laws and Karnaugh maps, multi-levelsynthesis, timing hazards,logic levelsand noise margins,Fan-out, Fan-in.Single bitadders and subtractors, multi-bit adders, BCD adder, multi-bit subtraction using adders,signed multiplier, unsigned multiplier, code converters, parity bitgenerators/checkers,magnitude comparator. Delay, Area and Power analysis in combinational circuit designs.Conversionofreal-timestatementsintoBooleanexpressionsanddesignofgate-levellogiccircuits.

Unit-III (10hours)

Bistable elements, Latches and Flip-flops : S-R latch , S‘ – R‘ Latch, S-R latch withenable, D latch, Race-around condition and elimination methods. Edge triggered

D flipflop, Edge triggered D flip flop with asynchronous inputs, master-slave flip-flop, edgetriggeredJ-Kflip-flopwithasynchronousinputs,Tflip-flops.Excitationtables,Characteristicequations.

Flip-floptiming consideration:set-uptime,hold-timediscussionusingpositiveedge-triggeredD-Flip flop.

Unit-IV **(14hours)**

Frequency division and counting. Design and analysis of asynchronous counters, Delayconsiderationsandlimitationsonmaximumclockfrequency,Designandanalysisofs ynchronouscounters.BCDcounter,Ringcounter,Johnsoncounters.Statediagramovervie w (Present States, Next states, Present outputs, Present inputs).Serial / Paralleldatatransferregisters: PIPOregister,SISO register,PISOregister,SIPOregister.

Unit-V **(10hours)**

Decoders: Binary decoder, synthesis of logic functions using decoders, cascading binarydecoders,seven-segmentdecoders,applications.
Multiplexers:synthesisof logic functionsusingmultiplexersapplications.
Demultiplexers:Realization,1-4and1-8linedemultiplexers,demultiplexertree.Encoders:Priorityencoders.Implementationoffunctionsusingprogrammablelogicdevices:PAL, PLA, PROM.

Unit-VI **(8hours)**

Memory – Structure and Timing: Static RAM, Dynamic Ram. Architecture: CPLD, FPGADesignandanalysisofDigitalcircuits:DigitalClock,Digitalcalendar,Trafficlightcontroller,Mobile number sequencegeneratorsand otherrelevant topics

Learning ResourcesTextbooks

1. RonaldJTocci,NealS.Widmer,GregoryL.Moss,*'Digitalsystems'*Pearson10th edition.
2. JohnF.Wakerly, *'DigitalDesign'*,Pearson4th edition

Referencebooks

1.StephenBrown,ZvonkoVranesic,*'FundamentalsofDigitalLogicwithVerilogDesign'*,TMH, 2ndedition.

WebResources

1. Prof.Shankar Balachandran,NPTEL-IIT Madras,*'DigitalCircuits&Systems'* URL:https://nptel.ac.in/courses/117106114/
2. Prof.SSrinivasan,NPTEL-IITMadras,*'DigitalCircuitsandSystems'* URL:https://nptel.ac.in/courses/117106086/

CourseOutcomes: At theend ofthe course, thestudent willbe ableto

CO1	Applytheknowledgeof simplificationinobtainingoptimaldigitalcircuits
CO2	StudyandexaminetheSSI,MSI,LSIandProgrammableelements
CO3	Analysetheoperationof synchronousandasynchronousstatemachines
CO4	Designanycombinationalorsequentialdigitalcircuitstomeetthegiven specifications
CO5	Analyze anydigitalcircuitand todebugsuch circuit
CO6	Prototypea realtimeapplicationonEDAtool

AssessmentMethod

AssessmentTool	Weeklytests/Assignments (inasemester)	Monthly tests(inasemester)	EndSemesterTest	Total
Weightage(%)	10%	30%	60%	100%

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20EC2181	AnalogElectronicCircuitsLaboratory	PCC	0L: 0T:3P	1.5credits

CourseLearningObjective

To make understand the concept of single stage and multistage amplifier designusingBJTsandMOSFETs

ListofExperiments

1. CharacterizationofMOSFET.
2. DesignandAnalysisofSinglestageamplifierusingMOSFETs
   i. Common Source configuration.ii.Common Gate configuration.iii.Common drainconfiguration.
3. DesignandAnalysisofMultiStageAmplifierusingMOSFETs
   i. Cascade Amplifier.ii.Ca scodeAmplifie r.
4. DesignofamplifiersusingCurrentmirrors.
5. DesignandanalysisofSinglestageamplifierusingBJTs
   i. Common Emitter Configuration.ii.Common Collector Configuration.iii.CommonBa seConfiguration.
6. Differential amplifiers with passive load (Designing a

specified valueof CMRR).

7. Stepresponseofadifferentialamplifieranddesigningforarisetime.
8. Singletunedamplifierdesign.
9. DesignofClass-Bpoweramplifier.
10. Design,buildandtestPublicaddressingsystem.
11. TermProject.

Note: It is mandatory to perform experiment on any one of the EDA Tools (LT spice tool)beforetheexperimentisdoneonhardware.Allexperimentsmustbeunique,designspecificationsshouldnotbe commonin the lab

Courseoutcome

AfterthecompletionofthisLaboratorycourse,thestudentwillbeableto

CO1	DeterminethecharacteristicsBJTamplifiersinCE,CB,CCconfigurations
CO2	Determinethecharacteristicsof MOSFETamplifiersinCS,CG,CD configurations
CO3	DeterminethecharacteristicsofCascadeandCascodeamplfiers
CO4	Designingfeedbackamplifierswithdifferentconfigurations
CO5	Designofdifferentialamplifierswithactiveandpassiveloads
CO6	Designandtestingofpublicaddressingsystem
CO7	Designofasimpleelectroniccircuitwhichusesmultistageamplifiers

AssessmentMethod

AssessmentTool	Experiments	Report/Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage(%)	25%	15%	40%
EndSemesterExamination weightage(%)			60%

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20EC2183	DigitalSignalProcessing Laboratory	PCC	0L: 0T: 3P	1.5credits

CourseLearningObjective

1. To perform experimental analysis on mathematical tools of Digital Signal ProcessingusingMATLAB andalsoon Digital SignalProcessors
2. ToassociateDigitalSignalProcessingtorealtimeapplications

Listof Experiments

PartA:ExperimentsusingMATLAB

1. GenerationofvariousContinuous-timeanddiscrete-timesignals, Study of various basic operations on discrete time signals (both dependent &independentvariables)
2. DTFTandDFT,DFTSpectralAnalysis
3. Sampling,Convolution,LTIsystems,andDifferenceEquations
4. DifferenceEquations,z-Transforms,Pole-ZeroDiagrams,BIBOStabilityand
5. QuantizationEffects
6. FIRFilterDesign
7. IIRFilterDesign
8. TermProject

PartB:ExperimentsUsingDSPProcessor

1. To perform the linear convolution and circular convolution of the two givendiscretesequences
2. Toimplementthe FIRfiltersthatmeetthegivenspecifications
3. ToimplementtheIIRfiltersthatmeetthegivenspecifications
4. Toanalyzetherealtimeaudiosignalandextractvariousfeatures
5. Toanalyzeanimageandextractvariousfeatures

6. TermProject

Note: Above experiments will be implemented on Raspberry Pi boards also with pythonprogramming.

Courseoutcome: Afterthecompletionofthiscourse,thestudentwillbeableto

CO1	Generatecontinuousanddiscretetimesignals
CO2	MatlabimplementationofDTFTandDFT
CO3	MatlabimplementationofSamplingandConvolutiononLTIsystems
CO4	UtilizingZ-transformsonsignalanalysis
CO5	DesignofFIRandIIRFiltersusing Matlab
CO6	AnalysisofrealtimeaudiosignalsandimageextractionusingDSPProcessors
CO7	DesignandanalysisofaprototypeapplicationusingDSPprocessorand simulationofthesameusingMatlab

AssessmentMethod

AssessmentTool	Experiments	Report/Viva-Voce/ project	Quiz/MCQ/Lab	Total
Weightage(%)	25%	15%		40%
EndSemesterExaminationweightage(%)				60%

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20EC2185	**Internetof ThingsLab**	**ESC**	**0L: 0T: 3P**	**1.5Credits**

CourseLearningObjectives

1. ToassessthevisionandintroductionofIoT.
2. TounderstandIoTMarketperspective.
3. To implement Data and Knowledge Management and use of Devices in IoTTechnology
4. ToindulgeindesigningofprototypehardwarefordifferentIoTapplication

Course ContentExercise I

Introduction&OverviewofInternetofthings

TheInternetofthingstodayandtomorrow,IoTarchitectureoutline,FunctionalblocksofIOT,industrialIOT,IOTenabledSmartdevicesinmarket,ApplicationareasforIOT, Challenges in IOT. Hardware and Software tools required for IOT applicationdevelopment.
development, Overview of IOT based on Particle Hardware platforms and IDE's for

Exercise -II

Exploringthearduinoboardanditssoftware IDE

TheArduinoboard,Thecommandarea,textareaandmessagewindowarea.Setupfunction,Controllingthehardware,loopfunctionality,verifyingyoursketch,uploadingandrunningyoursketchandfinallymodifyingyoursketchaccordingtoyourrequirement.

Exercise-III

Introductiontosensorsanddisplays

Interfacing sensors to Arduino boards about the sensor, the circuit connections, sketch(softwareprogram), Application.Andinterfacing displaystoarduinoboard

Exercise-IVCommunication

Wireless communication, introduction to Bluetooth module, interfacing to Arduino in bothonewaycommunicationandtwowaycommunication,controllinganLEDinwirelessmode,interfacingwifimodulewitharduinocontrollingthingsbyusinglocalnetwork.

Exercise - V

IntroductiontoNodeMCU(ESP32Wi-Fi SoC)

ControllingthethingswithNodemcuusingwificommunicationinbothwaysandinterfacingnodemcuwithvariousperipheraldevices.CompareEsp8266withotherarduinoboards

Exercise-VI

Introductionto Cloudplatforms

IOTdevicetocloudstoragecommunicationModel,needofCloudservicesinIOT,differentCloud storage services available today, Cloud Data processing and frame format, Role ofSmartphones in IOT, Examples on Homeautomation andSmartcity development,Introductionto cloudslikeTemboo, Blynk, Pubnubetc.

Exercise-VII

Introductionto GSM,GPSModule

InterfacingArduino (uno)withGsm, Module2G communication and interfacingGPSmodulefor tracking location.

Exercise-VIII

InterfacingtoExternaldevices

InterfacingArduinowithExternalstorage,Ex:SDcard(reading,writing)HandlingInterruptsandmemorymanagementandEthernetcommunication.

Exercise-IX

IntroductiontoRasberrypi

Features,ComparisonwithArduino,HardwaredetailsandProgramming.

Exercise-XAppInventor

Createappswithcoding,DesigningappsandinterfacingwithArduino.

Exercise-XI

Any one of the project from the list belowProject -I

1. Home Automation with blue tooth and wifi and controlling the things with MobileApps
2. Designingwaterlevelcontroller.

Project-II

1. DesigningwomensafetysystemwithGPSandGSMmodule
2. DesigningsecuredcarparkingsystemusingGPSandGSMmodule

Project-III

1. Uploadingsensorinformationtocloud,operatingandMonitoring
2. DesigningSmartHospitalwithIoTdevices.

Learning resourcesTextBooks:

1. Cuno Pfister, 'Getting started with the Internet of Things :Connectingsensorsand Microcontrollers to the Cloud', O'Reilly Media Inc. Publications
2. Daniel Kellmereit, Daniel Obodovski, 'The Silent Intelligence: The Internet of Things', DND Ventures LLC Publications

ReferenceBooks:

1.PethuruRajandAnupama C. Raman , ' *The Internet of Things: EnablingTechnologies,Platformsand'use cases*,CRCPress

2.Arshdeep Bahga and Vijay Madisetti,'*InternetofThings:Ahands-onapproach* ', UniversitiesPress

Webresources:

1. ProfSudipMisra,NPTEL-IITKharagpur,'*Introduction to Internet of Things'*
URL:https://nptel.ac.in/courses/106105166/

Courseoutcomes: Attheendofthecourse,thestudentwill

CO1	UnderstandandanalyzeconceptsofInternetofThings
CO2	Familiarwitharduinoboardanditssoftware
CO3	Interfacingsensorswitharduinoboardanditsworking
CO4	Analyzebasicprotocolsinwirelesssensornetwork
CO5	UnderstandNodeMCUarduinoboardforglobalcommunication
CO6	Understandcloudplatformtooperateourdevicesthroughcontroller
CO7	DesignIoTapplicationsindifferentdomainandbeabletoanalyzetheir performance

AssessmentMethod:

AssessmentTool	(Internal Exam)Hardware Projectsubmission	EndSemesterLabExamination	Total
Weightage(%)	40%	60%	100%

20EC2203	**LinearIntegratedCircuits**	**PCC**	**3L: 1T: 0P**	**4credits**

CourseLearningObjectives

1. Tostudythebasic principles,configurationsandpracticallimitationsofop-amp.
2. Tounderstandthevariouslinearandnon-linearapplicationsofop-amp
3. To analyze and deign op-amp oscillators, single chip oscillators and frequencygenerators

4. To understand the operation of the most commonly used D/A and A/D convertertypesanditsapplications

Coursecontent

Unit-I **(10hours)**

FeedbackAmplifiers

Feedbackconcept,GeneralcharacteristicsofNegativefeedbackamplifier,Differentfeedbackamplifiers(Voltge-seriesfeedback,Current-seriesfeedback,Current-shuntfeedback,Voltage-shuntfeedback),Effectofnegativefeedbackoninputandoutputimpedances,gain & bandwidth

Unit-II *(10hours)*

OperationalAmplifiers

Ideal op-amp parameters, non-ideal op-amp, opamp in negative feedback, bandwidth andslewrate on circuit Performance.

Op-ampapplications-summingamplifier,integrator,differentiator,Instrumentationamplifier, V to I and I to V converter, comparator, precision Rectifier, log and antilogamplifier.Active filters.

Unit-III *(12hours)*

Waveshapingcircuits&Oscillators

Postive feedback concept, Barkhausen criterion and design of RC phase oscillators, WienBridge oscillator. Ring oscillator, LC oscillators and crystal oscillators, MultivibratorsAstable, Monostable and Bistable Multivibrators, Schmitt trigger, square and triangularwaveformgenerators. –

Unit-IV *(8hours)*

DC-DCConverters

Introduction,PerformanceparametersofDC-DCconverters,Frequencylimitingparameters,Typesof converters: Buck, boost andbuck-boost.

Unit-V *(10hours)*

PLL

Basic PLL topology and principle, Major building blocks of PLL- analog and digital phasedetector,VCO,applicationsof PLL.

Unit-VI *(10hours)*

DataConverters

Analog vs discrete time signals, Sample-and-Hold circuits, ADC architectures (Flash ADC,Successive Approximation ADC, Dual slope ADC. DACs(Binary weighted resistors, R-2RDACand current steeringDAC). INL &DNL

Learning ResourcesTextbooks

1. BehzadRazavi,*'FundamentalsofMicroelectronics',*WileyPublications
2. Sedra and Smith, *'Microelectronics Circuits',* Oxford Publications,6th Edition.3.

R Jacob Baker, 'CMOS Mixed SignalCircuit Design', Wiley Publications

ReferenceBooks

1. Boylestad R. L. and L. Nashelsky, *'Electronic Devices and Circuit Theory'*, 10/e or11/e, Pearson,2009.
2. MillmanJ.andC.Halkias,*'IntegratedElectronics'*,2/e,TMH,2010.
3. NeamenD.,*'ElectronicCircuitAnalysisandDesign'*,3/e,TMH,2006
4. Spencer R. R. and M. S. Ghausi, *'Introduction to Electronic Circuit Design'*,Pearson, 2003

WebResources

1. Prof D Nagendra Krishnapura, NPTEL-IIT Madras, *'Analog Integrated CircuitDesign'*URL:https://nptel.ac.in/courses/117106030/
2. ProfK Radhakrishna Rao, NPTEL-IIT Madras,*'Electronicsfor AnalogProcessing-II'*,URL:https://nptel.ac.in/courses/117106088/

Courseoutcomes: Attheendofthecourse,thestudentswillbeableto

CO1	InfertheDCandACcharacteristicsofoperationalamplifiersanditseffecton outputandtheircompensationtechniques.
CO2	Elucidateanddesignthelinearand nonlinearapplicationsofanop-amp and specialapplicationICs.
CO3	Explainandcomparetheworkingofmultivibratorsusingspecialapplication IC555andgeneralpurposeop-amp.
CO4	Classifyandcomprehendtheworkingprincipleofdataconverters.
CO5	IllustratethefunctionofapplicationspecificICssuchasVoltageregulators, PLLanditsapplicationincommunication.

AssessmentMethod

Assessment Tool	Weeklytests (Insemester)	Monthlytests (Insemester)	EndSemesterTest	Total
Weightage(%)	10%	30%	60%	100%

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20EC2281	**CommunicationSystems-1 Laboratory**	**PCC**	**0L: 0T: 3P**	**1.5credits**

CourseLearningObjective

1. Analyzeandspecifythefundamentalparametersofacommunicationsystem.
2. To strengthen the ability to identify and apply the suitable modulation techniques forthegiven real worldproblem.
3. To write and execute programs in MATLAB to implement various modulationtechniques.

Listof Experiments

1. MathematicalmodelingofrealtimestochasticprocessusingMATLAB
2. AmplitudeModulationandDemodulation
3. FrequencyModulationandDemodulation
4. Samplingtheoremverification
5. PulseWidthModulation(PWM)
6. PulsePositionModulation(PPM)
7. DeltaModulation
8. PulseCodeModulation(PCM)
9. Termproject.

Courseoutcome

Afterthecompletionofthiscourse,thestudentwillbeableto

CO1	Demonstrate understanding of various amplitude modulation and demodulationtechniques.
CO2	Demonstrateunderstandingoffrequencymodulationanddemodulation technique.
CO3	Analysisofrealtimecommunicationsystems
CO4	Evaluatetheadvantagesanddisadvantagesofcommunicationssystems,from thepointofviewanalogmodulations.
CO5	Togainknowledgeinpracticalapplicationsofcommunicationsystems.
CO6	Todesignasimplemodelofacommunicationsystemwhichusesanalog modulationtechniques

AssessmentMethod

AssessmentTool	Experiments	Report/Viva-Voce/ Quiz/MCQ/Lab Project	Total
Weightage(%)	25%	15%	40%
EndSemesterExaminationweightage(%)			60%

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20EC2283	LinearIntegratedCircuits Laboratory	PCC	0L: 0T: 3P	1.5credits

CourseLearningObjective

1. Experimentallydemonstratethefrequencyresponseofamplifiers
2. Practicalknowledgeondifferenttypesofmultivibratorsandtheirapplications
3. IntroductorydesignsonAnalogtoDigitalConverters
4. PracticalexposuretoCMOScircuitdesignespeciallyoperationalamplifiers
5. FamiliarizationwithCADtoolforanalogcircuitdesign

Listof Experiments

1. DesignandanalysisofFeedbackamplifiers.
2. Frequencyresponseofinverting&non-invertingamplifier.
3. DesignofanInstrumentationamplifier.
4. Schmitttrigger&NoisesuppressionusingBistablemultivibrator.
5. Monostable&Astablemultivibratorusingopamp.
6. DesignofamplifierusingCMOSinverters.
7. Two- bitflashADCdesign.
8. Design of a typical CMOS inverter(sizing) using EDA tool and finding transfercharacteristics&finding the propagationdelay.
9. Designofatwo inputCMOSNAND&NORgates(sizing)usingEDAtool.
10. DesignofafullydifferentialsinglestageopampusingresistiveloadsusingEDAtool
11. DesignofasinglestageopampusingdiodeconnectedloadusingEDAtool
12. TermProject(DesigningPublicAddressingSystem).

****EDAtoolmaybeMentorGraphics/Synopsys/Cadencetools***

Note: It is mandatory to perform experiments (1-7) on LTspice tool before the experiment isdone on hardware. All experiments must be unique, design specifications should not becommoninthelab.

Courseoutcome:

AfterthecompletionofthisLaboratorycourse,thestudentwillbeableto

CO1	Toanalyzethefrequencyresponseofamplifiers

CO2	Experimentallyknowthenoisesuppressioninbistablemultivibrators
CO3	UtilizationofIC555timer
CO5	DesignofAnalogtoDigitalConverters

CO6	Designof CMOScircuitsusing CADtool
CO7	Designofoperationalamplifiers
CO8	Designofaprototypeprojectusingtheconceptsofanalogelectroniccircuits

AssessmentMethod

AssessmentTool	Experiments	Report/Viva-Voce/ Quiz/MCQ/Lab Project	Total
Weightage(%)	25%	15%	40%
EndSemesterExaminationweightage(%)			60%

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20EC2285	**RoboticsLaboratory**	**ESC**	**1L: 0T: 3P**	**2.5credits**

CourseLearningObjectives:

1. Todifferentiatedifferenttypesofrobots.
2. Toanalyzethecomponentsofrobots,sensors,actuators.
3. To be exposed to coordinate transformations, I/O logic, wireless and wiredcommunication.
4. ToexploretheapplicationsofArduinoandRaspberrypiforRobotics
5. Togetfamiliarizationwithaerialrobotics:Drones

CourseContent:

Exercise-I

IntroductiontoRobotics

What is robotand robotics, already designed robots, Manualand Autonomous robots,Different types of industrial ARM robots, and arm design, Coordinate transformations formore motor moments, Electrical connections of different boards and modules: How toconnectclosedcircuit,digital andanalog pinsconnections.

Exercise-II

Logicdesign,Actuatorsandsensors

Logic and binary math conversions: OR, AND, XOR, XNOR gates, binary and hexadecimalconversions,IntroductiontoArduino,Actuators,Sensors,Wiredandwirelesscommunication, I/O communication through USB cable, Bluetooth HC05, RF modules,DTMFmodule, Xbeemodules.

Exercise-III

BasicrobotsandRaspberryPi

Linefollower:LinefollowerrobotdesignandcontrolwithArduinoboard,Obstaclesavoider:Obstacle avoider robot with IR sensors and Arduino board, Mobile controller: Mobilecontroller robot with DTMF module and HC05 module, Introduction to Raspberry pi: WhatisraspberryanddifferencesbetweenArduinoandraspberrypi,Applicationsofrobotics.

Exercise – *IV*

IntroductiontoAerialrobotsandDrones

ListofExperiments:

1. IntroductiontoRobotics:Study ofdifferentpartsofarobot.
2. Study of various aspects with respect to on-board sensors, actuators, drivers andotherperipherals.
3. Familiarizationwith8051,8052micro-controllerboard.
4. FamiliarizationwithArduinoBoardsalongwithActuatorTesting.
5. BuildingLineFollowerRobot.
6. Enhanced Line Follower Robot design using state machines and coding for statemachines.
7. Introduction to Bluetooth, Wi-Fi module, DTMF and building a Mobile ControllerRobot.
8. IntroductiontoRaspberryPi.
9. UsageofGPIO andRaspberry PiCameraModule onRaspberry Piboard.
10. ColourDetectionandSegmentationandbuildingcolourtrackingRobot.
11. IntroductiontoAerialRobots(Drones,UAVetc.)
12. IntroductiontoPixhawkAuto-Pilot.
13. CalibrationofDroneandFlightTest.
14. TeamProject.

TextBooks:

1. JohnJ.Craig, ‘*Introduction to Robotics: Mechanics and Control*’, PearsonPublications,2005.
2. Siegwart R and Nourbakhsh I.R,*Introduction to Autonomous MobileRobots*, Prentice Hall India,2005.

ReferenceBooks:

1.MurphyRobinR, *Introduction toAIRobotics* , MITPress,2000.

2. MykePredko,"Programming Robot Controllers" – McGraw-Hill,1stedition, 2003.

VideoReference:

1. Prof. Khatib, Stanford University, 'Introduction to Robotics'
URL:https://see.stanford.edu/Course/CS223A

CourseOutcomes:

CO1	Learnerswillbeabletodifferentiatedifferenttypesofrobots.
CO2	Learnerswillbeabletoanalysethecomponentsofrobots,sensors,actuators.
CO3	Learnerswillbeabletoexplainthecoordinatetransformations,I/Ologic, wirelessandwiredcommunication
CO4	LearnerswillbeabletoanalysetheArduinoandRaspberrypiusageinrobotics
CO5	Learnerswillbeabletodesignandcontrolbasictwo-wheelrobotmodel

AssessmentCriteria:

20EC3101	**CommunicationSystems-2**	**PCC**	**3L: 1T: 0P**	**4credits**

Courseobjectives

1. TounderstandthefunctionalblockdiagramofDigitalcommunicationsystem.
2. Tounderstandtheneedforsourceandchannelcoding.
3. Tostudyvarioussourceandchannelcodingtechniques.
4. To understand a mathematical model of digital communicationsystemforbiterrorrateanalysisof differentdigitalcommunicationsystems.

Coursecontent:

Unit-I **(12hours)**

BasictoolsofDigitalcommunication,TransmissionPulseShaping,PowerSpectralDensity,Additive White Gaussian Noise (AWGN) Channel, Optimal Receiver Design, Signal-to-NoisePower Ratio (SNR),Matched Filtering(MF)

Unit-II ***(8hours)***

Maximum Likelihood (ML) Receiver, Probability of Error, Binary Phase Shift Keying andassociatedProb. ofError,AmplitudeShift Keying(ASK) andOther Schemes.

Unit-III ***(10hours)***

Signal Space Theory, Frequency Shift Keying (FSK), Quadrature Amplitude Modulation(QAM), M-ary Phase Shift Keying (MPSK) and associated Prob. of Error, Pulse ShapingFilter Design, Nyquist Pulse Shaping Criterion, Raised-Cosine Filter, Passband-BasebandEquivalence.

Unit-IV ***(12hours)***

Introduction to Wireless Communication, Performance of Digital Modulation in FadingChannels,Introduction toInformationTheory,Channel Capacity.

Unit-V ***(8hours)***

Source Coding, Entropy Codes, Huffman Coding, Linear Block Codes, Hamming WeightandDistance Properties, Syndrome Decoding,

Unit-VI ***(10hours)***

ConvolutionalCodes,TrellisStructureandDecodingofConvolutionalCodes.

Text books

1. S. Haykin, '*Communications system*' ,Wiley,4^{th}Edition2009.
2. JohnG.Proakis, Masoud Salehi, '*Digital Communications*', McGrawHill,2008, 5^{th}Edition.

Referencesbooks

1. Herbert Taub, Donald L Schilling, 'Principles *of Communication Systems*' – GoutamSaha,McGraw-Hill,2008,3^{rd} Edition.
2. Wayne Tomasi, '*Electroniccommunication systems*',Pearson,5^{th}edition.
3. R.P. Singh, S. Sapre, '*CommunicationSystems:Analogand* Digital',McGraw-HillEducation,2012.

WebReferences

1. Prof. Aditya K. Jagannatham, NPTEL-IIT Kanpur, '*Principles Of CommunicationSystems-II*'.URL: https://nptel.ac.in/courses/108104098/

Courseoutcomes: Attheendofthecourse,thestudentswillbeableto

CO1	UnderstandbasiccomponentsofDigitalCommunicationSystems.
CO2	DesignoptimumreceiverforDigitalModulationtechniques
CO3	AnalyzetheerrorperformanceofDigitalModulationTechniques
CO4	UnderstandtheredundancypresentinDigitalCommunicationbyusingvarious sourcecodingtechniques
CO5	Knowaboutdifferenterrordetectinganderrorcorrectioncodeslikeblock codes,cycliccodesandconvolutioncodes

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20EC3103	**ComputerOrganizationand Architecture**	**ESC**	**3L: 1T: 0P**	**4credits**

CourseLearningObjectives:

Toexposethestudentstothefollowing:

1. HowComputerSystemswork&thebasicprinciples.
2. InstructionLevelArchitectureandInstructionExecution.
3. Thecurrentstateofartinmemorysystemdesign.
4. HowI/Odevicesareaccessedanditsprinciples.
5. Toimparttheknowledgeonmicroprogramming.

CourseContent

Unit ~~-~~ I **(10hours)**

Architecture of 8086 microprocessor, special functions of general purpose registers,8086flagregisterandfunctionof8086flags,pindiagramof8086,minimumand maximummodeof 8086 configuration and timing diagrams.Addressing modes of 8086, Instruction sets of8086.

UnitII – ***(12 hours)***

IntroductiontoMIPSarchitecture,MIPSInstructionSetArchitecture,Procedures,RecursivePrograms,ArchitectureExamples,IntroductiontoAssessingandUnderstandingPerformance, CPU Performance and its Factors, Evaluating Performance, Benchmarks andtheperformance of recentIntelProcessors.

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UnitIII ***(12hours)***

IntroductiontoProcessor:DatapathandControl,LogicdesignConventions,BuildingaDatapath,SimpleImplementationscheme,Multi-cycleImplementation,Exceptions,Microprogramming: Simplifying Control Design, Introduction to Digital Design Using aHardware Design Language.

UnitIV – ***(10hours)***

Introduction to Pipelining, A pipelined Data path, Pipelined Control, Data Hazards andForwarding,DataHazardsandStalls,BranchHazards,Exceptions,AdvancedPipelining.

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UnitV ***(8hours)***

Introduction to Memory Hierarchy, The Basic of Caches, Measuring and Improving CachePerformance,VirtualMemory,CommonFramework forMemoryHierarchies.

UnitVI – *(10hours)*

Introduction to Storage, Networks and other Peripherals, Disk Storage and Dependability,Networks, Busses and other Connections between Processors, Memory and I/O Devices,Interfacing I/O Devices to the Processor, Memory and Operating System, I/O PerformanceMeasures,Designing anI/OSystem.

Learning ResourcesTextBooks

1.DavidA.PattersonandJohnL. Hennessy'*ComputerOrganizationandDesign*', MorganKaufmann Publishers, 3rd Edition.

ReferenceBooks

1. Ian McLoughlin '*ComputerArchitecture – An Embedded approach*',McGraw-HillEducation (Asia),1st Edition.

Webresources

1.Prof AnshulKumar,NPTEL- IIT Delhi, '*ComputerArchitecture*' .URL:http://nptel.ac.in/courses/106102062/

Courseoutcomes: Attheendofthecourse,thestudentwillbeableto

1	AbletowriterecursiveprograminMIPS.
2	Abletoconstructcosteffectivecomputersystem.
3	Abletodifferentiatedifferentdesignsandorganizations.
4	Abletohandledesignissuesinthedevelopmentofprocessororothercomponentst hat satisfiesdesign requirements.

20EC3181	**Communicationsystems-2 Laboratory**	**PCC**	**0L: 0T: 3P**	**1.5credits**

CourseLearningObjective

1. Toinculcate practicalknowledgeonvariousdigitalcommunicationtechniques
2. To understand the type of digital communication technique required for specificpurposes

Listof Experiments

1. ModulationandDemodulationofAmplitudeShiftKeying(ASK)
2. ModulationandDemodulationofFrequencyShiftKeying(FSK)
3. ModulationandDemodulationofPhaseShiftKeying(PSK)
4. SimulationofBERperformanceofASKoverAWGNchannels

5. SimulationofBERperformanceFSKoverAWGNchannels
6. SimulationofBERperformancePSKoverAWGNchannels
7. SimulationofBERperformanceofDigitalmodulationschemesoverRayleighfading.
8. Study and analysis of Digital Communication techniques in real timetelecommunicationsystems
9. TermProject

CourseOutcomes

Attheendofthecourse,thestudentwillbeableto

CO1	UnderstandthepracticalaspectsofPulsewidthmodulation,pulseposition Modulation
CO2	UnderstandthepracticalaspectsofAmplitudeshiftkeying,Frequencyshift keyingandphaseshiftkeying
CO3	Differentiatethedifferencebetweendifferentcommunicationtechniques
CO4	Understandthedifferencebetweenanalogcommunicationtechniquesanddigital communicationtechniques
CO5	Designasampletelecommunicationsystemusingdigitalcommunication Techniques

20EC3182	**Microprocessors,Microcontrollers andComputer NetworksLab**	**PCC**	**0L: 0T: 3P**	**1.5credits**

CourseLearningObjective

1. Experimental exploration of features of microprocessors and microcontrollersandimplementation of variousoperations
2. Interfacing microprocessors and microcontrollers with other electronicscomponentslike Display,Sensors,Actuatorsetc
3. FamiliarizingwithNetworkingprotocolsandcodingforinterfacingthem.

Listof Experiments

8085ProgrammingandInterfacing

1. Arithmeticoperations
2. Interface7segmentdisplayswith8085using8255.
3. Interface8279Keyboard/DisplayICwith8085.
4. Generatesquarewaveandsawtoothwaveformsbyusing8085.
5. InterfaceADCandDACto8085.
6. Interfacing and programming of stepper motor and DC Motor speed control using8085.

8051programmingandInterfacing

1. Basicprograms
2. Interfacing8279Keyboard/DisplayICwith8051
3. InterfaceADCandDACwith8051.
4. SerialCommunicationusingSerialPeripheralInterface(SPI)with8051.
5. Generatesquarewaveandsawtoothwaveformsbyusing8051.
6. Interfacing and programming of stepper motor and DC Motor speed control using8051
7. SensorInterfacingwith8051

ComputerNetworks

1. To write a C/Python program to develop a DNS client server to resolve the givenhostname.
2. Towriteaclient-serverapplicationforchatusingUDP
3. Toimplementprogramsusingrawsockets(likepacketcapturingandfiltering)
4. TowriteaC/Pythonprogramtoperformslidingwindow
5. To get the MAC or Physical address of the system using Address ResolutionProtocol.
6. To simulate the Implementing Routing Protocols using border gatewayprotocol(BGP)
7. To simulate the OPEN SHORTEST PATH FIRST routing protocol based on thecostassigned to thepath.

CourseOutcome

AfterthecompletionofthisLaboratorycourse,thestudentwillbeableto

CO1	Designandimplementprogramsusing8051microcontroller
CO2	Designandimplementprogramsusing8085microprocessor
CO3	Interfacingwith8051microcontroller
CO4	Interfacingwith8085microprocessor
CO5	Comparisonofmicroprocessorand microcontroller
CO6	Exploringthefeaturesofadvancesmicrocontrollersandmicroprocessorsover 8051microcontrollerand8085microprocessorrespectively
CO7	Programmingandimplementingnetworkprotocols
CO8	Designandanalysisofaprototypefora simplerealtimeapplication

20EC3185	**RFandMicrowaveEngineering Laboratory**	**PCC**	**1L: 0T: 3P**	**2.5credits**

CourseObjective

1. Knowaboutthebehaviorofmicrowavecomponents
2. Understandtheradiationpatternofhornantenna

Listof Experiments

1. ModelingofRectangularwaveguidesusingCADtools.
2. Measurementofguidewavelengthanddeterminationoffrequency.
3. Measurementofdirectionalcouplersuchascoupling,directivity,etc.
4. ModelingofMicrowavecomponentsusingCADtools
5. MeasurementofS-parametersofwaveguideT-junction.

6. Gunnoscillatormeasurementssuchaspowerversusfrequency,I-Vcharacteristics
7. ReflexKlystroncharacteristicsmeasurement
8. UnknownImpedanceMeasurementusingSmithchart.
9. Measurement of radiation characteristics of horn antenna such as radiation patternsandgain.
10. TermprojectusingMMICcomponents

AssessmentMethod

AssessmentTool	Experiments	Report/Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage(%)	25%	15%	40%
EndSemesterExaminationweightage(%)			60%

Courseoutcome:

Afterthecompletionofthis Laboratorycourse,thestudentwillbeableto

CO1	DemonstratethecharacteristicsofMicrowavesources
CO2	DemonstratethecharacteristicsofdirectionalCouplers
CO3	Totestthecharacteristicsofmicrowavecomponents

CO4	Toanalyzetheradiationpatternofantenna
CO5	Tomeasureantennagain
CO6	Practicemicrowavemeasurementprocedures
CO7	TodesignaprototypeprojectusingMMICcomponents

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Coursecode	CourseName	Course Category	L-T-P	Credits
20EE2101	NetworkAnalysis	PCC	3-1-0	4

CourseLearningObjective

1. Tomakethestudentscapableofanalyzinganygivenelectricalnetworks.
2. ToknowthebehaviorofthesteadystatesandtransientsstatesinRLCcircuits.
3. ToknowthebasicLaplacetransformstechniquesapplicationtoelectricalnetworks.
4. Tounderstandthetwo-port networkparameters.
5. TounderstandthepropertiesofLCnetworksandfilters.

CourseContents:

Unit-INetworkTheorems **(12hours)**

MeshandNodalAnalysis,NetworksTheorems:SuperpositionTheorem,Thevenin'sTheorem,Norton'sTheorem,Max-imumpowertransferTheorem,andReciprocityTheorem.

Unit-IITimeDomainAnalysisofElectricalNetworks

(10hours) Transient analysis of First-order Circuits: Finding Initial Conditions, Special Cases.Natural and forced responseofRL, RC Circuits, Concept of Time constant. Transient analysis with different Excitations viz Step, Impulse andSinus-oidal.

Unit-IIITimeDomainAnalysis ofElectricalNetworkscontd **(8hours)**Transie

Unit-IVCircuitAnalysisUsingLaplaceTransform **(10hours)**Introdu

Unit-VTwoPortNetworks (12hours)

Two Port Network parameters. Relationship of two-port variables, Open circuit Impedance parameters, short circuitAdmittance parameters, Transmission Parameters, Hybrid Parameters, Relationship between parameter sets, Reci-procityandSymmetry,Interconnectionoftwo-portnetworks.

Unit-VIBasicFiltersandtheirfrequencyresponse **(8**

offfrequency,bandwidth,qualityfactor,attenuationconstant,phaseshift,characteristicimpedance.

LearningResources:

TextBooks

1. WilliamH.Hayt,JackKimmerly,StevenM.Durbin,Engineering CircuitAnalysis,TataMcgrawHill,8th edition.
2. D.RoyChowdary,“Networks andsystems”,Newageinternationalpublishers,2009

ReferenceBooks

1. M.E.VanValkenburg,NetworkAnalysis,Pearsonpublications,3rd edition.
2. CharlesK.Alexander,MatthewN.O.Sadiku,FundamentalsofElectricCircuits,McgrawHill5th edition.
3. FranklinFKuo,“NetworkAnalysis&Synthesis”,WileyIndiaPVT.Ltd.,secondEdition,2006

WebResources

1. ProfS.CDuttaRoyNPTEL-IITDELHI,'CircuitTheory'URL:https://nptel.ac.in/courses/108102042/

2. Prof T K Basu, NPTEL-IIT Kharagpur, 'Networks, Signals and Systems'URL:http://nptel.ac.in/courses/108105065/

CO1	Analyzetheelectriccircuitsusingnetworktheorems
CO2	Deducetransient responseforcircuits
CO3	Understandsecond-orderresponse
CO4	ApplyLaplacetransformationsforsolvingelectriccircuitsproblems
CO5	Analyzeelectriccircuitsusingtwo-portnetworksandrelevanttheorems

CourseOutcomes:Attheendofthecourse,thestudentwillbeableto

S.No	UnitNumber	NumberofHours		Totalnumber ofclasshours
		Lecturehours(L)	Tutorialhours(T)	
1	Unit I	10	2	12
2	UnitII	8	2	10
3	UnitIII	7	1	8
4	UnitIV	8	2	10
5	Unit V	11	1	12
6	UnitVI	7	1	8
Totalhours		51	9	60

Coursecode	Coursename	CourseCategory	L-T-P	Credits
20EE2102	**NetworkAnalysisLaboratory**	**PCC**	**0-0-3**	**1.5**

CourseLearningObjectives:
1. Tomakeunderstandandverifythedifferent NetworkTheorems.
2. Tomakeunderstandandobservethetimeresponseof circuits
3. Tounderstandthefrequencyresponseofelectriccircuits.
4. Toget knowledgeabouttwo-portnetworks.
5. TogetfamiliarwithMATLAB/Simulink

ListofExperiments:
1. VerificationofThevenin'sandSuperpositionTheorem.
2. VerificationofMaximumpowertransfertheoremandReciprocityTheorem.
3. StepresponseofFirst-order circuits.
4. FrequencyresponseofseriesRLCcircuit.
5. FindingZandYparametersofTwo-portnetwork
6. FindinghandABCDparametersofTwo-portnetwork
7. VerificationofKVL,andKCLinACcircuits.
8. VerificationofInterconnectionofparametersfortwo-portnetworks.

Anytwoof thefollowingneedtobedoneinasoftware platform

1. StepResponseofRL,RC,circuitsusingMATLAB/Simulink.
2. StepresponseofRLCcircuitusingMATLAB/Simulink
3. FrequencyresponseofLowpass,HighpassfiltersusingMATLAB/Simulink.

CourseOutcomesAt theendof thecoursethestudent willbeableto

CO1	UnderstanddifferentnetworkTheorems
CO2	AnalyzeTimeresponseFirstordercircuits
CO3	AnalyzeFrequencyresponseofseries RLCcircuits
CO4	Practicallyverifythenetworkparameters.
CO5	UnderstandthebasicsofMATLABandperformsimpleprograms.

Coursecode	CourseName	Course Category	L-T-P	Credits
20EE2103	PowerSystems-I	PCC	3-1-0	4

CourseLearningObjectives

1. TounderstandthedifferenttypesofConventionalpowergeneratingstations.
2. TounderstanddifferentNon-ConventionalEnergysources
3. Tounderstandandconceptsoftheeconomics ofgeneration
4. Toevaluatethetransmissionlineparameterscalculations
5. TounderstandtheperformanceofdifferenttypesofTransmissionlines.
6. Tounderstandtheconcept of undergroundcablesanddistributionsystems

UNIT-IConventionalpowergeneration

(08hours
)

Structure of power system: Generation, Transmission and distribution systems; Conventional sources of electric ener-gy,Thermal,Gaspowerplant model,powergeneration,hydropowergeneration,Nuclearpowergeneration.

UNIT-IINonconventionalpowergeneration

(10hours
)

Non-conventional sources of electric energy, Wind energy conversion: introduction, types of wind turbines, windgeneration and control. Solar energy: Solar photovoltaic cells and generation. Block diagram models of wind and so-larenergygenerationsystems.

UNIT-IIIEconomics ofpowergeneration

(10hours
)

Definitionsofconnected load,maximum demand,demandfactor,loadfactor, diversity factor, andload durationcurve.Baseloadandpeakloadplants,tariff.Problemsondifferentfactors.

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UNIT-IVTransmissionlineparameters

(12hours
)

Transmission line parameters: Types of conductors, calculation of resistance of solid conductors and effect of re-sistance on solid conductors, calculation of inductance for single-phase and three-phase, single anddouble circuitlines, the concept of GMR, GMD, symmetrical and asymmetrical conductor configuration with and without transpo-sition, Skin and Proximity effect, corona; Calculation of capacitance for2 wire and 3 wire systems, the effect ofground on capacitance, capacitance calculations for symmetrical and asymmetrical single and three- phase, single anddoublecircuitlines.

UNIT-VPerformanceofTransmissionlines

(12hours
)

Performance of short and medium-length transmission lines: Classification of transmission lines, short, medium,andlong line and their model representations, nominal-T, nominal-Pie, and A, B, C, D constants for symmetricalandasymmetrical networks,mathematicalsolutionstoestimate regulationandefficiency ofall typesof lines,Perfor-mance of long transmission lines: Long transmission line, rigorous solution, evaluation of A, B, C, Dconstants, repre-sentation of long lines, equivalent-T and equivalent Pie network models; Ferranti effect, chargingcurrent,effectonthe regulation of the transmission line, surge impedance and SIL of long lines, wavelength andvelocity of propaga-tionofwaves.

UNIT-VI UnderGroundCables,EHVandHVDCTransmission (8hours) Underg
grading,numerical problems, description of inter-sheath grading,HV cables.Needof EHVtransmission systems, types ofDClinks,comparisonofACandDCtransmission,theadvantageofDCtransmission,HVDCsystemsinIndia.

LearningResources:

TextBooks:

1. CLWadhwa,"ElectricPowerSystems",Newagepublications,NewDelhi,9thEdition,2007.
2. SinghSN,"ElectricPowerGeneration,TransmissionandDistribution",PrenticeHallofIndiaPvt.Ltd.,NewDelhi,2ndEdition,2002.
3. Solanki,"RenewableEnergyTechnologies:PracticalGuideforBeginners",PHILearningPvt.Ltd.,2008

Referencebooks:

1. M.V.Deshpande–ElementsofElectricalPowerStationDesign,ThirdEdition,WheelerPub.1998
2. H.Cotton&H.Barber-TheTransmissionandDistributionofElectricalEnergy,ThirdEdition,HodderArnold;
3. V.KMehta andRohitMehta,"PrinciplesofPowerSystems",S.Chand&CompanyLtd,NewDelhi, 2004.
4. D.Mukherjee:FundamentalsOfRenewableEnergySystems,NewAgeInternationalpublishers,2007
5. GilbertM.Masters:RenewableandEfficientElectricPowerSystems,JohnWiley&Sons,2004.

Webresources:

1. Prof.D.P.Kothari,NPTEL-IITDelhi,*'PowerSystemGeneration,TransmissionandDistribution(Encap-sulatedfromearlierVideo)*URL:https://nptel.ac.in/courses/108/102/108102047/

CourseOutcomes At theendofthecourse: Thestudentwillbeableto

CO1	Understandtheconceptsofpowersystems.
CO2	Understandtheoperationofconventionalgeneratingstationsandrenewablesourcesofelectricalpower.
CO3	Determinetheelectricalcircuitparametersoftransmissionlines
CO4	Understandingtheperformanceoftransmissionlines
CO5	UnderstandtheundergroundcablesandHighVoltagetransmission
CO6	UnderstandthebasicsofDistributionsystems

20EE3103	**ControlSystems**	**PCC**	**4L:0T:0P**	**4**

CourseLearningObjective

1. Toexplorethe modelingoflineardynamicsystemsviadifferentialequationsandtransferfunctionsutilizin gstate-paceandinput-outputrepresentations.
2. Analysisofcontrolsystemsinthetimeandfrequencydomainsandusingtransferfunctionands tate-spacemethods.
3. Studyoftheclassicalstabilitytests,suchastheRouth-HurwitzandNyquistcriterions,anddesignmethods usingroot-locusplots andBodeplots.

Coursecontent

Unit-I:Introduction **(6hours)**

Introduction-Openloopandclosedloopcontrolsystems-Transferfunctions-Blockdiagramsandtheirreduction-Signalflowgraphs-formula.

Unit-II:Mathematicalmodeling **(6 hours)**

Mathemat-ical modeling and transfer functionsof electrical circuitsandmechanical systems.PrincipleandoperationofServomotors andSteppermotors.

Unit-III:Timeresponseanalysis **(10hours)**

Standard test signals, step response of first and second order systems Time response specifica-tions steady state error static error and generalized error coefficients response with proportional,derivativeandintegralcontrollers.DesignofK_p,K_i,$k_v$parameters.

Unit-IV:Stabilityanalysis **(6hours)**

Stability concept, characteristic equation, location of roots in the s-plane for stability Routh-Hurwitz criterion, Root locus rules for the construction of root locus- construction of root locususingMATLAB/SIMULINK.

Unit-V:Stabilityanalysiscntd. **(8hours)**

Introduction-Bode Plots Gain margin and Phase margin - Polar plots - Nyquist stability criterionNeedfor compensators.IntroductiontoLagandleadcompensatorsin frequencydomain.

Unit-VIStatespaceAnalysis (10hours)

Concepts of state, state variables and state model, derivation of State models from block diagrams, Diagonalization, Solving the Time invariant state Equation,state transition Matrix anditsProperties ConceptsofControllabilityandObservability.

Learning ResourcesText Books:

1. B.C.Kuo,*Automaticcontrolsystems*,JohnWileyandSons, 8th edition,2003.
2. K.Ogata,*Moderncontrolsystems*,PrenticeHallofIndiaPvt.Ltd.,5th edition,2010.

References

1. I.J.NagrathandM.Gopal,*ControlSystemEngineering*,NewAgeInternational(P)LimitedPublishers,5thedition,2007.
2. NormanS.Nise,*ControlSystemEngineering*,WileyIndia,5th edition2000.

WebResources:

1. Prof.C.S.ShankarRam,NPTEL,IIT-Madras,ControlSystems.URL:https://archive.nptel.ac.in/courses/107/106/107106081/

Course outcomes: Attheendofthe course,thestudents willbeable to

CO1	Analyzecontrollabilityandobservabilityof linearsystems.
CO2	Designstate-spacecontrollerandappropriate(deterministic)observer.
CO3	Designcontrollerwithfrequencydesignmethods.
CO4	Applyroot-locusmethodfor analysisandsynthesis.
CO5	Applypoleplacementcontrollerdesign approach.
CO6	Designlinearquadraticregulatorfordiscrete-timesystems.

Coursecode	CourseCategory	L-T-P	Credits
20EE2201	ElectricalMachines-II	3-1-0	4credits

CourseLearningObjectives

1. TomakeunderstandtheconceptofACrotatingmachines.
2. TomakeunderstandtheconceptoftheInductionmotor
3. Tounderstandtheconceptofsynchronousgeneratorandmotor
4. Toget knowledgeaboutapplicationsofinductionandsynchronousmachines

UNITI:Three-phaseInductionmotor

(10hours
)

Polyphase Induction Motors-Construction Details of Cage and Wound Rotor Machines Production of a RotatingMagneticField-PrincipleofOperation-RotorEmfandRotorFrequency-RotorReactance,RotorCurrentandPfatStandstillandDuringOperation.

UNITII:ThreephaseInductionmotorcharacteristics

(10hours) Rotor Power Input, Rotor Copper Loss and Mechanical Power Developed and Their Inter Relation-Torque Equation-DeductionFromTorqueEquation-ExpressionsforMaximumTorqueandStartingTorque-TorqueSlipCharacteristic – GeneratorOperation - Double Cage and Deep BarRotors - Equivalent Circuit- PhasorDi- agram - CrawlingandCogging -CircleDiagram-NoLoad andBlocked RotorTests-PredeterminationofPerformance

UNIT III: Starting and speed control of Induction motor & Single Phase Induction Motor (10 hours) StartingMethodsandStartingCurrentandTorqueCalculations,SpeedControl-ChangeofFrequency;PoleChangingand Methodsof Consequent Poles; Cascade Connection. Injection of an Emf.Single Phase InductionMotors: Sin-gle phase induction motor – Constructional features - Double revolving field theory – Elementary idea of cross-fieldtheory–split-phase motors–starting methodsofsingle-phaseinduction motors.

UNITIV:SynchronousMachines&CharacteristicsofSynchronousGenerators

(10Hours) Constructional Featuresof the round rotorand salientpole machines – Armaturewindings–Integral slot andfractional slot windings; Distributed and concentrated windings – distribution, pitch and winding factors – E.M.FEquation - Harmonics in generated e.m.f. – suppression of harmonics – armature reaction – leakage reactance –synchronous reactanceandimpedance–experimentaldetermination-phasordiagram– loadcharacteristics.

UNITV:Regulation&Paralleloperationofsynchronous generators

(10 hours) Pre determination of Regulation by synchronous impedance method, Z.P.F method, M.M.F method. two reactionanalysis–determinationofXdandXq(Sliptest)Phasordiagrams–Regulation.Synchronizationofalternatorswithinfinitebusbar–

synchronizingpower,synchronizingtorque–paralleloperationandloadsharing-
Effectofchangeofexcitationandmechanicalpowerinput.

UNITVI:Synchronousmotors

(10Hours
)

Principle of operation – phasor diagram – Variation of current and power factor with excitation – V and Inverted VCurves - Power developed – Synchronous Condensers - Excitation and power circles – hunting and its suppression –Methods ofstarting– synchronousmotor.

LearningResources:

TextBooks:

1. IJNagrathandDPKothari,“ElectricMachines”, McGrawHillEducation,ThirdEdition,2004.
2. PSBimbhra,“ElectricalMachinery”, KhannaPublishers,SeventhEdition,2011.

ReferenceBooks:

1. MGSay,“PerformanceanddesignofACmachines”, CBSPublishers,ThirdEdition, 2002.
2. AEFitzgeraldandCKingsley, "ElectricMachinery”,McGrawHillEducation,SeventhEdition,2020.
3. JBGupta“TheoryandperformanceofElectricalMachines”,S.K.Kataria&SonsPublishers14th Edition,2009.

Webresources:

1. Prof.P.SasidharaRao,NPTEL,IIT-Madras,ElectricalMachines-IIhttps://nptel.ac.in/courses/108/106/108106072/
2. Prof.TapasKumarBhattacharyaNPTEL,IIT-Khragpur,ElectricalMachines-II,https://nptel.ac.in/courses/108/105/108105131/

CourseOutcomes:

Atthe end ofthecoursethestudentwillbeableto

CO1	UnderstandInductionmotoroperation,construction,andapplications
CO2	Understandthestartingandspeedcontroltechniquesforinductionmotors
CO3	UnderstandSynchronousgeneratoroperation,construction,andapplications
CO4	Analyzetheparalleloperationofalternators
CO5	UnderstandtheprincipleofoperationofSynchronousmotor
CO6	UnderstandtheapplicationsandstartingmethodsofSynchronousmotor

S.No	UnitNumber	Number ofHours		Totalnumber ofclasshours
		Lecturehours(L)	Tutorialhours(T)	
1	UnitI	8	2	10
2	Unit II	8	2	10
3	UnitIII	8	2	10
4	UnitIV	8	2	10
5	Unit V	8	2	10

6	UnitVI	8	2	10
Totalhours		48	12	60

Coursecode	CourseName	Course Category	L-T-P	Credits
20EE2203	**PowerSystems-II**	**PCC**	**3-1-0**	**4**

CourseLearningObjectives:

1. Interpret the entries of bus impedance and admittance matrices using the singulartransformation method, stepbystepmethodtoobtainprimarydataofloadflowanalysis.
2. Buildthealgorithmstoformthebusimpedanceandadmittancematricesforvariousconfigu rationsofprimitivenetworks.
3. Outlinetheconditionsofapowersystemtoundergosteady-state,dynamic,ortransientstabilitiesstudies.CourseContents:

UNIT-1PerUnit SystemofRepresentationandPowerSystemNetworkMatrices (10hours)

Per Unit system of Representation: Necessity, Advantages, Applications in Power Systems and Calculations.Single line diagram– Impedance diagram of a power system–Graph theory definition – Formation of elementnode incidence and bus incidence matrices – Primitive network representation, Y bus formation by direct andsingulartransformationmethods.

UNIT-IIPowerFlowStudies (10hours)

The necessity of power flow studies – Derivation of static power flow equations – Power flow solution using Gauss-Seidel Method – Newton Raphson Method (Rectangular and polar coordinates form) –Decoupled and FastDecoupledmethods – Algorithmic approach – Problems on 3–bus system only. Merits and demerits of different load flow tech-niques.

UNIT-IIISymmetricalComponentsandSymmetricalFaultAnalysis

(10hours) Symmetrical Components: Synthesis of Unsymmetrical Phasors from their symmetrical components, symmetricalcomponents of unsymmetrical phasors, Power in symmetrical components, Sequence impedances – Synchronous ma-chine–Transmissionlineandtransformers–Sequencenetworks.
Symmetricalfaultanalysis:ShortcircuitcurrentandMVAcalculations, faultlevels, applicationofseriesreactors.

UNIT-IVUnsymmetricalFaultAnalysis (10 **hours)** Unsymmetrical fault analysis: Unsymmetrical Faults in power systems, Single Line to Ground Faults,LinetoLineFaults,DoubleLinetoGroundFaults,andOpen-conductorFaults.

UNIT- VPowerSystemStability-I (10hours)

Power System Stability Analysis Elementary concepts of Steady-state– Dynamic and Transient Stabilities– Descrip-tion of Steady-State Stability Power Limit–Transfer Reactance–Synchronizing Power Coefficient – Power AngleCurve

UNIT-VIPowerSystemStability-II (10hours)

Determination of Steady-State Stability –Derivation of Swing Equation, Multi-Machine stability studies, Determi-nation of Transient Stability by Equal Area Criterion–Applications of Equal Area Criterion–Methods to improvesteady-stateandtransientstability.

LearningResources:

Textbooks:

1. JohnJGrainger,W.D.Stevenson, “PowerSystemAnalysis”, McGraw-Hill(India)Pub.ThirdEdition,2011.

2. KothariD.P.andI.J.Nagrath,“ModernPowerSystemAnalysis”,McGrawHillEducation;Fourthedition,2011.

3. JDuncanGloverandMSSarma,Thompson,“PowerSystemAnalysisandDesign”, ThirdEdition2006

Referencebooks:

1. C.LWadhwa,“ElectricalPowerSystems”,NewAgeInternational,SixthEdition,2012.
2. HadiSaadat,“PowerSystemAnalysis”,McGrawHill,SecondEdition,2002.
3. S.S.Vadhera,“Power SystemAnalysis&Stability”,KhannaPublishers,FourthEdition,2005.

Webresources:

1. Dr.B.Das,Computer-AidedPowerSystemAnalysis,IITRoorkeeNPTELURL:https://nptel.ac.in/content/syllabus_pdf/108107028
2. Prof.AKSinha,PowerSystemAnalysis,IITKharagpur.NPTEL URL: https://www.nptel.ac.in/courses/108105067/

Courseoutcomes: Attheend ofthecourse,thestudentwillbeableto

CO1	Abletodrawimpedancediagramsforapowersystemnetworkandtounderstandperunit quantities.
CO2	Abletoforma Y_{bus}forpowersystemnetworks.
CO3	Abletofindthefaultcurrentsforalltypesoffaultstoprovidedataforthedesignof protectivedevices.
CO4	Abletoanalyzethesteady-state,transient,anddynamicstabilityconceptsofapowersystem.

S.No	UnitNumber	Number ofHours		Totalnumber ofclasshours
		Lecturehours(L)	Tutorialhours(T)	
1	UnitI	8	2	10
2	Unit II	8	2	10
3	UnitIII	8	2	10
4	UnitIV	8	2	10
5	Unit V	8	2	10
6	UnitVI	8	2	10
Totalhours		48	12	60

20EE3201	Powersystemoperationandcontrol	PCC	4L:0T:0P	4Credits

Courseobjectives:

1. Tounderstandoptimaldispatchofgenerationwithandwithoutlosses.
2. Tostudytheoptimalschedulingofhydrothermalsystems.
3. Tostudytheoptimalunitcommitmentproblem.
4. Tounderstandthereactivepowercontrolandcompensationoftransmissionlines.

Coursecontents:

Unit-I:EconomicOperationofPowerSystems (10hours)

Optimal operation of Generators in Thermal Power Stations, - heat rate Curve – Cost Curve –Incremental fuel and Production costs, input-output characteristics, Optimum generation alloca-tion with line losses neglected. Optimum generation allocation including the effect of transmis-sionlinelosses–LossCoefficients,Generaltransmissionlinelossformula.

Unit-II:HydrothermalScheduling (10hours)

Optimal scheduling of Hydrothermal System: Hydroelectric power plant models, schedulingproblems-Short term hydrothermal scheduling problem, Short term renewable energy schedul-ingproblem.

Unit-III:Modeling (10hours)

Modeling of Turbine: First order Turbine model, Block Diagram representation of Steam Tur-binesandApproximateLinearModels.Modeling ofGovernor:MathematicalModeling ofSpeed Governing System – Derivation of small signal transfer function. Modeling of ExcitationSystem: Fundamental Characteristics of an Excitation system, Transfer function, Block Dia-gramRepresentationofIEEE Type-1Model.

Unit-IV:SingleArea& Two-AreaLoadFrequencyControl (10hours)

Necessity of keeping frequency constant. Definitions of Control area – Single area control – Block diagram representation of an isolated power system – Steady state analysis – Dynamic re-sponse–Uncontrolledcase

Unit-V:ReactivePowerControl (10hours)

Overview of Reactive Power control – Reactive Power compensation in transmission systems –advantages and disadvantages of different types of compensating equipment for transmissionsystems.`

Unit-VI:Loadcompensation

(10h

ours)

Specifications of load compensator, Uncompensated and compensated transmission lines: shuntandSeriesCompensation.(Qualitativetreatment).Introductionto HVDC&FACTS.

Textbooks:

1. Dr.K.UmaRao,*PowerSystemOperationandControl*,WileyIndiaPvt.Ltd.

2. GraingerandStevenson,*PowerSystemAnalysis*,TataMcGrawHill.

Referencebooks:

1. PSRMurthy,*OperationandControlinPowerSystems*,BSPublications.

2. PrabhaKundur,*Powersystemsstabilityandcontrol*,TheMcGrawHill.

3. C.L.Wadhwa,*PowerSystemAnalysis*,NewageInternational.

4. I.J.Nagrath&D.P.Kothari,*ModernPowerSystemAnalysis*,TataMcGrawHillPublishingCompanyLtd.

5. J.DuncanGloverandM.S.Sarma,*PowerSystemAnalysisandDesign*,CengageLearning.CourseOutcomes:Afterthe completionofcoursethe studentwillbeable to,

CO1	Computeoptimalscheduling ofGenerators.
CO2	Understandhydrothermalscheduling.
CO3	UnderstandimportanceofPIDcontrollersinsingle areaand twoareasystems.
CO4	understandreactivepowercontrolandcompensationfortransmissionline.
CO5	understandimportanceofPIDcontrollersinsingle areasystems.

20EE3102	PowerElectronicsLab	PCC	0L:0T:3P	1.5credits

CourseLearningObjective:

The course is introduced to the students to enable laboratory scale practical knowledge aboutpowersystemoperationandperformanceanalysisofbothhardwareandsoftware.

ListofExperiments:

1. To study the characteristics of Silicon Controlled Rectifier (SCR) and to finditsholdingand latchingcurrent
2. TostudytheswitchingcharacteristicsofIGBT.
3. Tostudytheswitching characteristicsofFET.
4. Tostudythefullwavebridgerectifiercircuitandunderstanditseffectsonpowerquality
5. Tostudysinglephaseinverterwithdifferentloadingconditions.
6. Tostudythreephaseinverterwithdifferentloadingconditions
7. To studySinusoidalPulseWidthModulation
8. To studyhighfrequencyswitching
9. Tostudytheperformance ofDC-DCbuckconvertercircuitatdifferentdutyRatios
10. Tostudytheperformanceofsinglephasefullbridgeinvertercircuitoperatinginsquarewavemodeusing IGBT
11. Tostudytheperformance ofDC-DCboostconvertercircuitatdifferentdutyRatios
12. GenerationofPWMpulsesusingmicrocontrollerkit.
13. Study of an inverter fed adjustable speed drive for a 3- phase inductionmotor.
14. SinglephaseandThreephaseuncontrolledrectifierwithSmoothingCapacitor

CourseOutcomes: Uponsuccessfulcompletionofthecourse,studentshouldbeableto

CO1	Understandthe basicconceptsofdevicecharacteristics andtriggeringTechniques
CO2	Understandthe operationofdifferenttypeofrectifier/convertercircuitswithdifferentloads
CO3	Understandthe operationofchoppers,AC voltagecontrollersandInverters

20EE3104	**ControlSystemsLab**	**PCC**	**0L:0T:3P**	**1.5credits**

Courselearningobjective:

The objective of the lab is to design a system and calculate the transfer function, analyzing thestability of the system (both open and closed loop, with positive and negative feedback) withtime domain approach and frequency response analysis, using MATLAB and also developingthe systemwhichisdynamicin naturewithstatespaceanalysisapproach.

ListofExperiments:

1. Timeresponse ofSecondOrdersystemsusingMATLAB
2. CharacteristicsofSynchros
3. ProgrammableLogicController-Studyandverificationoftruthtablesoflogicgates,simpleBooleanexpressions andapplication ofspeedcontrolofmotor
4. EffectoffeedbackonDCservomotor
5. TransferfunctionofDCmotor
6. EffectofP,PD,PI,PIDControlleronsecondordersystems.
7. LagandLeadcompensation-Magnitudeandphaseplot
8. PositioncontrolofDCmotor.
9. TemperaturecontrollerusingPID
10. CharacteristicsofACServomotor.
11. PSPICE simulation of of P, PD, PI, PID Controller using Op-Amp for secondordersystems
12. Stabilityanalysis(Bode,RootLocus,Nyquist)ofLinearTimeInvariantsystemusing MATLAB.
13. Statespace modelforclassicaltransferfunctionusingMATLAB

Course outcomes: Attheendofthe course,thestudentswillbe ableto

CO1	Recognize the symbols for the different parts of a block diagram: functionalblocks,summing blocksandbranchpoints
CO2	Model a mechanical (masses, dampers and springs) and electrical system(inductors,resistors,capacitors)intheformofatransferfunction
CO3	Determinetheimpulse,step,andrampresponseofasystem,givenatransferfunctionmodel
CO4	PerformRouth'sstabilitycriterion androotlocusofasystemtodetermine

	Stability
CO5	Forsystemswithunknownvalues,determinetherangeofvaluesforwhichthesystemwil lbestable andexplainhowaddinga poleor azeroaffectsthestability
CO6	Analyze feedback control systems in the time andfrequency domain touse statespaceconceptstodescribesystems
CO7	Recognizethe“type”ofasystem(basedonthenumberoffreeintegrators)anddiscussthe expectederrorcharacteristicsasrelatedtostep,ramp,andacceleration Inputs
CO8	Interpretdesigncriteriaasrelatedtotheclosedlooppolelocationon thecomplexPlane
CO9	Draw theFrequency responseplotslikeBode,NyquistandPolarplots(magnitudeandphase)foragivent ransferfunction
CO10	Designfeedbackcompensatorstoachieveasetofdesiredclosedloopsystemcharacterist icsanddesignacompensatorinthefrequencydomaintomeetspecific designrequirementsusingaleadcompensator,lagcompensator,orlead-lagCompensator

MANAGERIAL ECONOMICS AND FINANCIAL ANALYSIS

Course code	Course name	Course Category	L-T-P	Credits
20BM1201	**Managerial Economics and Financial Analysis**	**HSC**	**3-0-0**	**3**

Course Learning Objectives:

1. To strengthen students managerial skill.
2. To enhance the conceptual clarity in economic concepts.
3. To develop to forecasting capability.
4. It will help to produce multi-disciplinary thought.
5. It will enhance their conceptual and practical/hand on practice in accounting. 6. It will help to implement and understand the uses of ratios.

Course Contents:

Unit I: (7 hours) Introduction to managerial economics, consumer behavior, demand, demand analysis, demand forecasting, supply, supply analysis.

Unit II: (7 hours) Theory of production, production functions, concept of cost, cost analysis, break even analysis.

Unit III: (7 hours) Market structure-monopoly, oligopoly, monopolistic, prefect market; Types of business organizations-sole proprietorship, partnership, private ltd. Companies and public ltd. Companies, formation of company.

Unit IV: (8 hours) Introduction to capital, capital sources, capital budgeting- NPV, IRR, Payback period, profitability index.

Unit V: (8 hours) Introduction to financial accounting, rules of debit-credit, Double-Entry Book Keeping, Journal, Ledger, Trial Balance- Final Accounts (Trading Account, Profit andLoss Account and Balance Sheet with simple adjustments, Preparation of final account and other related accounting statements.

Unit VI: (8 hours) Financial statements, comparative statement analysis, common- size statement analysis, ,ratio analysis, time series (only theories).

Learning resources

Text book:

1. 1. Aryasri, A. R., *Managerial Economics & Financial Analysis*, McGraw Hill, 2014.

Reference Books:

1. Siddiqui., *Managerial Economics & Financial Analysis*, 2e, New Age International Private Limited, 2017.
2. . Pandey, I.M., "*Financial Management*", 11e, Vikas Publishing House, 2015.3. . Prasanna Chandra., "*Financial Management: Theory and Practice*", 9e, Mc Graw Hill Education, 2015.

Web resources:

1. Managerial Economics and Financial Analysis, Dr. Trupti , IIT Bombay
http://nptel.ac.in/courses/110101005/

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

CO 1	A student will be able to understand basic economics as well as management concepts.
CO 2	This subject will provide implication facilities of concepts.
CO 3	Students can be able to do primary data collection and classification.
CO 4	Students can also be able to forecast as well as generate trend series by utilizing the available secondary data.

To be filled ECEbos	Embedded Systems Lab	PCC	0L: 0T: 3P	1.5 credits

Course Content

1. Introduction to ARM Cortex M3 Processor
2. Introduction to Microcontroller MicroController

Experiments:

1. ALP to multiply two 16 bit binarynumbers.
2. ALP to find the sum of first 10integers.
3. ALP to find the number of 0's and 1's in a 32 bitdata.
4. ALP to determine the given 16 bit number is ODD orEVEN.
5. ALP to write data in RAM.
6. Interface a simple Switch and display its status through Relay, Buzzer andLED.
7. Interface a Stepper motor and rotate it in clockwise and anti-clockwisedirection.
8. Display the Hex digits 0 to F on a 7-segment LED interface, with an appropriate delay in between.
9. Interface a DAC and generate Triangular and Squarewaveforms.
10. Display Hello World message using InternalUART.
11. Demonstrate the use of an external interrupt to toggle an LEDOn/Off.
12. Using the Internal PWM module of ARM controller generate PWM and vary its duty cycle.
13. Interface and Control a DCMotor.
14. Interface a 4×4 keyboard and display the key code on anLCD.
15. Measure Ambient temperature using a sensor and SPI, ADCIC.
16. Interface 12 bit internal ADC to convert the analog to digital and display the same on LCD.
17. Design and submission of labproject

***ALP= Assembly level Program.**

Course outcomes: On successful completion of the course students will able to

CO 1	Understand the Architecture of ARM processor & its Registers
CO 2	Understand the Architecture and Interfacing of a Microcontroller
CO 3	Introduced to Assembly level programming and can implement basic operations
CO 4	Interface few basic devices with Micro controller.
CO 5	Control and Interface to devices to get a desired output.

22MC3201	**Career Development Course**	**MC**	**2L: 0T: 0P**	**0 credits**

Course Learning Objectives:

1.To enhance holistic development of students and improve their employabilityskills
2.To instill confidence in students and develop skills necessary to face the challenges ofcompetitive exams andplacements

Course Contents

Unit I **(1.5 hours)**
Number system: Base System, Exponents, Factorials, LCM & HCF, Properties of Numbers, Remainders, Successive Divisions
Sequence & Series: Arithmetic Progression, Harmonic Progression, Geometric Progression

Programming in C

UnitII **(8 hours)**
Arithmetic: Averages, Clocks & Calendars, Simple Interest & Compoud Interest, Mixture & Alligations, Percentages, Profit, Loss & Discounts, Ratio & Proportion, Speed, Time & Distance, Time & Work
Algebra: Binomial Theorem, Complex Numbers, Functions, Higher Degree Equations, Inequalities , Linear Equations, Logarithm, Quadratic Equations

Programming in C

UnitIII **(6 hours)**
Geometry: Mensuration, Lines & Angles, Circles, Polygons, Triangles, Co-ordinate Geometry, Trigonometry
Probability & Statistics: Mean, Median & Mode, Permutation & Combination, Probability Set Theory & Venn Diagram

Programming using Data Structures

UnitIV **(7 hours)**
Logical Reasoning: Logical Sequence, Premise, Assumption & Conclusion, Binary Logic, Blood Relations, Linear & Matrix Arrangement, Seating Arrangement, Coding & Decoding, Statements & AssumptionsPuzzles.
Analytical Reasoning: Course of Action Fact, Inference & Judgement, Logical Deduction, Statement & Assumption, Strong & Weak Arguments, Syllogism

Programming in Python

Unit V **(4.5 hours)**

Data Interpretation: Charts (Column, Pie & Bar), Tables Graphs (Line & Area), Venn Diagram, Data Sufficiency. Programming using JAVA Reading Comprehension

Unit VI *(3 hours)*

Verbal Ability: Cloze Test Error Spotting, Fill in the blanks, Sentence Correction, Word Usage, Para jumbles, Paragraph Completion, Paragraph Summary

Programming using JAVA Learning resources Text book

Sarvesh K Verma, *'Quantitative Aptitude Quantum CAT'*, arihant publications
Arun Sharma, Meenakshi Upadhyay, *' Verbal Ability and Reading Comprehension'* , McGraw Hill publications
Arun Sharma, *'Data Interpretation'*, McGraw Hill
publications Arun Sharma, *'Logical Reasoning'*, McGraw Hill
publications

Reference books

Nishit K Sinha, 'Logical Reasoning and Data Interpretation', Pearson publications
Arun Sharma, *'Quantitative Aptitude'*, McGraw Hill publications

Web resources
https://unacademy.com/
https://www.tutorialspoint.com/
https://www.indiabix.com/

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

CO 1	Improve aptitude, problem solving skills and reasoning abilities
CO 2	Improve Verbal ability skills, Data interpretation skills
CO 3	Understand the basic techniques required for solving Reading Comprehension
CO 4	Familiarize with the written tests of competitive exams, campus placements and PSUs
CO 5	Collectively solve problems in teams and group
CO 6	Adopt and acquire new techniques in solving problem

**** Pass/Failcourse.**
Note: All examinations will be only of objective type. CDPC team assistance is to be taken in preparation of question papers. For Monthly tests, negative marking may also be introduced

Course code	Course Name	Course Category	L-T-P	Credits
22ME2112	**Mechanical Technology**	**ESC**	**3-0-0**	**3**

Course Learning Objectives:

1. To impart basic knowledge on basics of thermodynamics and Laws ofthermodynamics.
2. To introduce basic knowledge about special casting, molding proceduresand different welding techniques used in industry.
3. To impart basic knowledge on power transmission by gear and beltdrives.

4. To know the working of thermal power plants, boilers andturbines.
5. To teach the working principle of Internal CombustionEngines.
6. To introduce basic knowledge on Refrigeration & AirConditioning

Course Content:

Unit-I **(07 Contacthours)**

Basics of Thermodynamics: Introduction and definition of thermodynamics, Dimensions and units, systems, surroundings and universe, Reversibility and Irreversibility,Quasi-staticprocess,Energy,HeatandWork.IntroductiontoLawof Thermodynamics: Zeroth Law of Thermodynamics, First law of thermodynamics and Second law ofthermodynamics.

Unit-II ***(09 Contacthours)***

Casting:Introduction,GeneralmethodinmakingaCasting,pattern:types,materials and allowances. Moulding materials and equipment, Preparation, properties of mouldingsands.
Welding: Principles of gas welding and arc welding, Soldering and Brazing.

Unit-III ***(07 Contacthours)***

PowerTransmission:Introductiontobeltandgearsdrives,typesofgears,Difference between open belts and cross belts, power transmission by belt drives. (theoretical treatmentonly).

Unit-IV ***(07 Contact*** **hours)**

Thermal Power Plant: Thermal power plant layout- Four circuits-Rankine cycle, Boilers: Fire tube Vs Water Tube; BobCock and Wilcox, Cochran Boilers, Steam Turbines, Impulse Vs Reaction Turbines, Compunding of Turbines.

Unit– V ***(7 Contacthours)***

IC Engines: Introduction, Main components of IC engines, working of 4-stroke petrolengineanddieselengine,workingof2-strokepetrolengineanddieselengine, difference between petrol and diesel engine, difference between 4- stroke and 2-strokeengines.

Unit– VI ***(7 Contacthours)***

Refrigeration & Air Conditioning: Definition – COP, Unit of Refrigeration, Applications of refrigeration system, vapour compression refrigeration system, simple layout of summer air conditioning system.

Learning resources Textbook:

1. Fundamentals of Mechanical Engineering / G.S.Sawheny-PHI.
2. An Integrated Course in Mechanical Engineering / R.K.Rajput /BiralaPublications.
3. I.C. Engines / V. GANESAN-TMH.
4. Strength of Materials by R.K. Rajput, S.Chand&Company.

5. Thermal Engineering / R.K. Rajput / LakshmiPublications.

Reference Books:

1. Thermodynamics and Heat Engines / R. Yadav / Central BookDepot.
2. Strength of Materials by R.K.Bansal, LaxmiPublishers.
3. Engineering Mechanics Statics and dynamics by A.K.Tayal, Umesh Publication, Delhi.
4. Fundamentals of I.C.Engines - P.W. Gill, J.H. Smith &Ziurys- IBH & Oxfordpub.

Web resources:

1. http://nptel.ac.in/courses.php
2. http://jntuk-coeerd.in/
3. RGUKT CourseContent

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

CO 1	Awareness on basics of thermodynamics and Laws of thermodynamics.
CO 2	Students will be familiarized with some of the special casting and molding procedures used in industry and different welding techniques with their respective applications.
CO 3	Imparted knowledge about gear and belt drives used in automobile and industrial applications.
CO 4	Understand the basic components of Thermal plant
CO 5	Imparted knowledge about IC Engines, External combustion Engines.
CO 6	Knowledge of Refrigeration and air conditioning systems, which is playing prominent role in the present day industry.

Course Code	Course Name	Course Category	L-T-P	Credits
22ME2202	**Dynamics of Machinery**	**PCC**	**3-1-0**	**4**

Pre-requisite: Kinematics of machinery

Course Objectives:

1. The objective is to introduce some of the components mainly used in ICEngines and make analysis of various forcesinvolved.
2. Subject deals with topics like inertia forces in slider crank mechanism; IC Engine components & the analysis like governors isintroduced.
3. It also deals with balancing of rotating & reciprocatingparts.
4. Studies are made about balancing of multi cylinder engines, Radial engines etc. study of primary & secondary forces are considered whilebalancing.
5. Finally, they are introduced to the topic of vibrations. The study deals with linear, longitudinal, & torsionalvibrations.
6. The idea is to introduce the concept of natural frequency and the importanceof resonance and criticalspeeds.

Course Contents:

Unit I: (12 contacthours)

Static Force Analysis; Reciprocating Engine Mechanism, Quick Return Mechanism, Four LinkMechanism,FrictioninLinkages,SliderinEquilibriumundertheActionofConcurrent Forces, Slider in Equilibrium under the Action of Non concurrent Forces, Inertia Forces ofA Reciprocating Engine Mechanism, Four Link Mechanism, Quick Return Mechanism, More Details of Reciprocating EngineMechanism.

UnitII: (12 contacthours)

Dynamics of Reciprocating Engine Mechanism, Correction Torque, Bearing Loads of A Reciprocating Engine Example, Turning Moment Diagram and Flywheel, Turning Moment DiagramandCrankshaftSpeedFluctuation,FlyWheel,FlywheelofAnInternalCombustion Engine, Flywheel of A Punch Press, Analytical Expressions for the Turning Moment, Flywheel for ReciprocatingMachinery.

UnitIII: (8 contact hours)

Balancing of rotating components; Unbalance in one Plane, Unbalance in Several Planes, BalancingMachinesBalancingofLinkages;InertiaForceofAReciprocatingMass,Balancing of Multi cylinder In-Line Engine, Firing Order.

UnitIV: (10 contact hours)

MechanismsforControl:GovernorsandGyroscopes;IllustrationOfMechanisms InControl, Governors, Watt Governor, Porter Governor, Pronell Governor, PerformanceParameters, pring Controlled Fly-Ball [Hartnell] Governor, Spring Controlled Governor WithAuxiliary Spring [Wilson-Hartnell Governor], Spring Controlled Governor with Bell Crank attachedto the Sleeve, Hartung Governor, Pickering Governor, Governor Effort and Power, Controlling Force, Friction and Insensitiveness, Centrifugal Effect of the RevolvingArms.

UnitV: (8 contact hours)

Gyroscopes, Gyroscopic Forces and Couple, Thin Rod Rotating About Its Centroidal Axis, Gyroscopic Stabilization, Stability of A Four Wheel Vehicle Moving on A Curved Path, Stability of A Two Wheel Vehicle.

UnitVI: (10 contact hours)

Introduction to Mechanical vibrations-Types of vibrations, Longitudinal vibrations; Free and Forced vibrations (un damped) ,Whirling of shafts, Torsional vibrations (single Rotor and Two-rotor system), critical speeds of shafts. Damped vibrations, effect of damping, vibration isolation.

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

CO 1	Explain various mechanisms used in machines

CO 2	Analyze stabilization of sea vehicles, aircrafts and automobile vehicles.
CO 3	Evaluate frictional losses, torque transmission of mechanical systsms.
CO 4	Analyze dynamic force analysis of slider crank mechanism and design of flywheel.
CO 5	Evaluate the natural frequencies of continuous systems starting from the general equation of displacement. .
CO 6	Solve problems related to balancing of reciprocating and rotary masses.

Leairning Resource Books

1. Rattan, Sarjit S. *Theory of Machines*. Tata McGraw-Hill Education,2014.

Reference Books:

1. Uicker, John Joseph, Gordon R. Pennock, and Joseph Edward Shigley. *Theoryof Machines and Mechanisms*. Vol. 1. New York, NY: Oxford University Press, 2011
2. Mallik, Asok Kumar, Amitabha Ghosh, and Gunter Dittrich. *KinematicAnalysis and Synthesis of Mechanisms*. CRC Press,1994.

Web Resources: https: //nptel.ac.in/courses/112101096// https://nptel.ac.in/courses/112104114//

Course code	Course Name	Course Category	L-T-P	Credits
22ME2203	**Fluid Mechanics & Hydraulic Machinery**	**PCC**	**3-1-0**	**4**

Course Objectives:

1. To learn about the properties offluids
2. To understand the statics of fluid and kinematics & kinetics of fluidflow
3. To understand internal and external flow offluids
4. To understand the importance of dimensionalanalysis
5. To obtain the force exerted by a jet of fluid on various configurations ofplates
6. To analyze the flow in hydraulic turbines andpumps

Course contents:

Unit-I: **(Contact hours8)**

Introduction and Basic concepts : Definition of fluid, distinction between a fluid and a solid, concept of continuum, Properties of fluids- mass density, specific weight, specific volume, specific gravity, dynamic and kinematic viscosity, Newton's law of viscosity, variation of viscosity with temperature, vapour pressure, boiling point, cavitation, compressibility and surface tension, capillarity.

Pressure and Fluid Statics : Fluid pressure at a point, Pascal's law, pressure variationwith temperature, density and altitude, Measurement of pressure- Piezometer, U-Tube Manometer, Single Column Manometer, U-Tube Differential Manometer, Micro manometers,pressuregauges,Hydrostaticforcesonhorizontal,vertical,inclinedandcurved surfaces, Buoyancy and stability of floating and submergedbodies.

Unit-II: *(Contact hours10)*

Kinematics of Fluids: Lagrangian and Eulerian description, Classification of fluid flow - steady and unsteady flow; uniform and non-uniform flow; laminar and turbulent flow; rotational and irrotational flow; compressible and incompressible flow; ideal and real fluid flow; one, two and three dimensional flows; Stream line, path line, streak line and stream tube; stream function, velocity potential function. One-, two- and three -dimensional continuity equations in Cartesian coordinates, velocity and acceleration, types of motion of fluid, vortex flow.

DynamicsofFluid: Eulerequation,Bernoulli'sequationanditsapplications(Venturimeter, orifice meter and pitot tube), Reynolds transport theorem - conservation of mass, Navier- Stokes equations Vortex Flow – Free andForced.

Unit-III: *(Contact hours10)*

Internal Flow: Loss of head through pipes, Darcy-Wiesbatch equation, minor losses, total energy equation, hydraulic gradient line, Pipes in series, equivalent pipes, pipes in parallel,
flowthroughsiphon,powertransmissionthroughpipes,analysisofpipenetworks,water hammer in pipes, frictional loss in pipe flow, shear stress and velocity distribution in pipe flow.

Externalflow: BoundaryLayerAnalysis-Assumptionandconceptofboundarylayertheory. Boundary-layer thickness, displacement, momentum & energy thickness, laminar and Turbulent boundary layers on a flat plate; Laminar sub-layer, smooth and roughboundaries, local and average friction coefficients, separation and Control of Boundarylayer.

Unit-IV: *(Contact hours10)*

LaminarandTurbulentflow: LaminarFlow-Laminarflowthroughcircularpipes,annulus and parallel plates, Stoke's law. Turbulent Flow- Reynolds experiment, Transition from laminartoturbulentflow,definitionofturbulence,scaleandintensity,Causesofturbulence, instability,mechanismofturbulenceandeffectofturbulentflowinpipes.Reynoldsstresses, semi-empirical theories of turbulence, Prandtl's mixing length theory, universal velocity distribution equation, Resistance to flow of fluid in smooth and rough pipes, Moody's diagram.

Dimensional analysis: introduction, Non dimensional numbers: Reynolds, Froude, Euler, Weber and Mach number, Dimensional homogeneity, methods of dimensional analysis- Rayleigh's method and Buckingham Pi theorem, model analysis, similitude, dimensionless numbers and its significance, model laws.

Unit-V: *(Contact hours10)*

Fluid Machinery: Hydraulic Pumps: Centrifugal pumps- parts of a centrifugal pumps, work done by the centrifugal pump, multistage centrifugal pump, specific speed of centrifugal pump,priming of centrifugal pump, characteristic curves of centrifugal pumps and cavitation. Reciprocating pumps- parts of a reciprocating pump, work done by reciprocating pump, slip of reciprocating pump, indicator diagram.

UnitVI: ***(Contact hours12)***

Fluid Machinery: Hydraulic turbines: classification of turbines, impulse and reaction turbines,Peltonwheel,FrancisturbineandKaplanturbine-workingproportions,workdone, efficiencies, hydraulic design –draft tube- theory functions andefficiency.
Performance of hydraulic turbines: Geometric similarity, Unit and specific quantities, characteristic curves, governing of turbines, selection of type of turbine, cavitation, surge tank, water hammer problem.

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

CO 1	Analyze mathematically fluid flow situations and they will be able to evaluate the performance of turbines and pumps.
CO 2	Identify importance of various fluid properties at rest and in transit.
CO 3	Derive and apply general governing equations for various fluid flows
CO 4	Explain the concept of boundary layer theory and flow separation
CO 5	Create velocity and pressure profiles for any given fluid flow.
CO 6	Evaluate the performance characteristics of hydraulic turbines and pumps

Text Books:

1. R. K. Bansal, *Fluid Mechanics and Hydraulic Machines*, Laxmi Publications, Revised Ninth Edition,2017.
2. P. M. Modi and S. M. Seth, *Hydraulics and Fluid Mechanics including Hydraulic Machines,*, Standard BookHouse.

References

1. Som & Biswas, *Introduction to Fluid Mechanics and Fluid Machines,* TMH,2003.
2. Yunus A.Cengel, Jhon M. Cimbala, *Fluid Mechanics,* McGraw-Hill,2006.
3. Sadhu Singh, *Fluid Mechanics,* Khanna Publishing House,Delhi.
4. Introductory Fluid Mechanics*, Katz, Cambridge Univeristy press,*2014.
5. Frank. M. White, *Fluid Mechanics,* McGraw-Hill, 2008.

Video Reference links:

Title	**Expert Name**	**Details of Expert**	**Web link**
Fluid Mechanics	Prof. S.K. Som	IIT Kharagpur	http://nptel.ac.in/courses/112105171/

Text Reference links:

Title	Expert Name	Details of Expert	Web link
Introduction to Fluid Machines and Compressible Flow	Prof. S.K. Som	IIT Kharagpur	**http://nptel.ac.in/courses/112105182/**

Course Nature	**Theory**			
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
22ME3101	**Heat Transfer**	**PCC**	**3-1-0**	**4**

Course Objectives:

1. The aim of the course is to build a solid foundation in heat transfer exposing students to the three basic modes namely conduction, convection andradiation.
2. To provide the platform to understand the concept of steady and unsteady conduction.
3. To provide the platform to understand the concept of forced and freeconvection.
4. To provide the platform to understand the concept ofradiation
5. To provide the platform to understand the concept of heat exchanger anddifferent type of heatexchanger
6. To provide the platform to understand the concept of condensation andboiling

Course contents:

UnitI: **(6 hours)**

Introduction: Introduction, Modes of heat transfer (Conduction, Convection, Radiation), Material properties of importance in heat transfer,thermal conductivity, Specificheatcapacity,combinedmodesofheattransfer,conceptofthermalcontact resistance.

UnitII: *(12hours)*

Heat Conduction: Steady state one-dimensional heat conduction with and without generation of heat in simple geometries: plane wall, cylindrical and spherical walls, electrical analogy, critical thickness of insulation, extended surfaces (fins) heat transfer : fin equation (Infinitely Long Fin, Negligible Heat Loss from the Fin Tip (Insulated fin tip),Convection (or Combined Convection and Radiation)), fin efficiency, fin effectiveness, Heat transfer in common configurations: plane walls, long cylinders, spheres, conduction shape factor, 2D steady state heat conduction, Unsteady conduction: Lumped heat capacity system, transient heat conduction in infinite and semi-infinite walls, Heisler chart, Biot number.

UnitIII: *(12hours)*

Convection: Forced convection: Non dimensional numbers and its physical meanings: Nusselt, Prandtl and Reynolds number, Derivation of energy equation, concept of thermal boundary layer and derivation of thermal boundary layer
equation,flatplateinparallelflow(solutionbyenergyintegralmethod),cylinderin cross flow, internal flows: concept of thermally fully developed flow and its corollaries,fullydevelopedpipeflow,fullydevelopedchannelflowwithconstant wallheatflux,turbulentflowinpipes,Reynoldsanalogy.**Freeconvection:**Vertical plate at constant temperature, derivation of governing equation, recognition of dimensionless terms, and solution by integralmethod.

UnitIV: *(10hours)*

HeatExchangers: Classificationofheatexchangers(parallelheatexchanger,counter flow heat exchanger, compact heat exchanger, cross-flow heat exchanger, Shell-and- tube heat exchanger, Regenerative heat exchanger, ccondenser, Boiler, concept of fouling factor, overall heat transfer coefficient, analysis of heat exchangers: LMTD and NTUmethods.

UnitV: *(10hours)*

CondensationandBoiling: Poolboiling–regimes-calculationsonnucleateboiling, critical heat flux and film boiling. Film wise and drop wise condensation – nusselt's theory of condensation on a vertical plate - film condensation on vertical and horizontal cylinders using empiricalcorrelations.

UnitVI: *(10hours)*

Radiation Heat Transfer: Emission characteristics and laws of black-body radiation – Irradiation – total and monochromatic quantities – laws of Planck, Wien, Kirchoff, Lambert,StefanandBoltzmann–heatexchangebetweentwoblackbodies– concepts of shape factor – Emissivity – heat exchange between grey bodies – radiationshields
– electricalanalogyforradiationnetworks.Computeraidedheattransferanalysiswith cases dealt in the class and visualize temperaturedistribution.

Learning resources

Text Books:

1. J. P. Holman, *Heat Transfer*, Eighth Edition, McGraw Hill, 1997

References:

1. . A. Bejan, *Heat Transfer,* John Wiley,1993
2. F. P. Incropera, and D.P. Dewitt, *Fundamentals of Heat and Mass Transfer*, John Wiley, Sixth Edition,2007.
3. Massoud Kaviany, *Principles of Heat Transfer*, John Wiley,2002
4. Yunus A Cengel, *Heat Transfer: A Practical Approach*, McGraw Hill,2002
5. Heat Transfer, Sanford Klein, 2012 Cambridge UniversityPress

Video Reference links:

Title	**Expert Name**	**Details of Expert**	**Web link**
Heat and Mass Transfer	Prof. U. N. Gaitonde, Prof. S.P. Sukhatme	IIT Bombay	**http://nptel.ac.in/courses/112101097/**

Course Outcomes: After completing the course, the students will be clearly able to

CO 1	Evaluate the concept of conduction and solve practical problems related to conduction.
CO 2	Analyze the concept of convection and solve practical problems relatedto forced and free convection.
CO 3	Analyze the concept of radiation and solve practical problems related to radiation.
CO 4	Evaluate the concept of heat exchanger and analyze different types of heat exchanger.
CO 5	Evaluate to improve the heat exchanging capacity of a heat exchanger.
CO 6	Analyze the practical problems related to radiation heat transfer in day to day life.

Course code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
22ME3102	**Design of Transmission Elements**	**PCC**	**3-1-0**	**4**

Pre-requisite: Design of Machine Elements

Course Objectives:

1. Enable students to attain the basic knowledge required to understand, analyze, design and select machine elements required in transmissionsystems.
2. Reinforce the philosophy that real engineering design problems are open-ended andchallenging

3. Impart design skills to the students to apply these skills for the problems in real life industrialapplications
4. Inculcate an attitude of team work, critical thinking, communication, planning and scheduling through designprojects
5. Create awareness amongst students about safety, ethical, legal,and other societal constraints in execution of their designprojects.
6. Develop an holistic design approach to find out pragmatic solutions to realistic domestic and industrialproblems

Course contents:

UnitI: **(Contact hours8)**

Design of springs: Helical, compound and leaf springs.

UnitII: ***(Contact hours10)***

Clutches&Brakes:DesignofClutches:Singleplate,multiplateandconeclutches. DesignofBrakes:BlockandBandbrakes:Selflockingofbrakes:Heatgeneration inBrakes**.**

UnitIII: ***(Contact hours10)***

Design of belt drives: Belts, Ropes and Chains: Flat belts: Length & cross section, Selection of V-belts, ropes and chains for different applications.

UnitIV: ***(Contact hours12)***

Spur & Helical Gears: Spur Gears: Definitions, stresses in gear tooth: Lewis equationandformfactor,Designforstrength,Dynamicloadandwearload.Helical Gears: Definitions, formative number of teeth, Design based on strength, dynamic and wearloads.

UnitV: ***(Contact hours10)***

Lubrication and Bearings: Lubricants and their properties, Mechanisms of Lubrication, Bearing modulus, coefficient of friction, minimum oil filmthickness, HeatGenerated,Heatdissipated,BearingMaterials,Introductiontorollingcontact bearings - Selection of BallBearings.

UnitVI: ***(Contact hours10)***

Design of IC engines parts: piston, connecting and crankshaft.

Learning resources Textbooks

1. V.B. Bhandari,*Design of Machine Elements,* Tata McGraw Hill Publishing Company Ltd., NewDelhi.

References

1. Joseph E. Shigley and Charles R. Mischke. *Mechanical*

Engineering Design:
McGraw Hill International Edition,

2. Robert L. Norton, *Machine Design:* Pearson EducationAsia.
3. Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S. K. Somani,*Machine Design:* Tata McGraw Hill Publishing Company Ltd., New Delhi, Special Indian Edition.
4. Andrew D Dimarogonas, *Machine Design: A CAD Approach*: John Wiley Sons,Inc.

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

CO 1	Understand and apply principles of design of a helical and leaf springs
CO 2	Synthesis the design of clutches and brakes
CO 3	Design belt drives, rope and chain drives for various applications.
CO 4	Design spur gears and helical gears for various applications
CO 5	Analyze rolling contact bearing and its selection from manufacturer's catalogue.
CO 6	Expertise in design of sliding contact bearing in industrial applications.

Course code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
22ME3103	**Applied Thermodynamics**	**PCC**	**3-1-0**	**4**

Course learning Objectives:

1. To familiarize with the terminology associated with IC engines and to understand the basics of IC engines.
2. To understand combustion, and various parameters and variables affecting it in various types of ICengines.
3. To learn about various systems used in IC engines and the type of IC engine required for variousapplications
4. To learn about the different types of gas turbineengines
5. To understand the basics of compressors andturbines
6. To understand the concept of rocketpropulsion

Course contents:

Unit-I: InternalCombustionEngines (10 Contact hours)

Basic engine components, working principles of engines, classification of IC engines, application of IC engines, engine performance parameters, air standard cycles – Carnot, Stirling, Ericsson, Otto, Diesel, Dual, Lenoir, Atkinson, Brayton Cycles, Comparison of cycles, Testing and performance characteristics, Heat balance and Indicator Diagrams.

Unit-II: (10 Contacthours)

Fuels and Fuel ratings, Fuel feed systems - Carburetor, Mechanical & Electronic Fuel injection systems, Ignition Systems - Battery and Magneto ignition systems.

Unit-III: *(10 Contacthours)*

Normal and abnormal combustion in SI and CI Engines, Design and operating Parameters affecting engine performance, engine friction and lubrication, heat rejection and cooling, engine emissions and their control, Rotary Engines, Supercharging.

Unit V: GasTurbineengine: **(10 Contact hours)** Simple gas turbine cycle – single and twin shaft arrangements, intercooling, reheating, regeneration, closed cycles, optimal performance of various cycles, combined gas and steam cycles; Introduction to Axial-Flow Gas Turbine; Introduction to Centrifugal and Axial-Flow Compressors; CombustionChambers.

UnitVI:Compressors *(10 Contacthours)*

Classification –positive displacement and roto dynamic machinery – Power producing and powerabsorbingmachines,fan,blowerandcompressor–positivedisplacementanddynamic types – reciprocating and rotarytypes.

Reciprocating: Principle of operation, work required, Isothermal efficiency volumetric efficiency and effect of clearance, stage compression, under cooling, saving of work, minimum work condition for stage compression.

Unit VI: Jet androcket propulsion **(10 Contact hours)** Principle of jet propulsion, turbojet, turboprop, turbofan, pulsejet, ramjet, scramjet, thrust and propulsive efficiency; Rocket Propulsion**:** Introduction, principles of rockets, characteristics of rocket propulsion, classification of rockets, solid, liquid and nuclear propellant rocket, electrical arc plasmarocket.

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

CO 1	Demonstrate the working of IC engines and effect of different parameters on the operational characteristics of IC Engines
CO 2	Describe the different types of cycles used in IC Engines
CO 3	Analyze the performance parameters of IC Engines
CO 4	Ccalculate the performance parameters of gas turbine engines
CO 5	Apply the compressor and turbine concepts in gas turbine engines
CO 6	Calculate the performance parameters of rocket engine

Learning resources Text Books:

1. M. L. Mathur & R. P. Sharma, *Internal combustion engines,* Dhanpat Rai Publications,2013.
2. H. Cohen, GFC. Rogers and HIH Saravanamuttoo, *Gas Turbine Theory,* Longman House, Burnt Mill, Harlow,1996.

References

1. V Ganesan, *Internal Combustion Engines*, TMH,2006.
2. Jack D. Mattingly, *Elements of Gas Turbine Propulsion,* TMH, 2005.

3. George P. Sutton, Oscar Biblarz, Rocket Propulsion Elements, John Wiley & Sons,2001.

Video Reference links:

Title	Expert Name	Details of Expert	Web link
Basic Thermodynamics	Prof. S.K. Som	IIT Kharagpur	nptel.ac.in/courses/112105123/

Text Reference links:

Title	Expert Name	Details of Expert	Web link
Applied Thermodynamics	Prof. T. Sundararajan, Prof. U.S. Premananda Shet, Prof. J.M. Mallikarjuna	IIT Madras	http://nptel.ac.in/courses/112106133/

Course code	Course Name	Course Category	L-T-P	Credits
22ME3182	**Heat Transfer Lab**	**PCC**	**0-0-3**	**1.5**

Objectives:

1. To demonstrate the concepts discussed in the Heat & Mass Transfercourse
2. To experimentally determine thermal conductivity andheat transfer coefficient through variousmaterials.
3. To experimentally measure effectiveness of heatexchangers
4. To conduct performance tests on refrigeration & air conditioningsystems

List of Experiments:

1. Determination of thermal conductivity of a metalrod.
2. Determination of overall heat transfer co-efficient of a compositeslab.
3. Determination of efficiency of apin-fin.
4. Determination of heat transfer coefficient in naturalconvection.
5. Determination of heat transfer coefficient in forcedconvection.
6. Determination of emissivity of a givensurface.
7. Determination of Stefan Boltzman constant.
8. Determination of effectiveness of parallel and counter flow heatexchangers.
9. Determination of heat transfer rate in drop and film wisecondensation.
10. Determination of Thermal diffusivity of material in transient heatconduction

Course Outcomes:

CO 1	To practically relate to concepts discussed in the Heat & Mass Transfer course.
CO 2	To conduct various experiments to determine thermal conductivity and heat transfer coefficient in various materials
CO 3	To select appropriate materials & designs for improving effectiveness of heat transfer.
CO 4	To conduct performance tests and thereby improve effectiveness of heat exchangers.

Text Books:

1. J. P. Holman, *Heat Transfer*, Eighth Edition, McGraw Hill,1997

References:

1. . A. Bejan, *Heat Transfer,* John Wiley,1993
2. F. P. Incropera, and D.P. Dewitt, *Fundamentals of Heat and Mass Transfer*, John Wiley, Sixth Edition,2007.
3. Massoud Kaviany, *Principles of Heat Transfer*, John Wiley,2002
4. Yunus A Cengel, *Heat Transfer: A Practical Approach*, McGraw Hill,2002
5. Heat Transfer, Sanford Klein, 2012 Cambridge UniversityPress

Course code	Course Name	Course Category	L-T-P	Credits
22ME3183	**Applied Thermodynamics Lab**	**PCC**	**0-0-3**	**1.5**

Objectives:

To understand the principles and performance characteristics of thermal devices

List of Experiments:

1. Determination of flash & fire points of a given liquidfuels
2. Determination of the viscosity of a given fueloil
3. Flame propagation andstability

   a. Studying the characteristics of flame stability and methods to improve the stabilitylimits

   b. Determination of flame speed based on conemethod

   c. Determination of relation between flame speed and air-fuelratio

   a. Smithells flame separation demonstrations

4. Determination of the Calorific value of a givenfuel
5. Determination of performance characteristics of Four Stroke PetrolEngine
6. Determination of performance characteristics of Four Stroke DieselEngine
7. Determination of performance characteristics of Four Cylinder DieselEngine
8. Determination of performance characteristics of Variable Compression Four Stroke SingleCylinder Engine (Multi-FuelEngine)

   a. Plotting a powercurve

   b. Determination specific fuel consumption andefficiency

   c. Determining volumetric efficiency and airratio

   d. Influence of compression ratio on petrolengine

   e. Influence of ignition point on petrolengine

   f. Determining the optimum ignitionpoint

9. Performance test on vapor compression refrigeration testrig
10. Determination of performance characteristics of Absorption RefrigerationSystem.
11. Performance test on air conditioning testrig.

Outcomes:

The students who have undergone the Lab will be able to measure various properties of fuels and characterize the performance of thermal machinery.

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Course code	Course Name	Course Category	L-T-P	Credits
22ME3281	Computer Aided Modeling and Simulation Lab	PCC	0-0-3	1.5

Course Objectives:

1. To impart the student's skills required for modelling and analysis using softwarepackage.
2. To impart skills required for writing MAT LABCode
3. To study 2D and 3D beam deflections by using simulationsoftware.
4. To study thermal analysis and fluid flow analysis by using simulationsoftware.

Learning Outcomes:

Students will be able to

1. Model simple mechanical parts using modelingpackage
2. Analyze different engineering problems using analysispackage
3. Write and execute MAT Lab code for solving engineeringproblems.

List of experiments:

a) Using Modeling Package: (Any threeexperiments)

1. Sketching of a drawing withdimensions
2. Modeling of Stuffing Boxparts
3. Assembly of parts of FlangedCoupling
4. Modeling of parts of Eccentric and generation of orthographicviews
5. Modeling of links of four bar mechanism and simulation ofmechanism

b) Using analysis Package: (Any sixexperiments)

1. 2- D trussanalysis.
2. Static Analysis ofBeam.
3. Static Analysis of 3-Dstructure.
4. Steady state Heat TransferAnalysis.
5. Transient thermal analysis
6. Free vibration analysis ofBeam.
7. Harmonic Analysis of aBeam
8. Analysis of AxisymmetricProblem.

9. Analysis of Plane Stressproblem.
10. Stress analysis of a composite plate.
11. Buckling analysis ofcolumn.
12. Optimization of cantileverbeam.
13. Fluid analysis of elbow using AnsysFluent
14. Fluid flow and Heat Transfer analysis of elbow using ANSYSFLUENT
15. Radiation and Natural Convection analysis by using ANSYSFLUENT
16. Transient thermal analysis of a CylindricalPipe

C) Using MATLAB (Any twoexperiments)

Introduction to MATLAB–Vector and Matrix Manipulations–Matrix functions– Tools for Polynomials – Non linear algebraic equations - Solving Differential equations– writingfunctionsubroutines–basicinputandoutputfunctions–plotting functions.

1. Analysis of Bar structure using Finite ElementMethod
2. Analysis of Beam Structure using Finite ElementMethod
3. Analysis of Truss using Finite ElementMethod
4. Displacement, velocity and acceleration analysis of four barmechanism.

Open Ended Experiment:

- Analysis of connecting rod with composite material

Reference Books:

1. Sham Tickoo, *SOLID WORKS 2017 for Designers*, CAD CIM Technologies,3rdEdition
2. Saeed Moaveni, *Finite Element Analysis: Theory and Application with ANSYS*, PearsonPublishers
3. Rao V Dukkipati, *MATLAB for Mechanical Engineers*, New Age InternationalPublishers.

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

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EMPLOYABILITY SUBJECTS

Course Code	Course Name	Course Category	L-T-P	Credits
MM2101	Mineral Processing and Extractive Metallurgy	PCC	3-1-0	4

Course Learning Objectives:

1. To introduce mineralogy and ore sampling. Further to familiarize on principles of grinding operations and grindingmills.
2. To understand the physical laws of moving solid influids.
3. To study principals and equipment's of heavy media separation, jigging and tablingoperations.
4. To study principals and equipment's of floatation, magnetic separation processes; electrostatic separationprocesses.
5. To provide thermodynamics and kinetics concepts involved in metals extraction.
6. To explain various techniques, unit process and operations used in metal extraction.

Course Content:

UNITI (12 Hrs)

Mineralogy: Physical Properties of Minerals, Classification of various Rock Forming Minerals and its Occurrence, Ore sampling; Comminution: Theory of liberation of minerals, Crushers - Jaw, Gyratory, Cone, Rolls and toothed roll crushers, Types of grinding operations, Grinding Mills - Critical Velocity, Ball mills, Rod mills, tube mills and Stirred mills, Comminution laws - Rittinger's laws, Kick's law and Bond's law; Screening, sizing and sampling.

UNITII (8 Hrs)

Stokes and Newton's laws, Terminal velocity and its relation with size, Relation between time and velocity, Relation between distance traveled and velocity, Equal settling ratio, Free and hindered settling ratios, Quantifying concentrating operations: Ratio of concentration, recovery, selectivity index and economic recovery. Classification of classifiers, study of settling cones, rake classifier, spiral classifier and cyclones.

UNITIII (10 Hrs)

Heavy media separation: Principles, flow chart, different media used, Heavy media separation using heavy liquids and heavy suspensions, Washability curves for easy, normal and difficult coal; Jigging: Theory of jigging, Jigging machines, Design considerations in a jig; Tabling: Study of stratification on a table, Shaking tables, Wilfley table, Humphrey's spiral classifier.

UNITIV (10 Hrs)

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Flotation: Principles of flotation, Factors affecting flotation, Classification of collectors and frothers, Regulators factors affecting their efficiency, Flotation machines- Pneumatic and mechanical flotation cells, Application of flotation process for Cu, Pb and Zn ores; Magnetic separation processes; Electrostatic separation process; Dewatering techniques.

UNITV **(10 Hrs)**

Thermodynamic basis of metal extraction: Ellingham diagrams, predominance area diagrams, Pourbaix diagrams, concept of activity and activity scales; Slags and mattes and their physico-chemical properties; Kinetics of extraction process: kinetic theory, reaction rate theory, reaction across interfaces.

UNITVI **(10 Hrs)**

Pyrometallurgy: Principles of roasting and smelting; Hydrometallurgy: Principles of leaching, types of leaching, Properties of leaching solutions; Electrometallurgy: Principles of electrowinning and electrorefining; Types of electrolytes: Aqueous and non-aqueous electrolytes; Refining: Principles of refining, Different methods of refining.

Learning resources Text book:

1. Barry A. Wills, James Finch, "Mineral Processing Technology: An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery" Butterworth-Heinemann; 8 edition,2015
2. Ghosh and H.S. Ray, "Principles of extractive metallurgy" New Age International Publishers; Third edition,2018

Course Code	Course Name	Course Category	L-T-P	Credits
MM2283	**Phase Transformations and Heat Treatment Laboratory**	**PCCL**	**0-0-3**	**1.5**

List of Experiments

1. Study of heat treating furnaces andatmosphere
2. Study of TTT and CCTdiagrams
3. Annealing of medium carbon steel and observation of microstructure & hardness
4. Normalizing of medium carbon steel and observation of microstructure& hardness
5. Hardening of medium carbon steel and observation of microstructure&hardness
6. Study of tempering characteristics of hardenedsteel.
7. Spheroidizing of high carbonsteel
8. Determination of hardenability of a given steel using Jominy end Quench Test
9. Study of age hardening phenomenon in an aluminum alloy orbrass
10. Case Carburizing of low carbon steel and determination of casedepth

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11. Re-crystallization studies on cold worked copper or Cu –alloys
12. Cooling curve Analysis of Pb-Snalloys

Assessment Method

Assessment Tool	Experiments	Record	Viva-Voce/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	Course Name	Course Category	L-T-P	Credits
MMXX15	**Engineering Polymers**	**PEC**	**3-0-0**	**3**

Course Learning Objectives:

1. **To understand the polymer molecule in terms of its chain structure and, in addition, how the molecule may be generated from repeatunits**
2. To understand the number–average and weight–average molecular weights, and degree ofpolymerization
3. To learn synthesis, properties and applications of polymericmaterials

Course Content:

Unit-I: (10 Hrs)

Introduction to polymers and plastics**;** Conception of polymers, formation of polymers, types of polymers reactions such as addition and condensation, Mechanism of polymerization - Thermoplastic and Thermosetting materials methods of polymerization.

Unit-II: (10Hrs)

Polymeric structure, raw materials and properties; Classification of polymers, raw materials for polymers and their sources. Brief study of structure of polymers and properties. Glass transition temperature and its significance. Crystallinity of polymeric materials, effect of time, temperature, catalysts and solvents on polymer properties, molecular weight ofpolymers.

Unit-III: (10Hrs)

Compounding and fabrication of plastics, calendaring and casting. Recycling of Plastics, Functions of the following types of additives used in Polymers. 1. Fillers 2. Lubricants 3. Reinforcing agents 4. Plastricizers 5. Stabilizers 6. Antioxidants7. Inhibitors8.Promoters9.Catalysts10.Refarders11.Limitators12.Colorants13.

Cross-linking 14. Blowing agents 15. Photo degradiants 16. Bio-degradiants, laminated polymers.

Unit-IV: (Hrs)

Thermoplastics; Methods of addition polymerization, raw materials, manufacturing methods, properties and uses of the following ethenoid polymers; Polyethene (LDPE and HDPE), Polypropylene, Poly Vinyl Chloride, Polystyrene, Expanded polystyrene, Polytetra fluorethylene.

Unit-V: **(10Hrs)**

Thermosetting resins; Introduction of thermosetting polymers, methods of condensation polymerizatin, raw materials, manufacturing method, properties and uses of Phenol-Formaldehyde resin, Urea-formaldehyde resins, alkylresins.

Unit-VI: **(10Hrs)**

Raw materials, manufacturing methods, properties and uses of the following plastics Acetals, Nylons, Polymethyl, Methocrylate (PMMA), Saturated polysters – PETP and PC, Cellulose acetate and viscose rayon. Introduction of natural rubbers and synthetic rubbers like Buna-S, Buna-N, Thiokol, Polyurethane rubber and Silicon rubber.

Learning resources

Text book:

1. V.R. Gowariker, N.V. Viswanathan and Jayadev Sreedhar, "Polymer Science" New Age International (p) Ltd., New Delhi ,2010.
2. F.W. Bill Mayer, "Text book of polymer science" 3rd Edition – John Wiley & sons, Inc., New York,2011.

Reference Books:

1. Raymond Seymour, "An Introduction to Polymer Chemistry", McGraw Hill, New York,1971.
2. Charles A Harper, "Handbook of Plastics, Elastomers and Composites", McGraw Hill, USA, 1997.
3. McCrum N G, Buckley C P and Bucknall C B ,"Principles of Polymer Engineering", Oxford University Press,1992.

Course Code	Course Name	Course Category	L-T-P	Credits
MM2103	**Introduction to Transport Phenomena**	**PCC**	**3-1-0**	**4**

Course Objectives:

1. To introduce the concepts of fluid flow, heat transfer and masstransfer
2. To learn the fundamental connections between the conservation laws in heat, mass, and momentumtransfer
3. To obtain the basic skills essential for process modeling of materialsprocessing

Course Content:

UNITI **(10 Hrs)**

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properties of fluids, types of fluid flow, viscosity of liquid and gases, laminar flow, momentum balance general momentum equation (GME) and its application in flow of falling film, flow through a circular tube, flow between the parallel plates, application of Navier StokesEquations

UNITII **(10 Hrs)**

Turbulent flow: friction factors, flow past submerged bodies, flow through packed bed of solids, fluidized bed; Energy balanced application in fluid flow: conservation of energy, flow through valves and fitting, flow from ladles.

UNITIII **(10 Hrs)**

Steady state and Transient conduction in solids, One dimensional steady state problems of heat flow through composite walls, cylinder and spheres, Unsteady conduction in one dimensional system, Use of Heisler charts and applications; Convective heat transfer, equation of energy, free and forcedconvections.

UNITIV **(10 Hrs)**

Radiation, Nature of thermal radiation, Black and Grey bodies, Stefan and Boltzmann law, Kirchhoff's laws, Intensity of radiation, lamberts law, View factor, Heat transfer between two black walls in an enclosure; Combined effect of convection, conduction and radiation, Overall heat transfer coefficient; Important application of steady heat flow in Metallurgy.

UNITV **(10 Hrs)**

Laws of diffusion and their application, concept of mass transfer co-efficient and concentration boundary layer, Interfacial mass transfer, overall mass balance.

UNITVI **(10 Hrs)**

Dimensionless analysis: Rayleigh's method, Buckingham method, use of differential equations, Similarity criteria; Reaction Kinetics: Basic definitions and concepts, reaction mechanisms, reaction rate theories

Learning resources

Text book:

1. David R. Gaskell, "An Introduction to Transport Phenomena In Materials Engineering", Momentum Press; 2nd edition,2012
2. K. Mohanty, "Rate Processes in Metallurgy" PHI Learning Pvt. Ltd., 3 edition, 2009

Reference Books:

1. N.J. Themelis, "Transport and Chemical Rate Phenomena", Gordon and Breach Publishers, New York,1995.
2. R. Byron Bird, Warren E. Stewart and Edwin N. Lightfoot, "Transport Phenomena", John Wiley,2012.
3. D. R. Poirier and G. H. Geiger, "Transport Phenomena in Materials Processing", John Wiley & Sons,2010

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

1. **Formulate conservation statements in heat, mass, and momentum at multiscales from microscopic to macroscopic in both steady and unsteadymodes**
2. Apply knowledge of mathematics and physics to transport phenomena related to

materialsprocessing
3. Design materials processing (e.g., leaching, casting, welding, heat treating, electrolyzing, etc.) based on transport phenomena

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
MM2202	**Iron making Technology**	**PCC**	**3-0-0**	**3**

Course Learning Objectives:

1. To learn construction features of blastfurnace
2. To learn raw materials, their properties and it's testing for Ironmaking.
3. To understand the preparation of burden for Iron making
4. To study thermodynamics of reactions involved in ironmaking
5. To study recent developments in Blast Furnacepractice
6. To learn alternative routes of ironmaking

Course Content:

Unit-I: **(10 Hrs)**

History of Iron making; Principles of Iron Making: Reduction, Smelting, Direct Reduction, Smelt Reduction; Blast furnace: Constructional features, Profile, Refractories, Accessories, Charging mechanism, Gas cleaning system, Hot blast generation, Cooling system.

Unit-II: **(10Hrs)**

Occurrence and distribution of raw materials (iron ore, coal and flux) for iron making; Iron ore: properties, types, beneficiation, sizing, valuation; Fuels: Classification of fuels (solid, liquid and gas), their processing and their importance in blast furnace. Coking of coal, coal washing. Testing of coke for blast furnace. Problems of metallurgical grade coke in India and recent developments in coke making and blending; Principles of theory of combustion, combustion calculation, waste heat utilization; Fluxes and theirEvaluation

Unit-III: **(10Hrs)**

Agglomeration of Iron ore fines, Sintering: Principles, Factors affecting sintering, sintering mechanism, sintering machines; Pelletisation: Theory of pelletisation, Water- particles system. Production of green pellets; disk and drum pelletizers, Induration of pellets: Shaft and traveling grate; Quality demands for the blast furnaceburden.

Unit-III: **(10Hrs)**

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Physical, thermal and chemical profiles, physical chemistry of blast furnace reactions - carbon-oxygen reaction, gas-solid reactions in different zones of blast furnace, slag-metal reactions, kinetics of reduction, thermal efficiency, desulphurization and desiliconisation, mass and energy balances, Gruner's theorem, RAFT calculation, the Rist diagram.

Unit-V: **(10Hrs)**

Process Developments: Fuel injection, Oxygen injection, High top pressure, High temperature blast, their effect on coke rate and metal-impurity distribution in slag and metal; Operations: Operational steps, Blast furnace irregularities and remedial measures, Blast furnace gas, properties, cleaning and utilization.

Unit-VI: **(10Hrs)**

Idea about direct reduction process – DRI, HBI; Principles and technology of different coal based and gas based direct reduction processes like Rotary kiln, Rotary hearth, Midrex, HyL etc.; Concept of other smelting reduction processes like Corex, Romelt, HiSmelt, Finex etc., Advances in iron making.

Learning resources

Text book:

1. Tupkary, R. H. & Tupkary V.R., "An Introduction to Modern Iron Making", Khanna Publishers, New Delhi,2004.
2. Ahindra Ghosh and Amit chatterjee, "Iron Making and Steel Making – Theory and Practice", Prentice Hall of India Private Ltd., New Delhi2008.

Reference Books:

1. Biswas, A. K., "Principles of blast furnace iron making: theory and practice", SBA Publications, Kolkata,1994.
2. Dipak Mazumdar, "A First Course in Iron and Steel Making", Orient Blackswan Private Limited - New Delhi, 2015
3. Bashforth R, "Manufacture of Iron and Steel Making", MIR Publishers,1983.

Course Code	Course Name	Course Category	L-T-P	Credits
MM2201	Corrosion Engineering	PCC	3-1-0	4

Course Learning Objectives:

1. To study fundamentals ofelectrochemistry
2. To study different forms of corrosion and itsmechanisms
3. To learn different testing methods involved for analysis of corrosion and monitoring
4. To know different methods of corrosionproduction
5. To study degradation of non-metallicmaterials

Course Content:

UNITI **(10 Hrs)**

Rajiv

Concept of Degradation process – Mechanical and chemical process, Importance of corrosion, Classification of corrosion, Electro-chemical principles and aspects of corrosion, Faradays laws, corrosion rate expression, thermodynamic aspects of corrosion, equilibrium potential, Nernst equation for electrode potential, EMF and Galvanic series, Pourbaix diagram (Fe, Ni, Al & Zn), calculation of Corrosion Rates, high temperature corrosion-vapor species diagrams.

UNITII **(10 Hrs)**

General corrosion-atmospheric corrosion, galvanic corrosion, general biological corrosion; Localized corrosion-filiform corrosion, crevice corrosion, pitting corrosion, localized biological corrosion; Metallurgically influenced corrosion-inter granular corrosion, de-alloying; Mechanically assisted corrosion-erosion corrosion, cavitation corrosion, fretting corrosion, corrosion fatigue, environmentally induced cracking- mechanisms of stress corrosion cracking and hydrogen embitterment.

UNITIII **(10 Hrs)**

Corrosion current density and corrosion rate, Exchange current density, over potential–polarization-activation and concentration polarization-Tafel equation, mass transport control, mixed potential theory and behaviour of galvanic couples in acidic environments, effect of oxidizer, combined polarization, factors affecting polarizations

and rate of corrosion, Passivity-potentiostatic polarization curves, factors affecting passivity, mechanism of passivators.

UNITIV **(10 Hrs)**

Corrosion Testing: Purpose and classification, Dimensional change-NDT techniques, microscopic examination, weight loss method, salt spray test, tests for intergranular corrosion, and stress corrosion cracking. Electrochemical polarization techniques, Tafel extrapolation, linear polarization, AC impedance methods- electrochemical impedance spectroscopy. Corrosion Monitoring: On-stream monitoring-electrical resistance, linear polarization, hydrogen test probe, ultrasonic testing, radiography and corrosion coupons. Off-stream monitoring-acoustic emission testing, eddy current inspection, liquid penetrationinspection.

UNITV **(10 Hrs)**

Factors affecting Corrosion: Environmental variables and Metallurgical variables; Prevention: corrosion control-design, selection of materials-alloying-stainless steel and brass, oxidation resistant materials-control of high temperature oxidation, cathodic and anodic protection methods, corrosion inhibitors-types, applications, corrosion in cold water pipes, galvanizing, painting and coating.

UNITVI **(10 Hrs)**

Hot corrosion: Introduction to high temperature corrosion, Pilling Bedworth Ratio, oxidation kinetics, oxide defect structures, Wagner-Hauffe valence approach in alloy oxidation, Catastrophic oxidation, Internal oxidation, considerations in high temperature alloy design, prevention of high temperature corrosion- use of coatings, molten salt corrosion, liquid metalcorrosion.

Learning resources

Text book:

1. Fontana M. G., “Corrosion Engineering”, McGraw Hill Education, 2nd Edition, 2017
2. Raj Narayan. “An Introduction to Metallic Corrosion and its prevention”, Oxford &BH, New Delhi,1983.
3. Denny Jones, “Principles and Prevention of Corrosion”, Prentice Hall of India, 1996.

Reference Books:

1. ASM Metals Handbook. Vol.13,”Corrosion”. ASM Metals Park. Ohio. USA. 1994
2. Hihara L.H. and Adler R.P.I., Environmental Degradation of Advanced and Traditional Engineering Materials, CRCPress,2012
3. Pierre R. Roberge, “Corrosion Engineering principle and practice” McGraw Hill Inc.,2008.
4. Kenneth R Trethewey and John Chamberlain, "Corrosion for Science and Engineering", Longman Inc.,1996.

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

1. **Identify types and mechanism of corrosion in engineeringproblems**
2. Test the materials for corrosionbehavior
3. Suggest the suitable corrosion prevention method to improve life ofmaterials

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
MM2281	**Corrosion Laboratory**	**PCCL**	**0-0-3**	**1.5**

List of Experiments

1. Study the effect of concentration and temperature on conductivity of an aqueous electrolyte (Aq. NaCl).
2. Verification of Faraday’slaws.
3. Determination of corrosion rate by weight lossmethod

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4. Determination of corrosion rate by electro-chemicalmethod
5. Perform and observe the corrosion phenomenon of (a) Stress Corrosion Cracking in Brass/Mild Steel, (b) Crevice Corrosion of Stainless steel in chloride solution, (c) Pitting of StainlessSteel.
6. Studytheeffectofpassivefilmforthesystemsof(a)AlinCuSO4Solution,
   (b) Stainless Steel in HNO3
7. Perform electrolytic deposition (copper plating and nickel plating) and study effect ofparameters.
8. Anodize the given aluminium sample and colour with a dye and to measure the thickness of the oxidefilm
9. Understand the principles in galvanic cell corrosion using "Ferroxyl" indicating testsolution.
10. Conduct electropolishing of stainless steel using Nitric acidbatch
11. Study the effect of inhibitors oncorrosion
12. Determination of film stability of industrial protective coatings on metal sheet substrates to saltspray.
13. Corrosion studies of Copper sample by using Scanning ElectronMicroscope.

Assessment Method

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3102	**Solidification Process and Casting**	**PCC**	**3-1-0**	**4**

Course Learning Objectives:

1. To learn different methods and materials of moulding and pattern making
2. To familiarize with different casting techniques
3. To study the principles of solidification and microstructure formation during casting process
4. To understand casting hydrodynamics and heat transport
5. To familiarize with casting practice of different alloys.

Course Content:

Unit-I : (12 Hrs)

Introduction: Foundry as a manufacturing centre, Scope and development of foundry, Types of foundries; Pattern: Types of patterns, Pattern materials, Pattern allowances, Pattern layout, Pattern making; Moulding and Core Making:Types of moulding equipment, Moulding materials, Moulding sands, Properties and selection of materials and additives used, Core and core making;

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Testing of Foundry Sand: Strength, Permeability, Moisture content, Shatter Index, Mouldability, Compactability, Loss on ignition, Clay content, AFS grain fineness number.

Unit-II : (12 Hrs)

Green sand moulding process, Dry sand moulding process, CO2 moulding process, No bake moulding process, Shell moulding process, Investment casting, Permanent moulding, Pressure die casting, Gravity die casting, Continuous casting, Electroslag casting, Squeeze casting, Slush casting, Thixocasting and rheocasting processes, Cosworth process, Magnetic moulding, Impulse moulding, High pressure moulding, Vacuum sealed moulding process.

Unit-III : (12 Hrs)

Thermodynamics of solidification: liquid phase, cooling curve analysis of pure metal and alloy, thermal undercooling, molar free energy; Kinetics of solidification: nucleation phenomena, homogeneous nucleation, heterogeneous nucleation, nucleating sites and agents, controlled nucleation, dynamic nucleation; Growth during solidification: structure of the Interface, normal growth, growth by surface nucleation, growth on imperfections; formation of planar, cellular, dendritic and equiaxed structures; Solidification of alloys: short range and long range solidifying alloys, constitutional undercooling, eutectic growth, factors influencing freezing and control of alloy constituents; Solidification defects: segregation, shrinkage, porosity, hot tears, cold cracks.

Unit-IV : (10 Hrs)

Fluid dynamics: Fluidity, measurement of fluidity, effects of various parameters on fluidity, capillary flow, feeding mechanisms, centreline feeding resistance, principles of fluid flow; Gating: elements of gating system and their characteristics, aspiration of gases in gating system, filling time calculation, design of gating system, pouring basin, spure, sprue base well, runner, ingates; slag trap and filters, gating ratios

Unit-V : (10 Hrs)

Heat transport: solidification in sand mold, solidification in metal mold; Risering: risering practice, blind and atmospheric risers, riser size and location, risering curves, caine's method, NRL method and modulus methods, feeding distance, optimum risering practice, feeding aids, chills, padding.

Unit-VI : (4 Hrs)

Analysis of Casting defects: Surface defects, Discontinuity, Dimensional defects, Internal defects;

Learning resources

Text book:

1. Peter Beelay, "Foundry Technology", Butterworth-Heinemann, 2001.
2. Ramana Rao T.V. "Metal Casting Principles and Practice", New Age International (P) Limited, 2003.
3. Jain.P.L. "Principles of Foundry Technology" Tata McGraw- Hill Publishing Co., Ltd, 1995.

Reference Books:

1. Flinn, R.A. "Fundamentals of Metal Casting", Addison – Wesley, 1963.
2. Srinivasan, N. K. "Foundry Technology" Khanna Publications, 2001.
3. Heine, R. W. Loper, C.R. and Rosenthal, P.C. "Principles of Metal Casting" Tata McGraw Hill Publishers, 2003.
4. A. K Chakrabarti, "Casting Technology and Cast Alloys", PHI, 2008
5. K C John, "Metal Casting & Joining" PHI, 2015
6. P. C. Mukherjee, "Fundamentals of Metal casting Technology", Oxford IBH, 1980.

Course outcomes:

At the end of the course, the student will be able to

1. Select proper materials and methods for moulding, pattern making for different products
2. Design gating and risering systems
3. Choose correct melting furnace and melting practice for different casting metals and alloys.
4. Analyze the irregularities and cause of defects in castings and apply the remedial measures for immediate rectification

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5. To design moulds and pattern for making castings, to inspect a casting

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MM2205	**Science and Technology of Ceramics**	**PCC**	**3-0-0**	**3**

Unit 1:
Applications of ceramics, classification of ceramics,fine ceramics, Introduction: oxide and non-oxide ceramics, their chemical formulae, Rules for structure formation in oxides/ionic solids, Crystallography: structures and structure determination, Atomic structure and bonding in materials.
Unit 2:
Review of Bonding Characteristics of Ceramics (Madelung Constant, Born-Haber Cycle, Non- Bonding Electron Effects, Crystal Field Effect, Jahn-Teller Distortion) Crystal structure of materials, crystal systems, unit cells and space lattices, determination of structures of simple crystals by x-ray diffraction, miller indices of planes and directions, packing geometry in metallic, ionic and covalent solids. Concept of amorphous, single and polycrystalline structures and their effect on properties of materials.
Unit 3:
Defects and dislocations in ceramics,non-stoichiometry and typical properties, Defects equilibrium, Defects diffusion, Ionic and defect conductivity, Electronic properties of ceramics Unit 4:
Powder Preparation: Physical methods (different techniques of grinding), chemical routes - coprecipitation, sol-gel, hydrothermal, combustion synthesis, high temperature reaction (solid state reaction).
Unit 5:
Basic principles and techniques of consolidation and shaping of ceramics: powder pressing- uniaxial, biaxial and cold isostatic and hot isostatic, injection moulding, slip casting, tapecasting, calendaring, multilayering.
Unit 6:
Ceramics for energy and environment technologies (fuel cell, lithium battery, gas sensor and catalytic support)
TEXT BOOKS;

1. Introduction to Ceramics – W.D. Kingery et al – John Wikey
2. FINCER proceedings of workshop on fine ceramics synthesis, properties and applications – T.R. Rammohan et al.
3. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007

REFERENCE;

1. Hand Book of Fibre-reinforced composite materials - Ed. Lubin.
2. Fundamentals of Ceramics – M W Barsoum
3. Ceramics – Mechanical Properties, Failure Behaviour, Material Selection – D. Munz & T. Fett
4. Ceramic Science and Technology – Vol. 2 Material Selection and Properties Ed., Ralf Riedel and I –Wei Chen, Wiely -VCH

Assessment Method

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Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3104	**Semiconductor Materials**	**PCC**	**3-0-0**	**3**

Course Content:

Unit-I

Semiconducting materials – History and its relevance in modern world, types of semiconductors, elemental semiconductors, Formation of energy bands insolids, Concept of hole, Density of states and Fermi level, Intrinsic and extrinsic semiconductors

Unit-II

Equilibrium Carrier concentration, Recombination and Generation of carriers, Carrier transport – Drift and Diffusion, Equations of state – Continuity and Poisson equation, formation of pn junction – energy band diagrams of –pn junction, BJT, MOS Capicitor

Unit-III

Introduction to compound semiconductors & alloys, commonly used compound semiconductors, outline of the crystal structure, dopants and electrical properties such as carrier mobility

Unit-IV

Band gap engineering, direct and indirect band gap semiconductors, optoelectronic applications such as LEDs, LASERS

Unit-V

General Overview of Organic Semiconductors - Electronic transport in crystalline organic materials and conductive polymers - basics of Molecular Quantum electronics - Optical and Electrical Properties of Organic Semiconductor Material

Unit-VI

Processing and Fabrication of organic semiconductors: Spin coating, Evaporation, Sputtering, Electrospinning, Drop casting, Templating

Learning resources

Text book:

1. Semiconductor devices: Physics and Technology, S. M. Sze, Wiley India Private Limited.
2. Semiconductor Optoelectronic Devices, Pallab Bhattacharya, Pearson.
3. R.E. Hummel; Electronic Properties of materials.
4. Suganuma Katsuaki, Introduction to Printed Electronics, Springer, 2014 **Assessment Method**

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits

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20MM3181	**Materials Characterization Laboratory**	**PCC**	**0-0-3**	**1.5**

List of Experiments

1. Quantitative image analysis of phase fraction, grain size, nodularity and nodule count.
2. Calculation of structure factor of different crystal structures.
3. Determination of crystal structure by X-ray Diffraction (XRD)
4. Determination of lattice parameter by XRD
5. Determination of crystallite size by XRD
6. Determination of lattice strain of a deformed sample using XRD
7. Fractography analysis using Scanning electron microscopy (SEM)
8. Determination of interlamellar spacing of pearlite using SEM
9. Chemical analysis using energy dispersive X-ray analysis in SEM (spot and line analysis).
10. Study of Wulff net diagram, Stereographic projection & Pole Figures
11. Study of DSC, TGA and FTIR. **Assessment Method**

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3201	**Metal Joining and Non Destructive Testing**	**PCC**	**3-1-0**	**4**

Course Learning Objectives:

1. To learn principles of different materials joining processes
2. To study different welding process equipment'sand its operations
3. To study formation of microstructures during welding, brazing and soldering
4. To understand principles of joining of ferrous and non-ferrous alloys
5. To provide a brief knowledge about the basics of NDT and its classification. **Course Content:**

Unit-I : (10 Hrs)

Scope of metal joining, Techniques of metal joining, Mechanisms for obtaining metallic continuity, Classification of welding processes; Arc Characteristics: Plasma, electron emission and ionization potential, arc temperature, influence of magnetic fieldson arcs, arc blow, metal transfer, effect of polarity, effect of gases, Power Sources: Power source characteristics, static and dynamic characteristics, CC and CV power source designs,current and voltage relationships, solid state power sources.

Unit-II: (10 Hrs)

Detailed description about the process equipment, control of parameters, consumable,specifications for electrodes and filler metals and applications related to the following processes: Shielded metal arc welding,gas metal arc welding, flux cored arc welding, gas tungsten arc welding, plasma arc welding, submerged arc welding, studarc welding.

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Unit-III: (10 Hrs)

Principles, advantages disadvantages and fields ofapplication of the following welding processes:Oxy-fuel gas welding, Electro Slag Welding, Resistance welding, Electron Beam Welding, Laser beam Welding, thermit welding , solid state welding processes – friction welding, friction stir welding, explosive welding, ultrasonic welding, diffusion welding.

Unit-IV: (10 Hrs)

Thermal cycles in welding: Heat transfer in weldments, dissipation of welding heat, cooling rates, weld metal coolingcurves, peak temperature, calculating width of heat affected zones, solidification rate and effects of heat input; Development of residual Stresses and distortion; Comparison of welding processes based on these considerations, WELDING DEFECTS: Defects-appearances, their causes and remedies.

Unit-V: (10 Hrs) Scope and advantages of NDT, Comparison of NDT with DT. Classification of different NDT techniques. Liquid Penetrant Inspection: principle, applications, advantages and limitations, dyes, developers and cleaners, fluorescent penetrant test. Magnetic Particle Inspection: Principles, applications, magnetization methods, magnetic particles, dry technique and wet technique, demagnetization, advantages and limitations. Magnetic Flux Leakage Testing-principle, instrumentation and applications. ULTRASONIC TESTING: Types of ultrasonic waves, characteristics of ultrasonic waves, attenuation, couplants, probes, EMAT. Inspection methods-pulse echo, transmission and phased array techniques, types of scanning and displays, angle beam inspection of welds, time of flight diffraction (TOFD) technique, LASER ultrasonic testing, calibration: ASTM Test blocks, IIW-reference blocks.

Unit-VI: (10 Hrs)

ELECTROMAGNETIC INDUCTION TECHNIQUES: Principle, instrumentation and applications of Eddy current testing and remote field testing. RADIOGRAPHY TESTING: Sources-X-rays and Gamma rays and their characteristics-absorption, scattering. Filters and screens, Imaging modalities-film radiography and digital radiography (Computed, Direct, Real Time, CT scan). Problems in shadow formation, exposure factors, inverse square law, exposure charts, radiographic equivalence. Penetrameters, safety in radiography.

Learning resources

Text book:

1. Parmer R.S., "Welding Engineering and Technology", 1stEdition, Khanna Publishers, New Delhi, 2008.
2. Robert and Messler, Principles of Welding (Processes, Physics, Chemistry and Metallurgy), Wiley IntersciencePublishers, 2008
3. "Non Destructive Evaluation and Quality Control", Metals Handbook, Vol. 17, 9th Ed., ASM, 1989

Reference Books:

1. Lancaster, The Metallurgy of Welding, 6th Edition, William Andrew Publishing, NY, 2007
2. S Kou, Welding Metallurgy, John Wiley, USA, 2003
3. Welding Hand Book Vol. 5; 7th edition, AWS.
4. Baldev Raj, Jayakumar T, Thavasimuthu M, Practical Non-Destructive Testing, 3rd Ed., Narosa, 2009
5. Srivastava, K.C., "Handbook of Magnetic Particle Testing", Oscar Publications, 1998

Course outcomes:

At the end of the course, the student will be able to

1. Identify suitable joining methods for ferrous and non ferrous alloys
2. Explain formation of microstructure and development of mechanical properties during welding, brazing and soldering
3. Analyze different defects formation during joining processes and makes suitable remedies.
4. Recognize the importance of Nondestructive testing in the inpection and quality control.

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Explain the principles and procedures of nondestructive techniques.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MM3181	**Metal Joining and Non-Destructive Testing Laboratory**	**PCC**	**0-0-3**	**1.5**

List of Experiments

1. Preparation of a butt joint with mild steel plates using Arc welding process and observe the microstructure of welded joint
2. Welding and visual inspection of defects of mild steel specimens by gas welding
3. Preparation of a butt joint with mild steel strip using Tungsten Inert Gas (TIG) welding process and observe the microstructure of welded joint
4. Preparation of a butt joint with mild steel plate using MIG welding process and observe the microstructure of welded joint
5. Preparation of a butt joint with Aluminum plate using Friction Stir welding process and observe the microstructure of welded joint
6. Study the effect of various parameters of soldering and brazing processes on strength of joint.
7. Dye penetrant inspection.
8. Magnetic Particle inspection.
9. Ultrasonic thickness measurement and flaw detection.
10. X-ray radiography (Film Interpretation).
11. Eddy current testing. **Assessment Method**

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MMM402	**Advanced Materials and Processes**	**PEC**	**3-1-0**	**4**

Course Content:

Unit – 1 :

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Platonic solids, Quasicrystals, Symmetry of crystal structure (CTORHMT), Nano-crystalline Materials, Grain size variation from micron to nano size by several methods, Effect of grain boundaries, Phase solubility in nano crystalline state, Techniques to get nano crystalline state (Synthesis).

Unit – 2 :

Introduction, Zr-Ni system, Peak broadening effect, Solid state amoriphization, Amorphization criteria, Inherent grain stability, Factors affecting amorphization, Liquid state amorphization, Desiliconization, De-phosphorization, De-sulphurization.

Unit – 3 :

Introduction, Classification of quasicrystals, Effect of oxygen in quasicrystalline phase formation, Nano quasicrystals.

Unit – 4 :

Rapid solidification, Mechanical alloying, Emulsification droplet techniques, Advantages of extension of solid solubility. Ti-alloys, Shape memory alloys, Psuedo elasticity.

Unit – 5 : Introduction, Al-Si alloys, Al-Li alloys, Effect of the shape of precipitate, Nano composites of Al based alloys, Al-Ti alloy, Al-Ni alloys, Glass forming ability of Al-alloys.

Unit – 6 :

Strengthening mechanisms in pure metals, Effect of under cooling, strengthening mechanism in alloys, Ni-based, Fe-based & Co-based super alloys, Introduction to MMCs, In-situ composites, Advantages of In-situ processing and examples.

Learning resources

1.Video lectures by Dr.B.S.Murthy at https://www.youtube.com/watch?v=v1qwttBOdA&list=PL716BC63A7418B310.

Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MM4111	**Super alloys**	**PEC**	**3-0-0**	**3**

Course Objectives:

1. Acquire knowledge about super alloys and knowing the applications of super alloys.
2. Understanding the microstructure of wrought heat resistant alloys, Ni-base & Co-base alloys.
3. Understanding the dependency of properties on microstructure of super alloys.
4. Acquiring the knowledge of melting and forming methods involved in production of super alloys.

Unit-1 :

Introduction to super alloys, Guide to selection of super alloys, Wrought Super alloys, Heatresistant Castings.

Unit-2 :

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Microstructure of Wrought Heat –Resistant Alloys, Microstructure of Ni-base & Co-base heat resistant casting alloys. Temperature and Time-dependent Transformation. Application to Heat Treatment of High temperature Alloys.

Unit-3 :

Relationship of properties to Microstructure in super alloys. Fracture properties of super Alloys. High temperature corrosion and use of castings for protection. Effect of physical metallurgy and process variables on the microstructure of wrought super alloys. Process and Metallurgical factors affecting on super alloys and other high temperature materials.

Unit-4 :

MELTING PROCESS: Melting of super alloys: Principles and practices of vacuum Induction. Melting and Vacuum Arc Re-melting.

Unit-5 :

FORMING METHODS: Forming and fabrication of Super alloys: Recent developmentsP/M of super Alloys-Production of components by Hot-Isostatic pressing. Casting Methods- Improving turbine blade performance by solidification control-The development of single crystal turbine blades.

Unit-6 :

Quality of super alloys casting: Heat Treating of Heat resistant alloys.

Text books:

1. Super alloys: Source book: Mathew J.Donachie .Jr.Editor:1984
2. The Super alloys: edited by Chester T.Sins and William C Haagel: 1972.Campbell IE 3.High temperature technology, John wiley and Sons Inc.;1956

Course Outcomes:

By the end of this course, students will be able to

1. Acquire knowledge about super alloys and knowing the applications of super alloys.
2. Study the microstructural aspects of wrought heat resistant alloys, Ni-base & Co-base alloys and correlate properties of super alloys with their microstructure.
3. Identify different melting and forming methods involved in production of super alloys.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MM4202	**Nuclear Materials**	**PEC**	**3-0-0**	**3**

Course Learning Objectives:

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1. To explain and describe the basics of nuclear technology and relevance of metallurgy to nuclear interactions and reactions.
2. The studies on radiation effects and thermal cycling on fissile and non-fissile materials.
3. To explain Reactor Components: Types and classifications of reactors. Materials for Nuclear Reactors.
4. The studies on Control rods, reflectors and shielding materials. Production and processing of Reactor Materials.
5. To gain a working knowledge of extraction and commercial production methods of nuclear metals like Uranium, Thorium, and Beryllium.
6. In detail studies on Nuclear Power Production in India and its economics

Course Content:

Unit-I :

Elementary Nuclear Physics and Chemistry: Structures of nucleus, radioactivity, bending energy: nuclear interaction: fission and fusion: nuclear reaction: energy, release and chain reactions: neutron cross-section: multiplication and criticality concepts and factors.

Unit-II:

Mechanisms of moderation, radiation detection, radiation effects on fissile and non fissile materials: radiation damage and radiation growth: thermal cycling: protection against radiations

Unit-III:

Reactor Components: Types of reactors and classifications. Materials for Nuclear Reactors: Considerations in selection and properties of common materials used as fuels, their physical and chemical properties: canning materials: coolants.

Unit-IV:

Control rods: reflectors and shielding materials. Production of Reactor Materials: Occurrence and general characteristics of nuclear minerals. Indian Resources: Flow sheets of processing of nuclear minerals for the production of nuclear grade uranium.

Unit-V:)

Flow sheets of processing of nuclear minerals for the production of nuclear grade
Thorium, beryllium and zirconium with emphasis on basic scientific principles involved.

Unit-VI:

Production and enriched uranium and fabrication of fuel elements. Processing of irradiated fuel for recovery of plutonium. Nuclear Power Production in India and its economics

Learning resources

Text book:

1. Metallurgy in Nuclear Power Technology: Wright JC, Iliffe Book Ltd., 1962.
2. Nuclear Reactor Metallurgy: Wilkinson WD and Murphy WF, Van Nostrand, 1958.

Reference Books:

1. Principles of Nuclear Reactor Engineering: Glasstone S and Snesonske A Macmillan, London.
2. Uranium and Thorium: Grainger L; George Newnes Ltd., London.
3. Nulcears Fuels: Gurinsky DH and Dienes JL; Macmillan.

Web resources:

1.https://nptel.ac.in/courses/112101007/downloads/Lecturenotes/Lecture1.pdf1

Course outcomes:

At the end of the course, the student will be able to

1. The student willget idea about the working of nuclear reactors and applications in nuclear reactor.
2. The student will be acknowledged with the Elementary Nuclear Physics and Chemistry involved in nuclear materials.
3. The student able to know the Justify the extraction techniques adopted for Uranium, Beryllium, Thorium and Zirconium.

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4. The student will understand the processing of nuclear minerals for the production of nuclear grade Uranium, Thorium, beryllium and zirconium.
5. The student will able to understand the Nuclear Power Production in India and its economics.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20BM4101	**Managerial Economics & Financial Analysis**	**HSC**	**3-0-0**	**3**

Course Learning Objectives:

1. To strengthen students managerial skill.
2. To enhance the conceptual clarity in economic concepts.
3. To develop to forecasting capability.
4. It will help to produce multi-disciplinary thought.
5. It will enhance their conceptual and practical/hand on practice in accounting.
6. It will help to implement and understand the uses of ratios.

Course Contents:

Unit I: **(7 hours)**
Introduction to managerial economics, consumer behavior, demand, demand analysis, demand forecasting, supply, supply analysis.

Unit II: **(7 hours)**
Theory of production, production functions, concept of cost, cost analysis, break even analysis.

Unit III: **(7 hours)**
Market structure-monopoly, oligopoly, monopolistic, prefect market; Types of business organizations-sole proprietorship, partnership, private ltd. Companies and public ltd. Companies, formation of company.

Unit IV: **(8 hours)**
Introduction to capital, capital sources, capital budgeting- NPV, IRR, Payback period, profitability index.

Unit V: **(8 hours)**
Introduction to financial accounting, rules of debit-credit, Double-Entry Book Keeping, Journal, Ledger, Trial Balance- Final Accounts (Trading Account, Profit and Loss Account and Balance Sheet with simple adjustments, Preparation of final account and other related accounting statements.

Unit VI: **(8 hours)**
Financial statements, comparative statement analysis, common- size statement analysis, ,ratio analysis, time series (only theories).

Learning resources

Text book:

1. 1. Aryasri, A. R., *Managerial Economics & Financial Analysis*, McGraw Hill, 2014.

Reference Books:

1. Siddiqui., *Managerial Economics & Financial Analysis*, 2e, New Age International Private Limited, 2017.

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2. . Pandey, I.M., "*Financial Management*", 11e, Vikas Publishing House, 2015.
3. . Prasanna Chandra., "*Financial Management: Theory and Practice*", 9e, Mc Graw Hill Education, 2015.

Web resources:

1. Managerial Economics and Financial Analysis, Dr. Trupti , IIT Bombay *http://nptel.ac.in/courses/110101005/*

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

CO 1	A student will be able to understand basic economics as well as management concepts.
CO 2	This subject will provide implication facilities of concepts.
CO 3	Students can be able to do primary data collection and classification.
CO 4	Students can also be able to forecast as well as generate trend series by utilizing the available secondary data.
CO 5	They have basic knowledge about accounting and its terminologies.
CO 6	They will be able to prepare and understand accounting tables.

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
23CH2103	Mechanical Unit Operations	PCC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Learn the basic principles of characterization of particles and bulk solids;
2. Familiarize the construction and operation of crushers, mixers, blenders, settling tanks, industrial sieving equipment and filtration equipment.
3. Explain mechanism and working of mechanical separation, mixing, filtration, transportation of particulates and size reduction equipment.
4. Calculate the power consumption of the equipment's for mixing, size reduction operations.
5. Illustrate the Scale-up and Designing procedure for process equipment like mixture, filter press, cyclones and clarifiers
6. To understand the miscellaneous mechanical operations.

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Course Content:

Unit I (8 contact hours)

Properties and handling of particulate solids

Introduction to Unit operations and their role in Chemical Engineering industries; Characterization of solid particles, differential & cumulative analysis; properties of particulate masses, storage of solids, flow out of bins

Unit II (7 contact hours)

Mixing and transportation of particulate solids

Agitation and mixing: Agitation of liquids, axial and radial flow impellers, power consumption in agitated vessels, types of mixers, mixers for cohesive solids, mixers for free flowing solids.

Transportation of solid particulate mass, belt, screw, apron conveyers, bucket elevators, pneumatic conveying.

Unit III (8 contact hours)

Size reduction equipment and mechanical separations

Size reduction: Principles of comminution, laws of crushing: Rittinger's law, Kick's law and Bond's law.

Size reduction equipment: crushers, grinders, ultra-fine grinders, cutting machines; Equipment operation: open-circuit and closed-circuit operation.

Mechanical separations: Screening; industrial screening equipments, capacity and effectiveness of screens.

Unit IV (8 Contact hours)

Filtration

Classification of filters, cake filters, centrifugal filters, principles of cake filtration, compressible and incompressible filter cakes, constant pressure filtration, principles of centrifugal filtration, continuous filtration, constant rate filtration, washing filter cakes, clarifying filters, liquid clarification, gas cleaning, principles of clarification, cross flow filtration and types of membrane filtration.

Unit V (7 Contact hours)

Separations based on motion of particles through fluids

Gravity settling processes: gravity classifiers, sorting classifiers - sink and float methods, differential settling methods; clarifiers and thickeners, flocculation, batch sedimentation, clarifiers and thickeners design; centrifugal settling processes - cyclone separators, cyclone analysis, hydroclones, centrifugal decanters, principles of centrifugal sedimentation.

Unit VI (7 Contact hours)

Miscellaneous separations

Coagulation, impingement separators, scrubbers, froth flotation-separation of ores, flotation agents; electrostatic precipitators and magnetic separators.

Learning Resources:

Text Book:

1. W.L. McCabe and J.C. Smith and Peter Harriott, *'Unit Operations in Chemical Engineering'*, McGraw Hill, 5th Edition

Reference Books :

1. C.M. Narayanan & B.C. Bhattacharyya, *'Mechanical Operations for Chemical Engineers '*, Khanna Publishers, 3rd Edition
2. J.H. Perry, *'Chemical engineers hand book'*, McGraw Hill, 7th Edition
3. Kiran D. Patil, *'Mechanical Operations (Fundamental principles and Applications)'*, NiraliPrakashan, Revised 2nd Edition
4. Walter L. Badger, Julius T. Banchero, Introduction to Chemical Engineering, McGraw-Hill Inc.,1955

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Web resources:

1. https://nptel.ac.in/courses/103107123/

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

CO 1	Illustrate and apply the basic methods of characterization of particles and bulk solids
CO 2	Demonstrate the construction and operation of crushers, mixers, blenders, settling tanks, industrial sieving equipment and filtration equipment.
CO 3	Choose mechanical separation, mixing, filtration, transportation of particulates and size reduction equipment needed for a particular process industry.
CO 4	Calculate the power consumption of the equipments for mixing, size reduction operations.
CO 5	Utilize the technological methods related to unit operations in process plant
CO 6	Scale-up and Design a mixing tank, filter press, cyclones and clarifiers

Course Nature			**Theory**	
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

22BE4101	**Environmental Studies**	**MC**	**2L: 0T: 0P**	**0 credits**

Course Learning Objectives

- To provide knowledge about multidisciplinary nature of environment, various sourcesof naturalenergy.
- Understanding of ecosystem structure and functionetc.
- Knowledge of biodiversity andconservation
- Understanding of problems caused by pollution and itsimpact
- Understanding about the various social issues related toenvironment.

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- Awareness for the Environment and humanhealth

Course Content

Unit-I **(5hours)**

The Multidisciplinary Nature of Environmental Studies: Definition, scope and importance; Need for public awareness.

Natural Resources: Renewable and Non Renewable Resources:

Natural resources and associated problems.

a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people. b) Water resources: Use and over- utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies. d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies. e) Energy resources: Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources. Case studies. f) Land resources: Land asa resource, land degradation, man induced landslides, soil erosion and desertification. Role of an individual in conservation of natural resources. Equitable use of resources' for sustainablelifestyles.

Unit-II *(5hours)*

Ecosystems: Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers, Energy flow in the ecosystem, Ecological succession, Food chains, food webs and ecological pyramids, Introduction, types, characteristic features, structure and function of the following ecosystem:-a. Forest ecosystem, b. Grassland ecosystem, c. Desert ecosystem, d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries).

Unit-III *(5hours)*

Biodiversity and It's Conservation: Introduction – Definition: genetic, species and ecosystem diversity, Biogeographical classification of India, Value of biodiversity: consumptive use,productive use, social, ethical, aesthetic and option values, Biodiversity at global, National and local levels, India as a mega-diversity nation, Hot-sports of biodiversity, Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts, Endangered and endemic species of India,Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

Unit-IV ***(5hours)***

Environmental Pollution: Cause, effects and control measures of:-a. Air pollution, b. Water pollution, c. Soil pollution, d. Marine pollution, e. Noise pollution, f. Thermal pollution, g. Nuclear hazards, Solid waste Management: Causes, effects and control measures of urban and industrial wastes, Role of an individual in prevention of pollution, Pollution case studies, Disaster management: floods, earthquake, cyclone and landslides.

Unit-V ***(5 hours)***

Social Issues and the Environment: From Unsustainable to Sustainable development Urban problems related to energy, Water conservation, rain water harvesting, watershed management, Resettlement and rehabilitation of people; its problems and concerns. Case Studies, Environmental ethics: Issues and possible solutions.• Climate change, global warming, acid rain, ozone layer depletion, nuclearaccidents and holocaust. Case Studies. Wasteland reclamation, Consumerism and waste products, Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest ConservationAct, Issues involved in enforcement of environmental legislation, Publicawareness.

Unit-VI ***(5hours)***

Human Population and the Environment: Population growth, variation among nations, Population explosion – Family Welfare Programme, Environment and human health, Human Rights, Value Education, HIV/AIDS, Women and Child Welfare, Role of Information Technology in Environment and human health, Case Studies.

Learning resources Text book

1. ErachBharucha, '*Textbook of Environmental studies*',UGC

Reference Books

Clark RS, '*Marine Pollution*', Clanderson Press, Oxford (TB).
De AK, '*Environmental Chemistry*', Wiley Eastern Ltd.

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

CO1	Well understanding about their surrounding natural resources and their conservation
CO 2	Able to understand the ecosystem food chain and habitat.
CO 3	Develop the practices for conservation of biodiversity
CO 4	To well understand the pollution courses, impact and prevention from pollution
CO 5	Able to bring about an awareness of a variety of environmental concerns.
CO 6	It attempts to create a pro-environmental attitude and a behavioral pattern in society that is based on creating sustainable lifestyles.

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Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

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22BM32XX	Product Design and Innovation	HSC	1L: 0T: 0P	1 credit

Note: Will be updated after dept of Management BOS.

Course Learning Objectives

1. To make awareness of the product designprocess.
2. This course will give an understanding of methods, tools and techniquesapplied
3. in productdesign.
4. This course will enhance the overview of innovation, product designprocess.
5. It will help to understand competitive benchmarking, aspects of human factorsin
6. product design, tools for creative concept.
7. one of the objective of this course is to explain lectures including case studiesand
8. hands-onexercises.
9. It will help students to generate creative ideas in to product design,considering
10. human factorsaspects.

Course Contents

Unit I **(2 hours)**

Need for Innovation and design ,user Innovation , introduction to product and Product design, difference between Product development and product design.

UnitII ***(2 hours)***

Need Problem Identification, user study by contextual enquiry, questionnaire study, Interview techniques, Persona and scenario mapping, product study and market study, design brief.

UnitIII ***(2 hours)***

Importance of human factors in product design, physical ergonomics, principles and issues, ergonomic assessment tool, Cognitive issues in product design.

UnitIV ***(3 hours)***

Creative techniques and tools, concept generation, concept evaluation, concept design and presentations.

Unit V ***(4 hours)***

Product prototype, model making work flow for prototype, tools and techniques for model making and prototyping, introduction to prototype driven innovation.

Unit VI ***(2 hours)***

Overview of materials and processes, Evaluation tools and techniques for User- Product interaction

Learning resources Text Books

1. Eppinger, S., & Ulrich, K., '*Product design and development*', McGraw-Hill Higher Education, 2015.

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2. Green, W., & Jordan, P. W. (Eds.), '*Human factors in product design: current practice andfuture trends*'. CRC Press,1999.

Reference Books

1. Sanders, M. S., & McCormick, E. J., '*Human factors in engineering and design*', Mcgraw-Hill book company,1993.
2. Roozenburg, N. F., &Eekels, J., '*Product design: fundamentals and methods*' (Vol. 2). John Wiley &Sons Inc., 1995.

Web resources:

1. Dr. DebayanDhar, NPTEL-IIT Guwahati, 'Product Design and Innovation'. URL:https://nptel.ac.in/courses/107103082/

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

CO 1	A student will be able to understand basic of production design
CO 2	This subject will provide implication facilities of methods, tools and techniques of production design.
CO 3	Students can be able to correlate human factor and competitive benchmarking in product design.
CO 4	Students can have practical experience by implementing theory in case studies.
CO 5	They can enhance their creativity in product design.
CO 6	They will be able to create their own product design with implementation of available theoretical knowledge.

Assessment Method

Assessment tool	Monthly Seminar	Report submission (End Semester)	Total
Weightage (%)	75%	25%	100%

*Note:

1. Industry personnel/start company founding personnel may be included in this course.
3. In Assessment Method, among one of the monthly seminars, the student is supposed to submit video recording of seminar and the same should be played in the classroom.

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Coursecode	Coursename	CourseCategory	L-T-P	Credits
20HS2103	ProfessionalEthics	MC	2-0-0	0

CourseLearningObjectives:

1. To enable the studentsto imbibe and internalize the Valuesand Ethical Behaviourin theirPersonal andProfessionallives.
2. Enablestudentstomaintaintheirprofessionalisminthefuture.
3. Toutilizeethicsintheirworkplace.
4. Toensureahealthyworkingenvironment

CourseContents:

UnitI:IntroductiontoProfessionalEthics **(5hours)**
Basic Concepts, Governing Ethics, Personal & Professional Ethics, Ethical Dilemmas, Life Skills, Emotional In-telligence, Thoughts of Ethics, Value Education, Dimensions of Ethics, Profession and professionalism, Profes-sional Associations, Professional Risks, Professional Accountabilities, Professional Success, Ethics and Profes-sion.

UnitII:BasicTheories (5hours
)
Basic Ethical Principles, Moral Developments, Deontology, Utilitarianism, Virtue Theory, Rights Theory, CasuistTheory, Moral Absolution, Moral Rationalism, Moral Pluralism, Ethical Egoism, Feminist Consequentialism, MoralIssues,MoralDilemmas,MoralAutonomy.

UnitIII:ProfessionalPracticesinEngineering
(7ho
urs) Professions and Norms of Professional Conduct, Norms of Professional Conduct vs. Profession; Responsibilities,Ob-ligationsandMoralValuesinProfessionalEthics,Professionalcodesofethics,thelimitsofpredictability andre-sponsibilitiesoftheengineeringprofession.CentralResponsibilitiesofEngineers–TheCentralityofResponsibili-ties of Professional Ethics; lessons from 1979 American Airlines DC-10 Crash and Kansas City Hyatt Regency WalkawayCollapse.

Unit-IVWorkPlaceRights&Responsibilities **(5hours)**Ethics in c
Res-ervation.Ethicsinchangingdomainsofresearch.

UnitV:Misconduct (4hours)
The US government-wide definition of research misconduct, research misconduct distinguished from mistakesanderrors, a recent history of attention to research misconduct, the emerging emphasis on understanding and fosteringresponsibleconduct,responsibleauthorship,reviewing &editing.

UnitVI:GlobalissuesinProfessionalEthics
(4hours
)
Introduction – Current Scenario, Technology Globalization of MNCs, International Trade, World Summits, Issues,Business Ethics, and Corporate Governance, Sustainable Development

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Ecosystem, Energy Concerns, Ozone Deflec-tion, Pollution, Ethics in Manufacturing and Marketing, Media Ethics; War Ethics; Bio-Ethics, Intellectual PropertyRights

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LearningResources

Textbooks:
ProfessionalEthics:R.Subramanian,OxfordUniversityPress,2015.
EthicsinEngineeringPractice&Research,CarolineWhitbeck,2nd edition,CambridgeUniversityPress 2015.

Referencebooks:
EngineeringEthics,ConceptsCases:CharlesEHarrisJr.,MichaelSPritchard,MichaelJRabins,4th edition,CengageLearning,2015.
Business Ethicsconcepts &Cases:ManuelGVelasquez,6e,PHI,2008.

Webresources:

Prof.A.K.Sharma,'*ProfessionalEthics*' https://nptel.ac.in/courses/109104068/30

CourseOutcomes:

At theendofthecourse,thestudentwillbeableto

CO1	ThestudentswillunderstandtheimportanceofValuesandEthicsintheirpersonallivesandprofes-sionalcareers.
CO2	Thestudentswilllearntherightsandresponsibilitiesasanemployee,teammember,andaglobalcitizen
CO3	Studentswilldevelopajudgmentalcapabilityforrightandwrong
CO4	Thiswillprovideasystematicfollowingofprofessionalcareer
CO5	Itwillcreateabetter workingenvironment

S.No	UnitNumber	NumberofHours		Totalnumber ofclasshours
		Lecturehours(L)	Tutorialhours(T)	
1	Unit I	5	0	8
2	UnitII	5	0	10
3	UnitIII	7	0	10
4	UnitIV	5	0	12
5	Unit V	4	0	12
6	UnitVI	4	0	08
Totalhours		25	0	25

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22HS3101	**Constitution of India**	**MC**	**1L: 0T: 0P**	**0 credits**

Course Learning Objectives

1. The basic objective of the course is to provide knowledge aboutinstitutions
2. It help to understands the processes to governing the society in a systematicway.
3. It helps to establish social Justice, Liberty, Equity andFraternity.
4. The course will introduce the idea of political system ingeneral
5. It provides idea about working process of constitutionalinstitutions.
6. To create awareness about the functioning of the judicial system inIndia.

Course Contents

Unit-I **(2hours)**

Introduction-Constitution' meaning of the term, Indian constitution sources and constitutional history, Features: Citizenship, Preamble, Fundamental Rights and duties, Directive Principles of State Policy.

Unit-II ***(3hours)***

Union Government and its Administration-Structure of the Indian Union: Federalism, centre-state relationship, President: Role, power and position, PM and Council of ministers, Cabinet and Central Secretariat, Loksabha, Rajyasabha.

Unit-III ***(2hours)***

Election commission- Election commission: Role and functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and functioning, Institute and Bodies for the welfare of SC/ST/OBC and women.

Unit-IV ***(2hours)***

State Government and its Administration- Governor: Role and position, CM and Council of ministers, state secretariat: Organization, structure and functions.

Unit-V ***(3hours)***

Local Administration-District's Administration head: Role and importance, Municipalities: Introduction, Mayor and role of Elected Representatives, CEO of Municipal Corporation, Panchayati raj: Introduction, PRI: Zilla Panchayat, Elected officials and their roles, CEO Zilla Panchayat: Position and role, Block level: Organizational Hierarchy (different departments), Village level: Role of elected and appointed officials, Importance of grass root democracy.

Unit-VI ***(3hours)***

Union Judiciary-Establishment and constitution of Supreme court, Appointment of Judges, Establishment of State High court, Establishment of common High court for 2 or more states, WRITS, PIL(Public Interest Litigation).

Learning resources
Text books

1. Durga Das Basu, *Constitutions of India*, 23rd ed, LexisNexis Publication.

Reference Books

Indian Polity by Laxmikanth
Indian Administration by SubhashKashyap
Indian Administration by Avasti and Avasti
Government and Politics of India by W.H.Mrrison Jones
Constitution of India by J.C.Johari

Web Resources

1. https://unacademy.com/

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

CO 1	The students will understand their fundamental rules and duties.
CO 2	The students will learn the political system and the system of elections in India.
CO 3	It is to provide the students the institutions and processes to govern themselves in the manner they prefer.
CO 4	Students can also be able to utilize the laws and facilities provided by constution
CO 5	It will provide over all idea about our legal system.
CO 6	It will enable students more strong in terms of law and practice in day to day life.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	0	0	100%	%100

**** PASS/FAIL course**
****

Course Code	**CourseName**	**Course Category**	**L-T-P**	**Credits**
20CS2103	**FormalLanguages andAutomata Theory**	**PCC**	**3-0-0**	**3**

CourseLearningObjectives:

1. *TounderstandanddesignFiniteStateMachinesandapplications.*

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2. **ToUnderstand aboutRegularExpressionsanditsapplications.**
3. *Understandingofformalgrammarsandtheirapplications.*
4. **Understandingvariousotherformallanguagesandtheirdesigningmodels.**
5. *TounderstandDecidabilityandUndecidabilityofvariousproblemsinthetheoretica lcomputerscience.*

UNITI:IntroductiontoAutomata (6 Contact hours) Strings,Alphabet,Language,Operations,Finitestatemachine,definitions,finiteautomatonmodel,acceptanceofstrings,andlanguages,deterministicfiniteautomatonandnon-deterministicfiniteautomaton,transition diagrams and Languagerecognizers.

UNITII: FiniteAutomata (9Contacthours)

NFA with Ɛ-transitions - Significance, acceptance of languages. Conversions and Equivalence:EquivalencebetweenNFAwithandwithoutƐtransitions,NFAtoDFAconversion,minimizationofFSM,equivalencebetweentwoFSM's,FiniteAutomatawithoutput-MooreandMealymachines,Equivalencebetween Mooreand Mealy.

UNITIII:RegularLanguages (6 Contact hours) Regularsets,regularexpressions,identityrules,ConstructingfiniteAutomataforagivenregularexpressions,ConversionofFiniteAutomatatoRegularexpressions.Pumpinglemma ofregularsets,Closureproperties of regularsets (Proofs notrequired).

UNITIV:Grammars (9Contacthours)

Regulargrammars:Rightlinearandleftlineargrammars,Equivalencebetweenregularlineargrammar and FA, Inter conversion, Context free grammar, derivation trees, and sentential forms.Rightmost and leftmostderivation ofstrings.
ContextFreeGrammars:Ambiguityincontextfreegrammars.MinimizationofContextFreeGrammars. Chomsky Normal Form, Greibach Normal Form, Pumping Lemma for Context FreeLanguages.Enumerationof properties of CFL(Proofs omitted).

UNITV:Push Down Automata (7Contacthours)

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Pushdownautomata,definition,model,acceptanceofCFL,Acceptancebyfinalstateandaccep tance by empty state and its equivalence. Equivalence of CFL and PDA, Inter conversion.(Proofsnot required).Introduction to DCFL andDPDA.

UNITVI:TuringMachine&ComputabilityTheory (8Hrs)
RecursiveandRecursivelyenumerablelanguages,andChurch'sHypothesis.TuringMachine: Introduction, Components of Turing Machine, Description of Turing Machine, Elements of TM,LanguageacceptedbyaTM,RoleofTMs,DesignofTMs,UniversalTuringMachine,Undecidabilityof Post Correspondenceproblem.

TextBooks:

Hopcroft,JDUllman "IntroductiontoAutomataandLanguageTheory",3rd Edition,2006
C.PapadimitrouandC. L.Lewis.Elements ofTheoryof Computation,Prentice-Hall,1981.

ReferenceBooks:

John.C.Martin,"IntroductiontoLanguagesandtheTheoryofComputation"McGraw-HillEducation,01-May-2010.
KamalaKrithivasan,Rama.R,"IntroductiontoFormalLanguages,AutomataTheoryandComputation",Pearson EducationIndia, 01-Sep-2009

WebResources

Indian Institute of Technology, Guwahati, " Formal Languages and AutomataTheory"

Courseoutcomes: Attheend ofthecourse, thestudent willbe able to

CO1	Constructfinitestatediagramswhilesolvingproblemsofcomputer science
CO2	AbilitytoconvertNFAtoDFAandEpsilonNFA toDFA
CO3	AbilitytoconvertREtoFiniteAutomataandvise versa
CO4	Designofnewgrammar andlanguage
CO5	Abilityto designPDAand NPDA
CO6	Abilitytolearndesign ofTuringmachine andFindsolutionsto theproblems usingTuringmachines

ForTheorycoursesonly:

CourseNature		**Theory**		
AssessmentMethod				
Assessment Tool	Weeklytests	Monthlytests	EndSemesterTest	Total
Weightage(%)	10%	30%	60%	100%

CourseCode	**CourseName**	**CourseCategory**	**L-T-P**	**Credits**
20CS3101	**OperatingSystem**	**PCC**	**3-0-0**	**3**

CourseLearning Objectives

1. Tolearn thefundamentals ofOperating Systems.
2. To learn the mechanisms of OS to handle processes and threads and theircommu

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3. Tolearnthemechanismsinvolvedin memorymanagementincontemporaryOS
4. Toknowthecomponentsandmanagementaspectsof concurrencymanagement
5. TolearnprogrammaticallytoimplementsimpleOSmechanisms

CourseContent:

Unit-I **(6ContactHours)**

Basics: Evaluation,definition,OperatingSystemFunctionalities,Typesof OperatingSystems,ComputerArchitecturesupporttoOperatingSystems:Kernelandusermo de.IntroductiontoSystemscalls.

Unit-II *(7ContactHours)*

Process Management: definition: Process and PCB, description, Life cycle, Process Scheduling:PreemptiveandNon-Preemptive;(RoundRobin,FIFO,SJFandprioritybased)Uniprocessorschedulingalgorithms , Multiprocessor and Real-timescheduling algorithms

Unit-III *(8ContactHours)*

ProcessSynchronization-

Peterson'sSolution,Banker'sAlgorithm,,Semaphores,CriticalRegions:Producer-consumer problems,Readerswriters problem, dining Philosophers problem.Monitors

Unit-IV *(7ContactHours)*

Introductiontodeadlocks,Resourceallocations,DeadlockConditions,Deadlockprevention, DeadlockDetection-safeandunsafestates,deadlockavoidance-Banker'salgorithms,andRecovery.

Unit-V *(10ContactHours)*

MemoryManagement:Partitioning,PagingandSegmentationandspaceallocation;Pagereplacementalgorithms,Analysisofpageallocationpolicies-WorkingSet,Virtualmemory,DemandPaging.

Unit– VI *(9ContactHours)*

FileSystemsAndSecondaryStorageManagement::Freespacemanagement:Contiguous, SequentialandIndexedAllocation,Filesysteminterface,FileSystemimplementation,DiskScheduling, Device drivers - block and character devices, streams, Character and Block deviceswitch tables,

Learning ResourcesTextbook:

1. Abraham Silberschatz, Peter Baer Galvin, Greg Gagne,"*Operating System Concepts*",JohnWiley & Sons Inc., 6th Edition.
6. William Stallings, "*Operating System: Internals and Design Principles*", Pearson, 5th Edition.

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ReferenceBooks:

1. AndrewSTanenbaum,"*ModernOperatingSystems*",PearsonPrenticeHall,4th Edition.
2. Systmes D M Dhamdhere, *Operating Systems - System Programming and Operating*, TataMcGraw Hill
3. GaryNutt,*OperatingSystems:AModernPerspective*,Addison Wesley, 2nd Edition.

Webresources:

1.PCPBhattm,December312009,*OperatingSystems*,https://nptel.ac.in/courses/106108101/

Courseoutcomes: Attheend ofthecourse, thestudent willbe able to

CO1	Identifythestructureof OSand basicarchitecturalcomponentsinvolvedinOS design.
CO2	ExplaintheMutual exclusion,DeadlockHandlingMethods
CO3	Designapplicationstosimulateprocessschedulingandmemorymanagement algorithms.
CO4	DifferentiatethesystemfunctionalitiesinbetweenoldandmodernOS
CO5	Telltheneedofprotectionandsecurityin OS

ForTheorycoursesonly:

CourseNature		**Theory**		
AssessmentMethod				
AssessmentTool	Weeklytests	Monthlytests	EndSemesterTest	Total
Weightage(%)	10%	30%	60%	100%

Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
CH2181	Fluid Mechanics Lab	PCC	0-0-3	1.5

Course Learning Objectives:

The objective of this Lab is to train the student how to operate the experimental setups and generate the required results from them using basics concepts learned in fluid mechanics course.

List of Experiments:

1. To Calculate the friction factor for the given pipe line.
2. To calculate the coefficient of discharge for an orifice meter.
3. To calculate the coefficient of discharge for a venturi meter
4. To verify the Bernoulli's theorem in a continuous fluid flow.ot
5. To calculate the coefficient of discharge for a V–Notch.
6. To calculate the coefficient of discharge for a rectangular –Notch.
7. To calibrate the Rotameter.
8. To calculate the efficiency of multi-stage centrifugal pump and study its characteristics.
9. To study the effect of superficial velocity and bed porosity and pressure drop in packed bed.
10. To study the effect of superficial velocity and bed porosity and pressure drop and determine the minimum fluidization velocity in fluidized bed.
11. Verification of Stokes law

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

CO1	The usage of basic equations derived in fluid mechanics course and checks their validity
CO2	Experiment with the usage of flow meters.
CO3	Design of fluidization and its operation.
CO4	Construction of different experiments in Chemical Industries like flow meters, pumps.

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

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Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
23CH2281	Heat Transfer Lab	PCC	0-0-3	1.5

Course Learning Objectives:

The objective of this Lab is to train the student how to operate the experimental setups and generate the required results from them using basics concepts learned in Heat transfer course.

List of Experiments

1. **Thermal Conductivity of Metal Rod**
   i. To Calculate the Thermal Conductivity of metal rod.
   ii. To plot the temperature distribution along the length of rod.
2. **Thermal Conductivity of Liquid**
   i. To determine the thermal conductivity of given liquid.
3. **Emissivity Apparatus**
   i. To determine the emissivity of a given test plate.
4. **Forced Convection Apparatus**
   i. To calculate the heat transfer coefficient for the flow of fluid over a hot surface.
   ii. Comparing heat transferring coefficients for different air flow rates and different temperatures of hot surface.
5. **Natural convection apparatus**
   i. To calculate the average heat transfer coefficient of a cylinder oriented vertically.
6. **Composite wall apparatus**
   i. To calculate total thermal conductivity, thermal resistance of the given composite wall.
   ii. To determine thermal conductivity of one material in composite wall.
   iii. Plot the temperature profile in composite wall at steady state.
7. **Shell and Tube Heat Exchanger**

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i. To calculate the heat duty.
ii. To calculate mean temperature difference (LMTD)
iii. To calculate overall heat transfer coefficient.

8. **Pool Boiling apparatus**
   i. To determine the critical heat flux of a given metal wire.

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

CO1	List the application of theoretical concepts discussed in heat transfer course practically and checks their validity.
CO2	Determination of thermal properties of any material.
CO3	Compile heat transfer coefficients in convection mode practically.
CO4	Analyzing the working of heat exchange equipment and their role in chemical industries.

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

Course code	Course name	Course Category	L-T-P	Credits
23CH2282	Mechanical Unit Operations Lab	PCC	0-0-3	1.5

Course Learning Objectives:

This course enables the students to:

1. Understand and apply engineering experimentation techniques and safety procedures common to the chemical industry.
2. Apply principles developed in chemical engineering courses to the analysis of chemical Engineering processes and unit operations.
3. To provide experience on analysis of size and size reduction.
4. To acquaint the students with the separations based on size.
5. Improve skills necessary for group work—interpersonal skills, coordination of the efforts of several persons, leader and subordinate roles, etc.

List of Experiments

1. a)To calculate the efficiency of a ball mill for grinding a material of known work index(Wi)
   b) To study the effect of RPM on the power consumption of ball mill.

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c) To calculate the Critical Speed (nc) of ball mill.

2. To determine the Efficiency of the Jaw crusher for crushing the material of known work index (Wi).
3. To calculate the percentage recovery of Coal in froth flotation cell from coal-sand mixture.
4. a)To calculate specific cake resistance.
   b) To calculate the medium resistance(R).
5. a) To determine the effect of initial concentration and initial suspension height on the sedimentation rates.
   b) To show the effect of flocculating agent.
   c) To show the effect of particle size distribution.
6. a) To demonstrate Gyratory sieve shaker.
   b) To report the screening analysis.

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

CO1	Analyze the characterization of particles and calculate the effectiveness of a given screen.
CO2	Calculate size reduction ratio, work index using ball mill and jaw crusher.
CO3	Estimate the power requirement using crushing laws for various crushers.
CO4	Apply separation techniques like forth floatation, sedimentation to separate a mixture.
CO5	Evaluate performance characteristics of filter press, cyclones, flotation cells and clarifiers.
CO6	Build a bridge between theoretical and practical concept used in industry

Course Nature			**Practical**	
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
23CH3101	Chemical Process Dynamics and Control	PCC	3-1-0	4

Course Learning Objectives:

1. To comprehend important Laplace transform and its properties.
2. To study the dynamics of first order system with different forcing functions.
3. To study the dynamics of second order system with different forcing functions.

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4. To analyze different components of a control loop.
5. To study the stability of the control system and tune controller parameters.
6. To study the advance controllers and control valves

Course Content:

Unit-1: **(12 Contact hours)**

Basic Principles: Laplace Transform, Inversion by Partial Fractions and Properties of Transforms Concept of deviation variables. Concept of transfer function. Properties of transfer functions – additively and multiplicity

Introduction to Instrumentation: measuring process variables such as temperature, pressure and flow.

Unit-2: **(10 Contact hours)**

Linear Open-Loop Systems: Dynamic response of First-Order System (thermometer for modeling) with different input/forcing function such as step, ramp, impulse, sinusoidal. Physical Examples of first order system.

Unit-3: **(10 Contact hours)**

Dynamic response of First-Order Systems in Series for interacting and non-interacting system, Dynamics of Second-Order Systems (U tube manometer for modeling) with different input/forcing function such as step, impulse, sinusoidal and Transportation Lag and use of Pade approximation

Unit-4: **(8 Contact hours)**

Linear Closed-Loop Systems: Control System, Controllers (P, PI and PID controllers) and Final Control Elements, Block Diagram of a Chemical-Reactor Control System, Closed-Loop Transfer Functions, Transient response of Simple Control Systems (servo and regulatory problem). Concept of offset.

Unit-5: **(10 Contact hours)**

Stability of dynamic systems: Routh-Hurwitz criteria; Root Locus method.
Frequency Response analysis: Bode plots; Bode Stability Criterion
Selection and Tuning of Controllers: Methods based on FOPDT model and Process Reaction Curve (PRC); Cohen-Coon optimum controller settings; Integral Error Criteria. Ziegler-Nichols

Unit -6: **(10 Contact hours)**

Advanced control strategies: Cascade Control, Feed Forward Control, Ratio Control
Control Valves: Control Valve Construction, Valve Sizing, Valve Characteristics, Valve Positioner.

Learning Resources:

Text book:

1. D.R. Coughanowr, '*Process Systems Analysis and Control*'. McGraw Hill, 3rd ed 1991

Reference Books:

1. G. Stephanopolous, '*Chemical Process Control'*, Prentice Hall, 1984.
2. Peter Harriott, '*Process control*' Tata McGraw-Hill 1964. (10th reprint 2008).
3. William L. Luyben, Michacl L. Luyben, '*Essentials of process control*', McGraw-Hill,1997

Web resources:

1. https://nptel.ac.in/courses/103105064/

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

CO1	Applications of Laplace transforms and its properties.
CO2	Determine the dynamic behavior of first order process
CO3	Analyze the dynamic behavior of first order in series and second order process
CO4	Categorize P, PI, and PID Controllers for various purposes.

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CO5	Analyze stability of feedback control system and Tune P, PI, PID Controllers
CO6	Importance of control valve sizing.

Assessment Tool	**Weekly tests/Assignments (In semester)**	**Monthly tests (In semester)**	**End Semester Test**	**Total**
Weightage (%)	10%	30%	60%	100%

Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
23CH3103	Chemical Reaction Engineering- II	PCC	3-0-0	3

Course Learning Objectives:

1. To learn how to deal with non -ideal reactors.
2. Exploring models available to determine conversions in non- ideal reactors.
3. To study the steps involved in fluid-solid catalytic reactions
4. Understanding the parameters affecting catalytic reactions.
5. To study models available to deal with fluid-solid reactions without catalyst.

Course Content:

Unit – I **(7 Contact hours)**

Characteristics of the RTD: RTD in real reactors, Diagnostics and troubleshooting.

Conversion in Non-ideal flow reactors: Predicting conversion and exit concentration, reactor modeling using RTD.

Unit – II **(7 Contact hours)**

zero parameter models: segregation model – macro and micro fluids, earliness and late mixing; maximum mixedness model, comparison of zero parameter Vs. maximum mixedness model.

One parameter models: The dispersion model- Axial dispersion, small deviation and large deviations from plug flow; correlations for axial dispersion,

Unit – III **(7 Contact hours)**

Chemical reaction and dispersion-first order and nth order reactions.

Tanks- in-series (T-I-S) model- the RTD for n equal sized tanks in series; Chemical conversion in first order and all other reaction kinetics of micro fluids, chemical conversion of macro fluids. Tanks- in-series Vs. dispersion model.

UNIT-IV (8 contact hours)

Catalysis and catalytic reactors: Introduction to Catalysts, steps in a catalytic reactions- Overview of Internal and External diffusion, Adsorption Isotherms, surface reaction, Desorption, The rate limiting step; Synthesizing a rate law, mechanism and rate limiting step for a solid catalyzed heterogeneous reaction.

Unit - V **(9 Contact hours)** **Diffusion and reaction:** External diffusion effects on heterogeneous reactions : External resistance to mass transfer, correlation for the mass transfer coefficient, Experimental methods for finding rates, design of packed bed catalytic reactors and Fluidized bed reactors.

Diffusion and reaction in a single cylindrical pore, Thiele modulus and internal effectiveness factor, extension to different particles, Falsified kinetics, heat effects during reaction.

Unit – VI **(8 Contact hours)**

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Fluid-solid non-catalyzed reactions: Introduction, selection of a model, progressive conversion model (PCM), shrinking core model (SCM), SCM for spherical particles of unchanging size, SCM for spherical particles of shrinking size, limitations of shrinking core model; Determination of the rate-controlling step.

Learning Resources:

Text book:

1. Octave Levenspiel , '*Chemical Reaction Engineering'*, Wiley – India, 3rd edition (2012)
2. H S Fogler, '*Elements of Chemical Reaction Engineering*', PHI, 4th ed.,2008.

Reference Books:

1. Smith J.M., '*Chemical Engineering kinetics*', McGraw-Hill, 3rd edition 1974.

Web resources:

1. https://nptel.ac.in/courses/103106117/
2. https://nptel.ac.in/courses/103101008/

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

CO1	Predict how real reactor deviates from ideal reactors such as PFR, MFR
CO2	List out parameters affecting the behaviour of non-ideal reactors. Diagnose and troubleshooting them.
CO3	Explore and apply different models available to predict the conversion in non- ideal reactors.
CO4	Analyzing the steps involved in catalytic reactions and the kinetics involved.
CO5	Design the parameters affecting rate of catalytic reactions.
CO6	Explore different mechanisms related to non-catalyzed solid-fluid reactions. Describe enzymatic reactions.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
23CH3105	Numerical Methods in Chemical Engineering	PCC	3-0-0	3

Course Objectives:

The course content enables the students to:

1. Understand errors arise in numerical calculations
2. Understand numerical solution to linear systems and single and multiple integrals
3. Understand single step numerical solution to Initial Value ODE's
4. Understand multi step numerical solution to Initial Value ODE's and system of equations.
5. Understand numerical solution to Boundary Value ODE's.
6. Understand numerical solution to PDE's.

Course Content:

Unit I **(8 Contact hours)**

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Errors in numerical calculations: Absolute, relative and percentage errors, a general error formula, errors in a series approximation, **Root finding:** Locating Roots of nonlinear equations formed in chemical engineering applications with one variable: Bisection method, Newton-Raphson method, Secant method, Regula-falsi method, Muller's method; Solution of system of nonlinear equations-Introduction, Iteration method, Newton-Raphson method for systems

Unit II **(7 Contact hours)**

Solution of Linear Systems: Direct methods-LU factorization, Thomas Algorithm, Iterative methods–Jacobi iteration method, Gauss-Seidel iteration method

Numerical Integration: Trapezoidal rule, Simpson's 1/3 Rule, Simpson's 3/8th rule single and multiple integrals.

Unit III **(8 Contact hours)**

Numerical solutions of IVP (ODE's) in Chemical Engineering: Single step methods -Taylor series method, Euler method, Picard's method of successive approximation, Runge Kutta Method.

Unit IV **(7 Contact hours)**

Multi step methods - Predictor-Corrector method, Euler PC method, Milne and Adams Moulton PC method. **System of first order ODE**, higher order IVPs

Unit V **(8 Contact hours)**

Numerical solutions of BVP: Finite difference method, shooting method, Newton's method for system of equations. Non linear BVP, higher order BVP

Unit VI **(7 Contact hours)**

Introduction, **finite difference approximations** to derivatives, Laplace's equation, parabolic equation, hyperbolic equation

Text Books

1. S.K. Gupta, '*Numerical methods in engineering*', 3rd edition, Tata McGraw Hill, 2013.

Reference Books:

1. Steven C. Chapra, '*Applied Numerical Methods with MATLAB for Engnineers and Scientists*', Third Edition, Tata McGraw Hill
2. B.S. Grewal,' *Higher Engineering Mathematics*', 40th edition, Khanna publishers, New Delhi, 2007
3. Erwin Kreyszig,' *Advanced Engineering Mathematics*', Johnwiley& Sons, 8th edition, 2007.

Web resources:

1. https://nptel.ac.in/syllabus/111107062/

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

CO1	Evaluate roots for linear and nonlinear equations
CO2	Able to find solution to linear equations and solution to single and multiple integrals.
CO3	Compute initial value ODE's.
CO4	Solving simultaneous ODE's.
CO5	Predict boundary value ODE's.
CO6	Compute PDE's.

Course Nature	**Theory**

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Assessment Method				
Assessment Tool	**Weekly tests/Assignments (In semester)**	**Monthly tests (In semester)**	**End Semester Test**	**Total**
Weightage (%)	10%	30%	60%	100%

Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
23CH3182	Numerical Methods in Chemical Engineering Lab	PCC	0-0-3	1.5

Course Learning Objectives:
The main objective of this lab is to make the student to understand
1. MATLAB software
2. The use of MATLAB for solving various kinds of mathematical problems numerically.
3. To write script files
4. Usage of functions.
5. Draw 2D and 3D plots.

List of Experiments
1. Root finding method for linear equation
2. Root finding method for non linear equation
3. Solution of linear systems
4. Single integral
5. Multiple integral
6. Initial value ODE using single step method
7. Initial value ODE using multi step method
8. Boundary value ODE
9. Boundary value non linear ODE
10. Partial Differential Equations

Course outcomes: At the end of the course, the student will be able to write MATLAB code to solve

CO 1	Root for linear equation
CO 2	Root for non linear equation
CO 3	Solution of linear equations
CO 4	Single integral
CO 5	Multiple integral
CO 6	Initial value ODE using single step method
CO7	Initial value ODE using multi step method
CO8	Boundary value ODE
CO9	Boundary value non linear ODE
CO10	Partial Differential Equations

Course Nature			**Practical**	
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total

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Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

Course code	Course name	Course Category	L-T-P	Credits
23CH3202	Plant Design and Economics	PEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. To learn fundamentals of engineering investments and economics
2. To demonstrate the importance of economic considerations in the design of process equipment and chemical plant facilities
3. To identify and understand the concepts of fixed capital investment, cash-flow analysis, and cost estimation
4. To know the importance of time value of money, and important engineering depreciation methods
5. To learn the profitability and financial analysis concepts in decision making among alternatives
6. To apply economic optimization methods to evaluate important chemical plant design options

Course Content:

UNIT –I **(7 contact hours)**

Chemical Engineering Plant Design

Introduction: General overall design considerations, General design considerations: health and safety hazards, environmental protection, plant location, plant layout, plant operation and control

UNIT – II **(8 contact hours)**

Process design development: Development of Design Database, Process Creation, Process Design, Process Flow diagrams, Piping and Instrumentation diagrams, equipment design and specifications, Materials and Fabrication Selection

Cost & Asset Accounting and Cost Estimation: Cash flow for industrial operations, factors affecting investment and production cost, capital investments, estimation of capital investments, cost indices: Engineering News–Record-Chemical Engineering Index–Marshall and Swift Cost Index, cost factors in capital investment

UNIT-III **(8 contact hours)**

Methods for estimating capital investments: estimation of total product cost, Gross Profit, Net Profit

Economic Evaluation of Process: Interest and Time Value of Money: types of interest, nominal and effective interest rates, continuous interest, present worth and discount, annuities, taxes and Insurance

UNIT-IV **(7 contact hours)**

Depreciation: types of depreciation, service life, salvage value, present value, methods for determining depreciation: Straight-Line Method, Declining-Balance (or Fixed Percentage) Method, Sum-of-the-Years-Digits Method, Sinking-Fund Method

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UNIT-V **(8 contact hours)**
Profitability, alternative investments and replacements: profitability standards, Methods for Calculating Profitability, discounted cash flow, net present worth, capitalized costs, payout period
UNIT-VI **(7 contact hours)**
Alternative investments, replacements, optimum design and design strategy: selecting an procedure with one variable, procedure with two or more variables, comparison of graphical and analytical methods, optimum production rates in plant operation, cyclic operations, economic pipe diameter

Text books:
1. M. S. Peters, K. D. Timmerhaus and R. E. West, *Plant Design and Economics for Chemical Engineering*, 5th Ed., McGraw Hill, 2003

Reference Books:
1. J. R. Couper, *Process Engineering Economics*, Marcel DekkarInc, 2003
2. Harry Silla, *Chemical Process Engineering, Design and Economics*, Marcel DekkarInc, 2003
3. H.E. Schweyer, *Process Engineering Economics*, McGraw-Hili, New York, 1955

Web resources:
1. http://www.ide.iitkgp.ernet.in/Pedagogy3/fullcourse.jsp?COURSE_ID=188
2. https://nptel.ac.in/courses/103103039/40

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

CO1	Identify the general design considerations and steps in the process design development for a successful project
CO2	Estimate fixed capital investment and total production cost
CO3	Use interests and taxes involved and ways and means of getting the capital requirements
CO4	Identify depreciation methods to find present value of equipment
CO5	Compare different profitability techniques and various alternatives for capital investments for important equipment in the project
CO6	Demonstrate the optimization techniques for process variables such as optimum pipe diameter, optimum production rates

Course Nature	**Theory**			
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
23CH3282	Mass transfer operations lab	PCC	0-0-3	1.5

Course Learning Objectives:
At the end of this course, the student will be able to:
1. To understand the basic principles of diffusion and convective mass transfer
2. To build a bridge between theoretical and practical concept used in industry

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3. To study the vapor liquid equilibrium, liquid - liquid equilibrium etc
4. To study the different separation operations and there use off for fluid-fluid operations
5. To understand the characteristics of solid-liquid separations

List of Experiments

1. Simple steam distillation
   Calculate the vaporizing efficiency of the steam distillation column.
2. Solid-liquid Extraction
   a) To calculate the percentage recovery of oil from oil seed.
   b) To show the effect of solvent temperature and solvent rate on the percentage recovery of oil from oil seeds.
3. Liquid-Liquid Extraction
   a) To determine the overall mass transfer coefficient (K_{wa},K_{ta}) for based on continuous phase and dispersed phase.
   b) To determine the overall height of transfer unit (H_{ow},H_{ot}) based on continuous phase and dispersed phase.
   c) To determine the individual height of transfer unit (H_w,H_t) based on continuous phase and dispersed phase.
4. Simple Batch Distillation
   a) To verify Rayleigh equation for batch distillation.
5. Rotary Dryer
   To plot the rate of drying curve.
6. Ion Exchange
   a) To deionize water to make it soft.
   b) To determine the exchange rate and saturation point.
7. Packed Bed Distillation Column
   a) To verify Rayleigh equation.
   b) To obtain the T-x data under total reflux condition at steady state and compare it with theoretical value.
   c) To operate the column under total reflux condition and calculate the minimum number of theoretical stages using fenske's equation
   d) To operate the column under any desired reflux condition and calculate the minimum number of theoretical stages using Mc-Cabe Thiele's method.
   e) To calculate the HETP for known packed height.
   f) To estimate batch distillation Curves for a binary system and verify the binary batch distillation equation for known packed height.
   g) To operate the column under total reflux condition and estimate HETP for the packing.
8. Gas Diffusion
   a) To determine the Diffusion Coefficient of a gas by evaporation from a liquid surface.
9. Cooling Tower
   a) Observation of the processes inside a cooling tower with forced flue.
   b) Determination of evaporation velocity.
   c) Mass balance use of psychometric maps
   d) Effect of the cooling load on the "approach" to wet bulb.
   e) Relation between air velocity, wet bulb approach and head loss.
   f) Determination of the cooling capacity.
10. Adsorption
    a) Illustrate the relationship between a breakthrough curve and a concentration profile.
    b) To demonstrate how the contact time affects adsorption.
11. Continuous Distillation Column
    a) To determine the variation with boil-up rate of pressure drop over the distillation column.
    b) To determine the overall column efficiency.

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c) To carry out a distillation at constant reflux ratio, varying top and bottom compositions with time.
d) To investigate the steady state distillation of a binary mixture under continuous operation.
e) To investigate the effect of the feed position under continuous operation.
f) To demonstrate a typical application of a PID controller, to observe the response of the process to a change in set point and to a disturbance, and to adjust the controller setting for optimum process control.
g) To demonstrate a typical application of a Programmable logic controller (PLC) with analog inputs and outputs. To observe the response of the process to a change in set point and to a disturbance. To adjust the settings of the PLC for optimum process control of the process.
h) To use PC control and data logging software with the UOP3CC.

12. Gas Absorption
a) To investigate the Absorption process when gas separating gas mixtures in packed column.
b) Determination of pressure losses in the column.
c) Representation of the Absorption process in an operating diagram.
d) To investigate the variables influencing the effectiveness of absorption

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

CO1	Perform experiments in relation to the Mass Transfer fundamentals.
CO2	Find out diffusivity and mass transfer coefficients.
CO3	Evaluate the effectiveness of different separation techniques
CO4	Compare the equilibrium data developed with the theoretical data.
CO5	Ability to design separation system for the effective solution of intended problem
CO6	Recognize the selection criteria for mass transfer process and equipments required by the industries.

Course Nature		**Practical**		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

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Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
23CH3252	Environmental Pollution and Control For Chemical Engineers	PEC	3-0-0	3

Course Learning Objectives:

1. Emphasize on this course is on the fundamentals of pollution control aspects
2. Learn about different air pollutants sampling and analysis methods
3. Learn air pollution control equipment.
4. Know the primary, secondary and advanced wastewater treatment process.

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5. Understand the solid, hazardous waste and their treatment and disposal methods.
6. Learn about EIA

Course Content:

Unit I **(10 Contact hours)**

Industrial Pollution Emissions and Indian Standards: Types of emissions from chemical industries and effects on environment, Type of pollution and their sources, Effluent guide lines and standards, Characterization of effluent streams, Oxygen demands and their determination (BOD, COD, and TOC), Oxygen sag curve, BOD curve interpretation, Controlling of BOD curve.

Unit II **(7 Contact hours)**

Air Pollution Sampling: Criteria and toxic air pollutants, Air pollution sampling and measurement: Ambient air sampling: collection of gaseous air pollutants, Collection of particulate air pollutants, stack sampling: Sampling system, particulate and gaseous sampling

Unit III **(7 Contact hours)**

Air pollution control methods and equipments: Particulate emission control: collection efficiency, Control equipments like gravity settling chambers, Cyclone separators, Fabric filters, Electrostatic precipitator, Scrubbers (Spray towers and Venturi scrubbers)

Unit IV **(7 Contact hours)**

Wastewater treatment Process-Methods of primary treatment; Screening, sedimentation, flotation, neutralization, secondary treatment: Biological treatment of wastewater and bacterial growth curve, suspended growth processes (activated sludge, aerated lagoon and stabilization pond), attached growth processes (trickling filter and rotating biological contactor).Advanced waste water treatment.

Unit V **(7 Contact hours)**

Solid waste management: Sources and classification, Methods of collection, Disposal methods (Landfill and incineration)

Health and environment effects, sources and disposal methods, Chemical wastes; Health and environment effects, Treatment and disposal.

Unit VI **(7 Contact hours)**

Environmental Management: Sustainable development, Environmental Impact Assessment (EIA), Environmental Ethics, Legal aspects.

Learning Resources:

Text book:

1. C.S. Rao, '*Environmental Pollution and Control Engineering*', 2nd Edition, Wiley, India, 2006.

Reference Books:

1. S.P.Mahajan, '*Pollution Control in Processes Industries*', TMH, 1985.
1. M.NarayanaRao and A.K.Datta, '*Waste water treatment*', 3rd Edition., Oxford and IBH, 2005.
2. M.N.Rao,H. V.N.Rao, '*Air Pollution*', Tata McGraw Hill Education Private Limited, India,2010.
3. H.S.Peavy, P.R. Rowe, G. Tchobanoglous, '*Environmental Engineering*', McGraw Hill, 1985.

Web resources:

1. https://nptel.ac.in/courses/123105001/

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

CO 1	List different types of pollution and apply knowledge for the protection and improvement of the environment
CO 2	Identify suitable sampling, analysis for air pollutants.
CO 3	Design suitable equipment for air pollutants.
CO 4	Select and use suitable wastewater treatment technique
CO 5	Elaborate the most appropriate technique to manage the solid waste.
CO 6	Discuss strategy of EIA

Assessment Method

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Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
23CH4136	Petroleum Refinery Engineering	PEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. This course will present an overview of modern petroleum refinery
2. To demonstrate the formation of crude oil and it's pretreatment
3. To deduce adequate knowledge of fractionation techniques for petroleum crude to products.
4. Acquire knowledge of the overall refinery operations, refinery products and its test methods.
5. This course provides major insights into secondary cracking process available to produce normal and value added products
6. To understand Hydro-treatment processes in refining.

Course Content:

Unit I **(7 Contact hours)**

Origin of petroleum crude oil. Evaluation of crude oil – evaluation and characterization of crude oil, TBP and other distillation tests.

Unit II **(6 Contact hours)**

Petroleum products, their properties, specification and testing – different properties like flash point, fire point, smoke point, aniline point, carbon residue, kinematic viscosity, pour point, freezing point etc.

Unit III **(8 Contact hours)**

Petroleum refinery distillation – pre-fractionation and atmospheric distillation of crude. Process design for atmospheric distillation. Stabilization of naphtha.

Unit IV **(8 Contact hours)**

Vacuum distillation of RCO. Reforming of naphtha. Other secondary processes like Thermal cracking, Vis-breaking.

Unit V **(8 Contact hours)**

Delayed coking process, FCC Unit. Hydro-cracking, Alkylation, Isomerization Process

Unit VI **(8 Contact hours)**

Hydro-treatment processes in refining: hydro-desulfurization, hydro-finishingProduction of lube oil base stock: Furfural/Phenol/NMP extraction, Solvent, dewaxing, propane deasphalting

Text Books:

1. B.K. BaskaraRao, *'Modern Petroleum Refining Processes'*, 4th Edition, Oxford & IBH Publishing.

Reference Books :

1. Ram Prasad, *'Petroleum Refining Technology'*, Khanna Publishers, 2002
2. Nelson W.L., *'Petroleum Refining Engineering'*, McGraw Hill, 4th edition
3. R. N. Watkins, *'Petroleum Refinery Distillation'*, Gulf Publishing company,1979
4. J. H. Gray & G. E. Handwerk, *'Petroleum Refining, Technology & Economics'*, CRC Press, 5th edition

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Web resources:

1. https://nptel.ac.in/courses/103102022/

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

CO1	Build a basic knowledge of petroleum refinery processes carried out in chemical industries.
CO2	Know fundamentals of petroleum refining, types of energy resources, fundamentals of crude oil treatment
CO3	Evaluate the properties of various petroleum products and their uses.
CO4	Acquire a knowledge of different refining processes involved in converting crude oil to various products.
CO5	The fundamentals and purposes of re-refining processes and properties of main oil products.
CO6	The importance of petroleum additives in modifying the final refinery products.

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	**Course name**	**Course Category**	**L-T-P**	**Credits**
23CH4226	Food ProcessEngineering	PEC/OEC	3-0-0	3

Course Learning Objectives:

The course content enables the students to:

1. Understand and identify the specific equipments used in food industry
2. Understand tha various unit operation involved in the fod processing industry
3. Understand and identify the specific processing technologies used for vegetables and fruits and the various products derived from these materials.
4. Understand the application of scientific principles in the processing technologies specific to the materials.
5. Having the knowledge of the transportation equipments in food industry
6. Grasp the changes in the composition of foods with respect to the type of processing technology used

UNIT - I **(7 Contact hours)**

Basic Components: Construction and working of pipes, valves, pumps. Material of construction compatible with foods, basic principles in lay out.

UNIT- II **(8 Contact hours)**

Unit Operations In Food Industry: Basic principles of Grinding; prediction of Crushing efficiency; Laws of crushing, pulverization and ultrafine grinding

Unit –III **(7 Contact hours)**

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Classification of crushing equipment; Construction and working principle of mostly used equipments, viz., Jaw crushers, gyratory crushers etc.

UNIT -IV **(7 Contact hours)**

Conveyors and Sieves: Classification of conveyors, selection of conveyors; conveying methods like belts, screw etc, Sieving and types of equipments

UNIT -V **(8 Contact hours)**

Drying: Basic principles, different methods of drying including, tunnel, sun, tray, spray drying and low temperature; design of dryer with mass and energy balance, drying time prediction.

UNIT -VI **(8 Contact hours)**

Freezing and Extrusion: Principles of freezing and Chilling, freezing equipment and methods, freezing time and rate calculation; Principle, types and design of extruders.

Learning Resources:

TEXTS BOOKS:

1. Berk, Zeki "*Food Process Engineering and Technology*" Academic Press, 2009.
2. Smith, P.G. "*Introduction to Food Process Engineering*". Springer, 2004.
3. Toledo, Romeo T. "*Fundamentals of Food Process Engineering*". 3rd Edition, Springer, 2007.

REFERENCES:

1. Rao, M.A. et al., "*Engineering Properties of Foods*". 3rd Edition. CRC/Taylor&Fransis, 2005.
2. Gopala Rao, Chandra "*Essentials of Food Process Engineering*". BS Publications, 2006

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

CO1	Identify the working principle of equipments used in food processing industry
CO2	List the various unit operation involved in the food processing industry
CO3	Identify the specific processing technologies used for vegetables and fruits and the various products derived from these materials.
CO4	Discuss the application of scientific principles in the processing technologies specific to the materials.
CO5	Design transportation equipment in food industry
CO6	Grasp the changes in the composition of foods with respect to the type of processing technology used

Course Nature	**Theory**			
Assessment Method				
Assessment Tool	Weekly tests/Assignments (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

20EC2103	**DigitalSignalProcessing**	**PCC**	**3L: 1T: 0P**	**4credits**

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CourseObjective

1. To understand the mathematical approach to manipulate discrete time signals,whichare usefultolearndigitaltelecommunication
2. Tostudythetransformationson digitalsignals.
3. Tounderstandtheconceptsofdigitalfilters

CourseContent

UnitI **(10hours)**

Introduction

A basic review of Signals and Systems, Basic elements of digital signal processing, Timedomain representation of discrete time signals, Basic Operations on sequences includingSampling rate alteration, Classification of sequences. Discrete time systems, Time domaincharacterizationofLTIDTS:Convolutionsum,Impulse&StepResponses,SimpleInterconnectionschemes,LinearConstantCoefficientDifferenceEquations(ofFinite-dimensionalLTIDTS),ClassificationofLTIDTS:FIR&IIR,Recursive,&Non-recursive.

Unit-II *(10hours)*

DiscreteTimeFourierTransform(DTFT)

Introduction,FourierTransformRepresentationofaperiodicDiscrete-TimeSignals,Periodicity-convergence of DTFT, Properties ofDTFT,SignalTransmissionThroughLTISystems,IdealandPracticalFilters,energyspectralDensity,PowerspectralDensity.

Unit-III *(12hours)*

DiscreteFourierTransform(DFT)

Sampling of DTFT, Discrete Fourier Transform(DFT) and its Inverse, DFT as a LinearTransformation, Properties of DFT, Linear Convolution Using the DFT, Filtering of LongDataSequencesUsing DFT, SpectrumanalysisUsing DFT.

FastFourierTransform(FFT)

Introduction,ComputationalComplexityoftheDirectComputationoftheDFT,Decimation-In-Time (DIT) FFT Algorithm, Decimation-in-Frequency (DIF) FFT Algorithm and theircomparison,Inverse DFTusingFFT Algorithm, ALinearFilteringApproach toComputationoftheDFT-TheGoertzelAlgorithm,TheChirp-zTransformAlgorithm

UnitIV *(10hours)*

Z transforms

Introduction ,Bilateral (Two-sided) Z-transform , Relationship Between Z-transform andDTFT,Z-Plane, Region-of-Convergence for Z-transforms and their properties, properties ofZ-transform,Z-

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TransformofCausalPeriodicSignals,InversionoftheZ-transform,AnalysisandCharacterizationof LTI SystemsusingtheZ-transform.

The Unilateral (One-Sided) Z-transform, Properties of unilateral Z-Transform. TransientResponse and Steady-State Response Block Diagrams Representation. Applications of Z-Transformin Signal Processing

UnitV - ***(8hours)***

FilterConcepts

Introduction,FrequencyResponseandFilterCharacteristics,Zero-PhaseFilter,LinearphaseFilter, simple FIR and IIR Digital Filter, All pass Filters, Minimum-Phase, Maximum-PhaseandNon-minimum(Mixed)PhaseSystems,averagingfilter,combfilter,Notchfilter.

Unit-VI ***(10hours)***

RealizationOfDigitalFilters

Introduction, FIR Filter, IIR Filter, Non-recursive and Recursive Structures, FIR FilterStructures,BasicStructuresforIIRSystems,LatticeStructuresforFIRandIIRsystems.

Learning ResourcesTextBooks

1. A.V.Oppenheim and R.W. Schaffer, *Discrete Time Signal Processing* , 3rd edition,PearsonEducation/PHI,2014.
2. JohnG.Proakis,DimitrisG.Manolakis, ‘*Digital Signal Processing, Principles,Algorithms,and Applications*’, 4thedition,PearsonEducation/PHI,2007

ReferenceBooks

1. Sanjit K Mitra, *Digital signal processing: A computer base approach* ,4thedition,TataMcGrawHill,2013
2. B.P.Lathi,RogerGreen, ‘*Essentials of DigitalSignalProcessing*’, CambridgeUniversityPress,2014

VideoReferenceLinks

1. ProfAlanV.Oppenheim,OCW-MassachusettsInstituteofTechnology(MIT), ‘Digital Signal Processing’. URL:https://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/index.htm
2. Prof S C DuttaRoy,NPTEL-‘Digital Signal Processing’ URL:http://nptel.ac.in/courses/117102060/
3. Prof T K Basu,NPTEL-‘Digital Signal Processing’ URL:http://nptel.ac.in/courses/108105055/

CourseOutcomes: Afterthecompletionofthecourse,thestudentswillbeableto

CO1	Interpret,representandprocessdiscrete/digitalsignalsandsystems

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CO2	Understandthespectralanalysisofsignals
CO3	Design&analyzeDSPsystemslikeFIRandIIRFilteretc
CO4	Familiarizewithmultiratesignalprocessing
CO5	FamiliarizewithapplicationsofDigitalSignalProcessing

AssessmentMethod

Assessment Tool	Weeklytests	Monthlytests	EndSemesterTest	Total
Weightage(%)	10%	30%	60%	100%

****

20ECXX10	DigitalLogicDesign	ESC	3L: 0T: 0P	3credits

CourseLearningObjective

1. TodiscusstherelevanceofDigitalLogicDesignwithComputerScienceandEngineeringcourse
2. To discuss the concepts of Number systems and representations, combinational design,sequential designs and complete system design at gate-level abstraction in computer Design.3.Todiscussthe importantfeaturesofICdesignlike area,power anddelay.

CourseContent

Unit-I **(8hours)**

Numbersystems-Representations-Conversions,errordetectionanderrorcorrection,Booleanconstantsandvariables,basic gates:operationandtruthtables,describinglogicgatesalgebraically,evaluatinglogiccircuitoutputs,implementingcircuitsfromBooleanexpressions,universalityof gates, Booleantheorems.

Unit-II ***(8hours)***

Combinational circuit minimization using Boolean laws and karnaugh maps, multilevelsynthesis, logic levels and noise margins. Single bit adders and subtractors, parallel adders,multi-bitsubtraction usingadders, signedmultiplier,unsignedmultiplier.

Unit-III ***(8hours)***

Decoders, Encoders, Multiplexers, Demultiplexers. Realization of various functions usingDecoders,Multiplexers. Priorityencoders. Implementationoffunctionsusingprogrammablelogicdevices:PAL,PLA,PROM

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Unit-IV ***(8hours)***

Bistable elements, Latches and Flip-flops : S-R latch, D latch, J - K Flipflop, D Flipflop,master/slave flip-flop, edge triggered J-K flip-flop with asynchronous inputs, T flip-flops.Excitationtables,Characteristic tables,Characteristic equations.

Unit-V ***(8hours)***

Frequency division and counting. Design and analysis of synchronous counters,asynchronouscounters.

Unit-VI ***(5hours)***

Registers: SIPO, PISO, PIPO, PISO. State diagrams for D-flipflop, T-Flip flop, J-K Flipflop,Mealy machinesandMoore machines.

Learning ResourcesText books

1. Ronald J Tocci, Neal S.Widmer, Gregory L.Moss,'Digital systems' Pearson 10th edition.
2. Stephen Brown, ZvonkoVranesic,'Fundamentals of Digital Logic with Verilog Design',TMH,2nd edition

Referencebooks

1.JohnF.Wakerly,'DigitalDesign',Pearson4th edition

WebResources

1. Prof.ShankarBalachandran,NPTEL-IITMadras,*'DigitalCircuits&Systems'* URL:https://nptel.ac.in/courses/117106114/
2. Prof. S Srinivasan, NPTEL-IIT Madras, 'Digital Circuits and Systems'URL:https://nptel.ac.in/courses/117106086/

CourseOutcomes

Attheendofthecourse,thestudentwillbeableto

CO1	Applytheknowledgeofsimplificationinobtainingoptimaldigitalcircuits
CO2	EmployBooleanalgebratodescribethefunctionof logiccircuits
CO3	Designcircuitswhichrepresentdigitallogicexpressions.Specifically,designagate-leveldigitalcircuittoimplementagivenBooleanfunction
CO4	StudyandexaminetheSSI,MSI,LSIandProgrammableelements
CO5	Analysetheoperationofsynchronousandasynchronousstatemachines
CO6	Designanycombinationalorsequentialdigitalcircuitstomeetthegivenspecifications
CO6	Analyseanydigitalcircuitandtodebugsuchcircuit
CO7	Prototypea realtimeapplication onEDAtool

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AssessmentMethod

AssessmentTool	Weeklytests/Assignments (Insemester)	Monthly tests(Insemester)	End SemesterTest	Total
Weightage(%)	10%	30%	60%	100%

20ECXX80	DigitalLogicDesignLab	ESC	0L: 0T: 3P	1.5credits

CourseLearningObjective

1. ToexposetotheconceptofDigitalknowledgeand itsapplications
2. TounderstandCombinationalandSequentialcircuits
3. Todesignaprototypedigitallogicdesign

.

Listof Experiments

1. Familiarization with logic gate IC's and Arduino kits
2. Designofcodeconvertersandcomparators(8-bit)onbreadboard
3. Adder related experiments: Half adder , full adder , half subtractor, full subtractor ,ripplecarry adder,BCDadder, carrylook aheadadder usingIC
4. Design of a binary multiplier and displaying its inputs and outputs on seven segmentdisplayunit
5. Familiarization with multiplexer, decoder, encoder. Design of Half adder, full adder,magnitudecomparatorandotherexamplesusingabovefamiliarizedcomponents
6. Bi-stable multi-vibrator design. Design and verification of SR,JK,D,T latch/flip-flops.Verificationand elimination ofRace AroundCondition
7. Flip-flopconversionsandDesignoffrequencydividers
8. Design of synchronous counters (Up and Down) and displaying result on sevensegmentdisplayunit
   a. Design of Mod $n \leq 2^n$counterdesign(total8states,designofmod6andmod7 withclear
   b. DesignandICverificationofDecadecounter
   c. Cascadingofcounters
9. Synchronouscounterdesignanddisplayingresultonsevensegmentdisplayunit
   a. Randomsequence
   b. Ringcounter/Johnsoncounter
10. Design and submission of term projectNote: based on 'C' coding or Python coding.

1. All the above experiments (except few exceptional cases) are to be implemented onArduino kitsalso.

2. It is mandatory to perform experiment on any one of the EDA Tools before theexperiment is done on hardware. All experiments must be unique, design specificationsshouldnot be commoninthelab.

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Courseoutcome

AfterthecompletionofthisLaboratorycourse,thestudentwillbeableto

CO1	Understandtheimplementationofdiscretedigitalcomponents
CO2	UtilizetheICsofDecoder,Multiplexer,Sevensegmentdisplayunitincombinationcircuitdesign
CO3	UtilizetheICsofsuitableFlipflopsinsequentialcircuitdesign
CO4	UtilizetheProgrammableLogicdevicesindigitaldesign
CO5	Understandtheconceptsofsetuptime,holdtime,propagationdelays
CO6	DesigncircuitswithoptimalfeaturesofArea,Poweranddelay
CO7	Designandimplementprototypesofcompletedigitalsystems

AssessmentMethod

AssessmentTool	Experiments	Report/Viva-Voce/Quiz/MCQ/Lab Project	Total
Weightage(%)	25%	15%	40%
		EndSemesterExaminationweightage(%)	60%

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20EC2201	**CommunicationSystems-1**	**PCC**	**3L: 1T: 0P**	**4credits**

Coursecontent:

Unit-I *(12hours)*

The Stochastic Process, Concept of Stationary and Statistical Independence, StationaryProcesses,Wide-SenseStationary,TimeAveragesandErgodicity,Mean-ErgodicProcesses,Autocorrelation Function and its Properties, Cross-Correlation Function and its Properties,CovarianceanditsProperties,

–

UnitII *(12 hours)*

Power Spectrum: Properties, Relationship between Power Spectrum and AutocorrelationFunction, Cross-Power Density Spectrum, Properties, Relationship between Cross-PowerSpectrumand Cross-Correlation Function

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UnitIII – *(8hours)*

Review of signals and systems, Frequency domain representation of signals, Principles ofModulationSystems,TimedomainandSpectralcharacteristicsofmodulatedsignals.

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UnitIV *(8 hours)*

Amplitude(Linear)Modulation:Amplitudemodulation,Singlesideband,Vestigialsideband,Coherentandnoncoherentdemodulation,SuperheterodyneAMReceiver**Angle (Exponential) Modulation,**Bandwidthof Angle-Modulated Waves,GenerationofFMWaves,Demodulation ofFM,FMreceiver.

Unit-V *(10hours)*

Quantization, Uniform Quantizers Midrise and Midtread, Quantization noise, Lloyd MaxQuantizationAlgorithm,NonuniformQuantizers,DeltaModulation,DifferentialPulseCodeModulation(DPCM).

Unit-VI *(10hours)*

Gaussian and white noise characteristics,Noise in amplitude modulation systems, Noise inAngle modulation systems, Pre-emphasis and Deemphasis, Noise considerations inPCM.Noisefigure, sensitivity calculations, linkbudget

Learning ResourcesTextbooks

1. Simon Haykins, '*Communication Systems*' ,JohnWiley&Sons,4thEdition.
2. GeorgeKennedy and Bernard Davis, ' *Electronics&CommunicationSystem* ', McGrawHillEducation2004.

ReferenceBooks:

1. Thomas, '*Communication theory*' ,McGraw-HillEducation.2nd Edition.
2. R. P. Singh, S. D. Sapre, '*Communication Systems*' ,McGraw-HillEducation,.
3. K.SamShanmugam, ' *AnalogandDigitalCommunication*, Willey, 2005
4. Wayne Tomasi, '*Electronics Communication Systems*' ,Person2009,6th Edition.

WebResources:

1. Prof. K.AdityaJaganathan, IIT Kanpur,'*Principles Of Communication System-1'*,URL:https://nptel.ac.in/courses/108104091/

Courseoutcomes: Attheendofthecourse,thestudentswillbeableto

CO1	Abletoanalyzeanddesignvariousmodulationanddemodulationanalogsystems
CO2	Understandthecharacteristicsofnoisepresentinanalogsystems.
CO3	UnderstandtheSignaltoNoiseRatio(SNR)performance,ofvarious AnalogCommunicationsystems
CO4	AnalyzeanddesignthevariousPulseModulationSystems.
CO5	UnderstandtheconceptsofMultiplexing:TimeDivisionMultiplexing(TDM) andFrequencyDivisionMultiplexing(FDM).

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AssessmentMethod

Assessment Tool	Weeklytests (inasemester)	Monthlytests (inasemester)	EndSemesterTest	Total
Weightage(%)	10%	30%	60%	100%

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20EC2202	DigitalSystemDesign	PCC	3L: 1T: 0P	4credits

CourseLearningObjectives

To make understand the student to know the Datapath and control path design aspects inDigitalSystemDesignandalsothedesignmodelingusingHardwareDescriptionLanguage

Coursecontent

UnitI **(6hours)**

HDLforDigitalSystemDesigns

Verilog HDL modeling of Combinational circuits design: Code converters, Multiplexers,Decoders,multi-bitadders,subtractors,multipliersothers.Timingcontrol,Blockingandnon-blockingassignments. Combinational Synthesis.

Unit-II *(6hours)*

HDLforDigitalSystemDesigns

Verilog HDL modeling of Sequential circuits design: Flipflops, synchronous counters,asynchronouscounters, registers. SequentialSynthesis.

Unit-III *(14hours)*

FiniteStateMachines

Mealy machines, Moore machines, Conversion of mealy machines to moore machines andvice-versa. Mealy and Moore model for serial-adder. Sequence detectors (overlap and non-overlap modeling techniques). Even parity and Odd parity detectors and generators usingstatemachines.

Unit-IV *(8hours)*

HDLforFiniteState Machines

Verilog HDL modeling of Finite state machines (Mealy and Moore models), modeling oftestbench.

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Unit-V *(14hours)*

DigitalSystemsmodeling

Datapath design, controlpath design, GCD system design, Traffic light controller design,vendingmachinedesign.CPUDesignandTest:SAYEHdatapathandcontrolpathd esign

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Unit-VI *(12hours)*

HDLModelingofUSBProtocolAnalyzer

Designoverview:Statemachineandsubcircuitpartitioning.

Verilog modeling: Digital Phase-locked loop, NRZI to Binary converter, CRC Checkersubmodules, Packet ID recognizer, state machine subcircuit, Top-level module, Test benchforentirecircuit, Simulation resultsanalysis.

Learning ResourcesTextBooks

1.Zainalabedin Navabi,'Verilog Digital System Design', Mc Graw Hill publications, SecondEdition.

2.Sunggu Lee, 'Advanced Digital Logic Design', Cengage Learning publications.

ReferenceBooks

1. Samir Palnitkar, *'Verilog HDL - A Guide to Digital Design and Synthesis'*, PearsonPublications
2. StephenBrown,ZvokoVranesic, *'FundamentalsofDigitalDesignusingVerilog',* McGrawHillpublications
3. IanGrout,*'DigitalSystemsDesignwithFPGAs andCPLDs'*,Elsevier-2008

WebResources

1. Prof S Shankar Balachandran, NPTEL-IIT Madras, *'Digital circuits & Systems'*.URL:http://nptel.ac.in/courses/117106114/
2. Prof S Srinivasan, NPTEL - IIT Madras, *'Digital circuits and systems'*URL:https://nptel.ac.in/courses/117106086/
3. DeepakKumarTala,URL:http://www.asic-world.com

CourseOutcomes

Attheendofthecourse,thestudentwillbeableto

CO1	UnderstandspecificationsofVLSIdesigns,Moore'sLaw
CO2	DifferentVLSIDesignflows-FPGA, ASIC
CO3	UnderstandtheconceptsofFiniteStateMachinesanditsrelevanceinICDesign
CO4	Modelingofdigitaldesignsusinghardwaredescriptionlanguage

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AssessmentMethod

AssessmentTool	Weeklytests/Assignments (inasemester)	Monthly tests(inasemester)	EndSemester Test	Total
Weightage(%)	10%	30%	60%	100%

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20EC1203	SignalsandSystems	PCC	3L: 1T: 0P	4credits

CourseLearningObjectives

1. Tounderstandthefundamental characteristicsofsignalandsystems.
2. To understand signal and systems in terms of both the time and transform domains,takingadvantageofthecomplementaryinsightsandtoolsthatthesedifferentperspectiveprovide.
3. To develop mathematical skills to solve problems involving convolution, filtering,modulationand sampling.

Course contentCoursecontent

Unit-I **(10hours)**

Mathematical representations of a signal, Common signals in Engineering: ExponentialandSinusoidalsignals,singularityfunctions-unitimpulsefunction,unitstepfunction,Transformations of the independent & dependent variables, size of a signal, absolutelyintegrable&squareintegrablefunctions,Characterization&Classificationof Signals,Modelingofsystems:input-outputdescription,typicalexamplesofsystems,Characterization,Classificationandpropertiesofsystems,Interconnectionsofsystems

Unit-II ***(10hours)***

System Response to Internal Conditions, The representation of CT signals in terms ofimpulses, the CT unit impulse response, system response to external input: convolution forCT LTI systems, Properties of Convolution, Properties of CT LTI systems: memorylesssystems, stability, invertibility, causality; unit step response, Differential equation models &Solutionofdifferentialequations:Natural&Forcedresponses,ZIR&ZSR,stabilityintermsofnatural response,System responsetocomplex exponentialinputs

Unit-III ***(12hours)***

Signals and Vectors, Signal comparison: correlation, Signal representation by orthogonalsignalset,TrigonometricFourierseries,WaveSymmetry,exponentialFourierseries,Convergence of the Fourier series and Gibbs Phenomenon, frequency spectra, PropertiesofFourier series, Power representation using Fourier series, LTI system response to periodicinputs.

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Unit-IV ***(10hours)***

Development of CTFT of an aperiodic signal, Convergence of CTFT, CTFT of some usefulfunctions, Magnitude and Phase representation of CTFT, The CTFT of periodic signals,Properties of CTFT, Frequency spectra of signals, Signal bandwidth, System bandwidth,Frequencyresponse ofLTIsystems, Energy and PowerDensitySpectra.

Unit-V ***(12hours)***

TheLaplaceTransform,RegionofConvergence,Laplacetransformofelementaryfunctions,PropertiesofLaplaceTransform,TheInverseLaplaceTransform,ResponseofLTIsystems,SystemFunctions,RelationshipbetweenLaplaceTransformandFourierTransform,Solutionofdifferentialand Integro-DifferentialEquations

Unit-VI ***(6hours)***

Periodic sampling, Sampling theorem, Pre filtering to avoid aliasing, Frequency domainrepresentationofsampling,Reconstructionofabandlimitedsignalfromitssamples,Samplingof band passsignals**.**

LearningResources

TextBooks

1. Alan V Oppenheim, Alan V Willsky, S. Hamid Nawab, '*Signals and Systems*', 2nd edition,Pearson/PHI,2015
2. B P Lathi, '*Principles of Signal Processing and Linear Systems*', 1st edition, OxfordUniversitypress,2009

ReferenceBooks

1. SimonHaykin,VanVeen,'*Signals&Systems*',2ndEdition,WileyPublications,2007.
2. MahamoodNahvi,'*SignalsandSystems*',McGrawHillPublishers,1st edition,2015.

WebResources

1. Prof. Alan V. Oppenheim, Massachusetts Institute of Technology (MIT), '*Signalsand System*' URL: https://ocw.mit.edu/resources/res-6-007-signals-and-systems-spring-2011/video-lectures/
2. Prof. K Svenkatesh, NPTEL-IIT Kanpur, '*SignalsandSystems*' URL:http://nptel.ac.in/courses/117104074/
3. Prof.V.G.K.Murti,NPTEL-IIT Madras, '*NetworksandSystems*' URL:http://nptel.ac.in/courses/108106075/

Rajiv

Courseoutcomes

Attheendofthecourse,thestudentwillbeableto

CO1	Analyzethespectral characteristicsofcontinuous-timeperiodicandaperiodic signalsusingFourieranalysis.
CO2	ClassifysystemsbasedontheirpropertiesanddeterminetheresponseofLSI systemusingconvolution.
CO3	AnalyzesystempropertiesbasedonimpulseresponseandFourieranalysis.
CO4	ApplytheLaplacetransformforanalyzecontinuous-timeanddiscrete-time signalsandsystems.
CO5	Understandtheprocessofsamplingandtheeffectsofundersampling.

AssessmentMethod

Assessment Tool	Weeklytests	Monthlytests	EndSemesterTest	Total
Weightage(%)	10%	30%	60%	100%

20EC2204	**Electromagnetic wavesandGuidedm edia**	**PCC**	**3L: 1T: 0P**	**4credits**

CourseLearningObjective

1. Introduce the fundamental importance of electromagnetic theory and wavepropagationphenomenaforanelectronicsandcommunicationen gineer.
2. Understanding guided media role for efficient power transmission incommunicationsystems,betweenmicrowavesubsystems,opticalfibers ystems.
3. Introducetothehigherordermodesofpropagationinguidingmedia.

CourseContent

Unit-I **(6hours)**

Introduction

Application,Reviewofvectoralgebra(dotproduct,crossproduct,scalarandvectorcomp onents of vector), coordinate systems (rectangular, cylindrical, spherical coordinatesystems),vectorcalculus(gradient,curl, divergence) ReviewofElectrostatics,Magnetostatics,electrodynamicsandMaxwellequationsandb oundaryconditions.

Rajiv

Unit-II *(8hours)*

Wave Propagation

Wave solution to Maxwell equations, Uniform plane wave solution, propagation constant ,Propagation of uniform plane waves in perfect dielectric and in lossy medium (conductor,lossydielectric), Wavepolarization, PowerandPoynting vector.

Unit-III *(8hours)*

Wavepropagationatinterfaces

Reflection,refraction,NormalIncidence,ObliqueIncidence,effectsofwavepolarizationinreflectionandrefractions,totalinternalreflection,Brewsterangle,phaseandgroupvelocities.

Unit-IV *(8hours)*

TransmissionLines:Parameters

Transmission Lines- Equations of Voltage and Current on TX line, Propagation constant ,characteristic impedance, reflection coefficient and VSWR, Impedance Transformation,Powertransferon TXline,Smithchart.

Unit-V *(6hours)*

Waveguides-I

General solution of TEM, TE, TM waves, parallel platewaveguide,rectangularwaveguide,circularwaveguide.

Unit-VI *(7hours)*

Waveguides-II

Coaxial line, power handling capacity, strip line, microstrip, wave velocity and dispersion,RFconnectors, excitationof waveguide.

Learning books *ResourcesText*

1. Matthew N.O.Sadiku, *'Elements of Electromagnetics'*, Oxford University Press ,6th edition,2014.
2. William H. Hayt Jr. and John A. Buck, *'Engineering Electromagnetics'*, 7th edition,2006, TMH.

Referencebooks

1. 1.E.C.JordanandK.G.Balmain , *'Electromagnetic Waves and Radiating Systems'*,PHI, 2nd Edition,2000.
2. John Kraus and Daniel fleisch, *'Electromagnetics with applications'* ,McGraw-hillinternationaledition ,5th edition ,1999.

WebResource

1. ProfDavidStaeling,MIT-Opencourseware, 'Electromagnetics and Applications'.
   URL:https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-013-electromagnetics-and-applications-spring-2009/index.htm
2. ProfRKShivgaonkar,NPTEL-IITBombay,*'TransmissionLinesandEMWaves'*

Rajiv

URL:http://nptel.ac.in/courses/117101056/

3. ProfHarishshankarRamachandra,NPTEL-IITMadras,*'ElectromagneticFields'* URL:http://nptel.ac.in/courses/108106073/

CourseOutcomes

Attheendofthecourse,thestudentwillbeableto

CO1	Applyvectorcalculustostaticelectric-magneticfieldsindifferentengineering situations.
CO2	AnalyzeMaxwell'sequationindifferentforms(differentialandintegral)

	applythemtodiverseengineeringproblems.
CO3	Examinethephenomenaofwavepropagationindifferentmediaandits interfacesandinapplicationsofmicrowaveengineering
CO4	Analyzetheconceptsofelectromagneticwavepolarization
CO5	Understandtheconceptsofguidingmediaanditsnecessityathighfrequency
CO6	Understandtheusageofsmithchartanditsimportanceinimpedancematching

AssessmentMethod

AssessmentTool	Weeklytests/Assignments	Monthlytests	End SemesterTest	Total
Weightage(%)	10%	30%	60%	100%

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20EC2282	DigitalSystemDesignLaboratory	PCC	0L: 0T: 3P	1.5credits

CourseLearningObjective

To get a practical exposure on the concepts present in Introductory to VLSI Theory courseand thereby acquiring sufficient knowledge in designing basic analog and digital VLSIsystems

Listof Experiments

1. FamiliarizationwithXilinxsoftwareandCircuitlevelEDAtool.
2. Implementation of combinational and sequential circuits using Gate-levelmodelingof VerilogHDL
3. Implementation of combinational and sequential circuits using data flow modelingof VerilogHDL
4. Implementation of combinational and sequential circuits using behavioralmodelingof VerilogHDL
5. ImplementationofFiniteStateMachinesusingVerilogHDL
6. ImplementationofComplexFiniteStateMachinesusingVerilogHDL
7. ASICimplementationofDigitalsystems
8. FPGArealizations
9. TermProject

**Circuit level EDA tool may be Mentor Graphics tool/ Cadence tools/Synopsys tools.References*

1. ProfAnanthaChandrakasan,MIT-Opencourseware, 'Introductory Digital Systems Laboratory'. URL: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-111-introductory-digital-systems-laboratory-spring-2006/labs/

Courseoutcome

AfterthecompletionofthisLaboratorycourse,thestudentwillbeableto

CO1	UnderstandingandutilizingtheVLSICADtools
CO2	Describedigitalsystemsusinghardwaredescriptionlanguage:Verilog
CO3	EfficientinwritingVerilogHDLindifferentmodelingtechniques
CO4	Implementdigitaldesignsonhardware:FPGA
CO5	ImplementingASICdesignsonMentorGraphics/Synopsys/Cadenceplatform
CO8	DesignansimpleanalogordigitalVLSIsystem

AssessmentMethod

Assessment Tool	Experiments	Report/Viva-Voce/Quiz /MCQ	*Term Project andViva-Voce	End Semester LabExam	Total
Weightage (%)	15%	15%	30%	40%	100%

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Course Code	Course Name	Course Category	L-T-P	Credits
20MM2103	**Mechanical Behaviour and Testing of Materials**	**PCC**	**3-1-0**	**4**

Course Objectives:

1. To explain concepts of stress and strain, analyze dislocation interactions with other defects.
2. To provide fundamental aspects of dislocation theories of plasticity behavior and various strengthening mechanisms
3. To study the various strengthening mechanisms
4. To introduce fracture mechanics
5. To study principles and equipment’s of tensile, hardness and impact testings.
6. To understand phenomenon of creep and its testing.

Course Content:

UNIT I **(10 Hrs)**

Introduction: Strength of materials-Basic assumptions-elastic and plastic behaviour-Average stress and strain-concept of stress, strain and the types of stresses and strains. Dislocation theory: dislocation types, dislocation loop, dislocations in FCC, BCC and HCP, Stress fields and energies of dislocations forces on dislocations, forces between dislocation- Interaction of dislocations, dislocation multiplication, dislocation pileups, Interaction with points defects.

UNIT II **(10Hrs)**

Fracture: Elementary theories of fracture, Griffith’s theory of brittle fracture, Ductile Fracture,
Notch sensitivity. Hardness Test: Methods of hardness testing Brinells, Vickers, Rockwell, Rockwell superficial, Shore and Poldi methods, Microhardness test, relationship between hardness and other mechanical properties.

UNIT III **(10 Hrs)**

TENSION TESTING: ASTM Standards and specification, Engineering stress & strain, True stress strain curves, Holloman - Ludwig equation, Plastic Instability (Necking), Testing machines-types, testing procedures, properties measured, specimen dimensions, Problems. TORSION TESTING & SHEARING TEST: ASTM Standards and specification Testing Machines and procedures.

UNIT IV **(10 Hrs)**

Impact Test: Notched bar impact test and its significance, Charpy and Izod Tests, significance of transition temperature curve, Metallurgical factors affecting the transition temperature, temper embrittlement. DBTT curve and its importance. Fracture toughness testing - COD and CTOD tests.

UNIT V **(10 Hrs)**

Fatigue Test: Introduction, Stress cycles, S-N Curve, Effect of mean stress, Mechanism of fatigue failure, effect of stress concentration, size, surface condition and environments on fatigue. Effect of metallurgical variables on fatigue. Low cycle fatigue - High cycle fatigue.

UNIT VI **(10 Hrs)** Creep and Stress Rupture: Introduction, The creep curve, Stress-rupture test, Structural changes during creep, Mechanism of creep deformation, theories of creep. Fracture at elevated temperature, Effect of Metallurgical variables on creep. Wear: Classification and mechanisms of wear, delamination theory, debris analysis, testing methods

Learning resources

Text book:

1. George E Dieter, “Mechanical Metallurgy", McGraw Hill Education, Third edition, 2017.
2. Thomas H.Courtney, “Mechanical Behaviour of Materials”, McGraw-Hilll, Boston, 2nd edition, 2000.

Reference Books:

1. Wulff et al, Vol. III “Mechanical Behavior of Materials", John Wiley and Sons, New York, 1983.
2. R.W. Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials", John Wiley and Sons, 1976.
3. A .K. Bhargava, C. P. Sharma, “Mechanical behaviour and testing of materials”, PHI Learning, First edition, 2011.
4. Suryanarayana, A. V. K., “Testing of Metallic Materials”, Prentice Hall India, New Delhi, 1979
5. Marc A. Meyers, Krishan Kumar Chawla “Mechanical Behavior of Materials”Cambridge University Press, 2008

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

1. Use the concepts of stress and strain to explain the elastic and plastic behaviour of the material
2. Relate the mechanical behaviour of materials to dislocation theory and presence of crystal defects
3. Design a process based on strengthening mechanisms for a given application
4. Understand response of materials under different kinds of stresses, temperature and environment
5. Identify engineering problem in using plastic deformation, fatigue, fracture and creep

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MM2181	**Mineral Processing and Extractive Metallurgy Laboratory**	**PCCL**	**0-0-3**	**1.5**

List of Experiments

1. Study and observations of mineral samples
2. Sampling of an ore from the bulk by (i) Coning and quartering method (ii) Riffle sampler methods
3. Determination and analyze of the size distribution of a fixed granular solid by using a test sieve stack and a vibratory shaker.
4. Verification of Stoke's Law.
5. Determining the reduction ratio of a jaw crusher.
6. Study of the variation of reduction ratio with process variables in Rolls crusher.
7. Study of the process variables on reduction ratio and particle size distribution in ball mill.
8. Determination of the grindability index of ores.
9. Verification of Laws of Communution.
10. Determination of the efficiency of a magnetic separator.
11. Determination of the efficiency of a jig.
12. Study of the particle separation by fluid flow using wilfley table.
13. Determination of the efficiency of a pneumatic separator.

To study the concentration of metallic and non-metallic ores by Froth-Flotation process.

Assessment Method

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM2182	**Phase Transformations and Heat Treatment Laboratory**	**PCCL**	**0-0-3**	**1.5**

List of Experiments

1. Study of heat treating furnaces and atmosphere
2. Study of TTT and CCT diagrams
3. Annealing of medium carbon steel and observation of microstructure & hardness
4. Normalizing of medium carbon steel and observation of microstructure& hardness
5. Hardening of medium carbon steel and observation of microstructure &hardness
6. Study of tempering characteristics of hardened steel.
7. Spheroidizing of high carbon steel
8. Determination of hardenability of a given steel using Jominy end Quench Test
9. Study of age hardening phenomenon in an aluminum alloy or brass
10. Case Carburizing of low carbon steel and determination of case depth
11. Re-crystallization studies on cold worked copper or Cu – alloys

Assessment Method

Assessment Tool	Experiments	Record	Viva-Voce/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM2183	**Mechanical Behaviour and Testing of Materials Laboratory**	**PCCL**	**0-0-3**	**1.5**

List of Experiments

1. Determination of the Brinell Hardness Values of Plain carbon steel and Aluminum alloy samples.
2. Determination of the Rockwell Hardness Values of Plain carbon steel and Aluminum alloy samples.
3. Determination of the Vickers Hardness Values of Plain carbon steel and Aluminum alloy samples.
4. Determination of Stress Strain Curve for AISI 1040 Steel and Identify elastic modulus, ultimate tensile strength, breaking stress, percentage elongation and percentage reduction in area.
5. Determination of Stress Strain Curve for Aluminum Alloy and Identify elastic modulus, ultimate tensile strength, breaking stress, percentage elongation and percentage reduction in area.
6. Determine the impact energy of given samples at different temperatures using Charpy impact tester and comment on the DBTT obtained.
7. Study of fatigue testing Machine and Determination of number of cycles to failure of a given material at a given stress.
8. Determination of creep behavior of lead at room temperature.
9. Determination of stiffness and modulus of rigidity of the spring wire.
10. Determination of wear coefficient of given materials

Assessment Method

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM2203	**Metal Forming**	**PCC**	**3-0-0**	**3**

Course Learning Objectives:

1. To learn theory of elasticity and plasticity
2. To understand the principles of mechanical working of metal
3. To study process equipment and parameters involved in Bulk metal forming and sheet metal forming
4. To study the causes and remedies of different metal forming defects **Course Content:**

UNIT I

Stress and Strain Relationship for Elastic Behavior: Description of stress at a point. State of stress in two dimensions. Mohrs circle of stress in two dimensions, state of stress in three dimensions. Mohrs circle of stress in three dimensions. Description of strain at point.

UNIT II

Elements of Theory of Plasticity: The flow curve. True stress and true strain. Von-Mises distortion energy criterion, maximum shear stress or Tresca criterion. Octahedral shear stress and shear strain. Basics of the theories of plasticity.

UNIT III

Fundamentals of Metal Working: Classification of forming processes, Mechanics of metal working for slab method and uniform deformation energy method. Cold working, Recovery, recrystallization and grain growth, hot working, Strain-Rate effects, Work of plastic deformation.

UNIT IV

Forging: Classification of forging processes, forging equipment. Forging in plane strain. Opendie forging, closed-die forging, Forging of a cylinder in plane-strain. Forging defects. Rolling of Metals: Classification of rolling process, rolling mills. Hot rolling, cold rolling, rolling of bars and shapes, forging and geometrical relationships in rolling. Simplified analysis of rolling load, rolling variables, problems and defects in rolled products. Theories of hot rolling, torque and horsepower, theories of cold rolling, torque and horsepower.

UNIT V

Extrusion: Classification of extrusion processes, extrusion equipment. Hot extrusion.

Deformation and defects in extrusion. Analysis of the extrusion process. Cold extrusion. Extrusion of tubing and production of seamless pipe and tubing.

UNIT VI

Drawing of Rods, Wires and Tubes: rod and wire drawing, tube drawing processes, deep drawing, residual stresses in rod, wire and tubes.SHEET METAL FORMING: Bending, wrap forming, spinning, stretch forming, deep drawing. Forming methods-rubber forming, shearing, blanking, bending, stretch forming, deep drawing, forming limit diagram, defects and application. **Learning resources**

Text book:

1. Dieter G E, "Mechanical Metallurgy", McGraw Hill Co., 2001.
2. Surender Kumar "Technology of metal forming processes" PHI Learning, 2008. **Reference Books:**

1. W. F. Hosford and R. M. Caddell, "Metal Forming: Mechanics and Metallurgy", Cambridge University Press, 2007
2. K. Lange, "Handbook of Metal Forming", SME, 1985.
3. ASM "Metals Handbook, Vol. 14, Forming & Forging", ASM, Metals Park, Ohio, USA, 1998.
4. P. N. Rao, "Manufacturing Technology - Vol.1" McGraw Hill Education; Fifth edition, 2018

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

1. Explain theory involved in metal forming processes
2. Design a process flow chart for fabrication of metals through mechanical working operations
3. Able to calculate process load for given metal forming operations
4. Identify metal forming defects and suggest suitable remedies.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MM2281	**MetalForming Laboratory**	**PCC**	**0-0-3**	**1.5**

List of Experiments

1. Determination of n and K values using tension test
2. Verification of hall-Petch relation in mild steel specimens.
3. Formability of sheet metal by Ericsson cupping test
4. Determination of friction coefficient using ring compression test

5. Cold working of low and high stacking fault energy materials
6. Effect of cold working on mechanical properties (Hardness) of copper and steel
7. Annealing of cold worked metals and alloys
8. To manufacture washer components using fly press (progressive dies /compound dies)
9. Deep drawing of a cup with / without blank holder by hydraulic press
10. To demonstrate the effect of friction and height-to-diameter ratio in the axisymmetric compression of a cylinder.
11. To analyze the load and metal flow in extrusion with different friction conditions and semi-die angles.
12. Determine Green Density and Strength Characteristics (hardness) of Coldcompacted and sintered (Conventional) compact of Copper Powder

Assessment Method

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3101	**Materials Characterization**	**PCC**	**3-1-0**	**4**

Course Learning Objectives:

1. To obtain knowledge on various structural and microstructural characterization techniques of materials.
2. To study the principles, theory and practice of various characterization techniques.

Course Content:

Unit-I : (10 Hrs)

Introduction, concept of resolution, Airy rings, numerical aperture, magnification, depth of field, depth of focus, lens defects and their corrections, principles of phase contrast – bright-field and dark-field contrast, polarized light microscopy, Quantitative microscopy, estimation of grain size, grain boundary area, relevance of light microscopy ideas to electron microscopy.

Unit-II: (10 Hrs)

Introduction, crystal geometry, lattice directions and planes, zone axis, interplaner spacing and angle, Stereographic projection, Bragg's condition of diffraction, X-ray scattering, application of X-ray diffraction – phase identification, estimation of grain size, particle size, residual stress.

Unit-III: (10 Hrs)

Principle, construction and operation of TEM, Interaction of electrons with specimen, reciprocal space and lattice, Ewald sphere, diffraction from finite crystal, preparation of specimens, bright and dark field imaging, selected area diffraction, indexing of diffraction patterns.

Unit-IV: (10 Hrs)

Construction and working principle of SEM. Resolving power, magnification, depth of field, depth of focus, image contrast, Secondary electron, back scattered mode of imaging and energy dispersive analysis of x-rays, Sample preparation techniques.

Unit-V: (10 Hrs)

Scanning Tunneling Microscopy (STM) & Atom Force Microscopy (AFM), Scanning Transmission electron Microscopy (STEM)

Unit-VI: (10 Hrs) Principles of differential scanning calorimetry (DSC), differential thermal analysis

(DTA), Dilatometry, Thermogravimetric analysis (TGA), Dynamic mechanical anaylsis, ThermoMechanical Anaylsis.

Learning resources

Text book:

1. P. J. Goodhew, J. Humphreys, R. Beanland, "Electron microscopy and analysis", CRC Press, 3rd edition, 2000.
2. B.D. Cullity, S.R. Stock, "Elements of X-Ray Diffraction", Pearson; 3 edition, 2001.
3. Brown, M.E., "Introduction to Thermal Analysis: Techniques and Applications", Springer-Verlag New York Inc.; 2nd edition, 2001

Reference Books:

1. P.J. Grundy and G.A. Jones, "Electron Microscopy in the Study of Materials", Hodder & Stoughton Educational, 1976.
2. D.B. Williams and C.B. Carter, "Transmission Electron Microscopy", Springer; 2nd edition, 2009.
3. C.S. Suryanarayana, and M. Grant Norton, "X-ray Diffraction: A Practical Approach",
4. Springer, 2013.
5. D.A. Skoog, F.J. Holler and S.R. Crouch, "Principles of Instrumental Analysis", Thomas Brookes/Cole, 6th Edition, 2007

Course outcomes:

At the end of the course, the student will be able to

1. Determine crystal structures of materials
2. Analyse microstructure of materials at different length scales
3. Analyse defects and fracture surfaces of the tested materials
4. Indicate instrumentation associated with and operating principles of various techniques

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3103	**Non Ferrous Extractive Metallurgy**	**PCC**	**3-0-0**	**3**

Course Learning Objectives:

1. To learn principles of different extraction methods
2. To study process flow and parameters involved in extraction of different nonferrous metals

Course Content:

Unit-I : (7 Hrs)

Early developments in metal extraction- Sources of nonferrous metals- Principles of metals extraction: Thermodynamic principles, homogeneous and heterogeneous reactions, Ellingham diagrams, kinetic principles, principles of electro-chemistry

Unit-II : (8 Hrs)

General methods of extraction :Pyrometallurgy – calcinations ,roasting and smelting, Hydrometallurgy – leaching, solvent extraction, ion exchange, precipitation, and electrometallurgy – electrolysis and electro-refining, General methods of refining: Basic approaches, preparation of pure compounds, purification of crude metal produced in bulk

Unit-III : (8 Hrs)

Extraction of metals from oxide sources: Basic approaches and special features of specific extraction processes, extraction of metals such as magnesium, aluminum, tin and ferro-alloying elements, production of ferro alloys.

Unit-IV : (8 Hrs)

Extraction of metals from sulphide ores: Pyro-metallurgy and hydro-metallurgy of sulphides, production of metals such as copper, lead, zinc, nickel.

Unit-V : (8 Hrs)

Extraction of metals from halides: Production of halides and refining methods, production of reactive and reactor metals. Methods of extraction of metals such as titanium,rare earths, uranium, thorium, plutonium, beryllium, zirconium.

Unit-VI : (6 Hrs)

Production of precious metals : Methods applied for gold, silver and pt. group of metals, Secondary metals and utilization of wastes,Energy and environmental issues in nonferrous metals extraction

Learning resources

Text book:

1. Ray H S, Gosh A, "Principles of Extractive Metallurgy", New Age international Publishers, 2007.
2. Ray H. S., Sridhar R., Abraham K. P, 'Extraction of Non- ferrous Metals', Affiliated East West Press, 2008 **Reference Books:**
   1. Rosenquist T., 'Principles of Extractive Metallurgy', 2nd Edition McGraw Hill, 1983
   2. Raghavan R., "Extractive Metallurgy of Non-Ferrous Metals", Vijay Nicole Imprints, 2015.
   3. Bray J.L., "Extraction of Non-ferrous Metals", John Wiely & Sons, 1959
   4. R.D. Pehlke, "Unit processed in extractive metallurgy", American Elsevier Pub. Co., 1973.

Course outcomes:

At the end of the course, the student will be able to

1. Explain process flow-sheet for an nonferrous extractive process.
2. Analysis and interpret significance of the results for the extraction of nonferrous metals like Al, Cu, Mg, Sn, Ni, Zn, Ag, Au, Pb etc.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L – T - P**	**Credits**
20MM3105	**Steel Making Technology**	**PCC**	**3-0-0**	**3**

Course Learning Objectives:

1. To learn important raw materials required for steelmaking and earlier steel making practices.
2. To learn thermodynamics and kinetics involved in production of steel
3. To provide the knowledge on production of steel through various technologies
4. To understand different secondary steel making practices to produce quality steel 5.To study continuous casting practices

Course Content:

Unit-I :

Steel scenario-Global and Indian, Raw materials for steel making, Factors affecting efficiency of steel making, Earlier steel making processes: Bessemer, OH, Kaldo, Rotor processes, Reasons for their extinction, Development of Twin Hearth process. Concept of mini and integrated steel plant.

Unit-II:

Physical chemistry of carbon, silicon, manganese, phosphorus and sulphur reaction; Slags: their constitution and properties and the theories predicting their behavior, Control of nitrogen and hydrogen in steel, Deoxidation practice, Desulphurization techniques.

Unit-III:

BOF practice, Equipment, Operation and Process, slag Metal reactions in B.O.F., Raw material and flux practices, Modifications and further Development in Conventional BOF, Oxygen Lance: Design, Construction and Operation, Top and Bottom Blown processes, Its advantages and disadvantages.

Unit-IV:

Arc and Induction furnace: merits and limitations; Electric Arc furnace (EAF): mechanical and electrical components, transformer rating and furnace capacity, refractory practices, raw material selection and melting practice; Induction furnace (IF): principle, type, construction, refractory lining and melting practice; Furnace practices for Carbon and Low Alloy Steels.

Unit-V:

Clean steel, Stirring techniques- ladle metallurgy, Vacuum treatments & Decarburizing techniques: Argon oxygen decarburization (AOD), Vacuum oxygen decarburization (VOD), degassing processes (RH & REDA process),Vacuum Induction Melting (VIM),

Post solidification treatments: Vacuum Arc Re-melting (VAR), Electro slag Re-melting (ESR), Injection metallurgy, Secondary refining furnaces (Ladle and SKF furnaces).

Unit-VI:

Casting pit side practice, Types of Moulds, Teeming Methods, Killed, Semi Killed, and rimmed Steels, Solidification of steels. Ingot defects and remedies; Continuous casting practice; factors affecting heat transfer in contiguous casting practice; defects.

Learning resources

Text book:

1. Ahindra Ghosh and Amit Chatterjee, “Iron Making and Steel Making-Theory and Practice”, PHI, New Delhi 2010.
2. Tupkary R J, “An Introduction to Modern Steel Making", Khanna Publishers, New Delhi, 2010.

Reference Books:

1. A.K. Chakrabarti, “Steel Making”, Prentice-Hall of India Pvt. Ltd, 2005
2. Bashforth R, “Manufacture of Iron and Steel Making”, MIR Publishers, 1983.
3. Fruehan R J “The Making, Shaping and Treating of Steel: Steel Making and Refining", The AISE Steel Foundation, 1999.
4. Turkdogan E T, “Fundamentals of steel making” Maney Publishers, 2010.
5. Dipak Mazumdar, James W Evans, “Modeling of steel making process” CRC Press, 2009.

Course outcomes:

At the end of the course, the student will be able to

1. Classify different kinds of furnaces and their ancillary equipments used for Steel making
2. Analyze the irregularities and cause of failures in production of steel and apply the remedial measures for immediate rectification
3. Design the treatment to the liquid steels for attaining better properties.
4. Apply the physical chemistry concept to explain new developments in steel making industry

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**

20MM3182	**Solidification Process and Casting Laboratory**	**PCC**	**0-0-3**	**1.5**

List of Experiments

1. Study of cooling curves of pure metal and alloys.
2. Study of Foundry tools
3. Determination of sand fineness number and distribution of the dry sand.
4. Determination of moisture content of the green sand
5. Determination of flowability and compactibility of green sand
6. Determination of permeability of the green sand with varying clay and moisture content.
7. Determination of the variation of sand properties like green hardness, green compact strength with additives in sands.
8. Determination of the variation of hot compact hardness and hot shear strength with additives in sands.
9. Determination of clay content in sand.
10. Determination of the shatter index of green sand.
11. Preparation of green sand mould using given split pattern.
12. Study of different melting furnaces.
13. Melting and Casting of Al alloys

Assessment Method

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3201	**Computational Materials Engineering**	**PCC**	**3-0-0**	**3**

Course Content:

Unit-I :

Introduction to U buntu and freeware software for simulation

Unit-II:

Tools for the simulation-short introduction to- The C programming language, GNU plot – the plotting freeware, GNU Octave for computations and plotting, Scilab: the scientific computation package, Some miscallaneous freeware

Unit-III:

Dealing with Data- Plotting, fitting, interpolation, Numerical Integration, Numerical Differentiation

Unit-IV:

Structure, thermodynamics and phase transformations- structure and defects, regular solution model, Diffusion and precipitate growth kinetics, spinodal decomposition, ordering.

Unit-V:

Introduction to the concepts in statistical mechanics

Unit-VI:

Molecular Dynamics- Introduction to open-source software LAMMPS, basics of molecular dynamics for atomic systems, simple molecular dynamics code for 2D structures Monte Carlo simulation for atomic systems, simple code for 2D structures

Learning resources

Reference Books:

1. Materials Science and Engineering, V Raghavan,Prentice-Hall India, 2004
2. Advanced Engineering Mathematics,E Kreyzig, Wiley-India,1999
3. Introduction to Methods of Numerical Analysis, S. S. Sastry, EEE edition
4. Computer Oriented Numerical Methods , V Rajaraman, EEE edition
5. Introduction to Computational Materials Science: Fundamentals to Applications, Rechard LeSar, MRC, Cambridge University Press-2013.
6. **Assessment Method**

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MMM107	**Powder Metallurgy**	**PEC**	**3-0-0**	**3**

UNIT – I:

Historical background, steps in powder metallurgy, advantages of powder metallurgy process, advantages of powder metallurgy processing over conventional material processing, applications of powder metallurgy, limitations of powder metallurgy, recent trends; Powder production methods: Mechanical – milling, machining, other impaction techniques, mechanical alloying, Chemical –reduction, thermal decomposition, hydride-dehydride process, Physical methods – electrolytic deposition, gas atomization, water atomization, centrifugal atomization, other atomization approaches, atomization limitations.

UNIT – II:

Powder treatments – cleaning of powders, grinding, powder classification and screening, blending and mixing; coating of metal powders; Metal powder characteristics: sampling, metal powder characterization – chemical composition analysis, particle shape analysis, particle size, measurement techniques – microscopy, screening, sedimentation, light scattering, light blocking, x-ray techniques; microstructural features; packing and flow characteristics of powders – angle of repose, flow rate; density – apparent density, tap density; porosity; compressibility of metal powder; strength properties.

UNIT – III:

Powder pressing – powder shaping and compaction, binders; powder compaction methods – pressure less compaction techniques, pressure compaction techniques; classification of powder metallurgy parts; cold isostatic compaction – process, types, advantages, applications;.

UNIT – IV:

Powder rolling – steps involved, influence of powder characteristics on powder rolling, advantages, disadvantages, application; miscellaneous compaction techniques – continuous compaction, explosive compaction; High temperature compaction: principles of pressure sintering – uniaxial hot pressing, hot extrusion, spark sintering, hot isostatic pressing, injection moulding.

Unit-V Types of sintering – solid state sintering, liquid phase sintering, activated sintering, reaction sintering, rate controlled sintering, microwave sintering, self-propagating high temperature synthesis, gas plasma sintering, spark plasma sintering; sintering theory – thermodynamics of solid state sintering process, stages in solid state sintering, driving force for sintering, sintering mechanisms; variables – process variables, material variables; effects of sintering – dimensional changes, microstructural changes;

UNIT – VI

Sintering atmospheres – need for sintering atmosphere, functions of a sintering atmosphere, hydrogen, reformed hydrocarbon gases, nitrogen based mixtures, dissociated ammonia, inert gases, vacuum. **Post sintering operations**: introduction, sizing, coining, repressing, re-sintering, impregnation, Infiltration, heat treatment, steam treatment, machining, joining, plating, and other coatings. Powder metallurgy product: Porous Bearings, Porous Filters, Sintered Carbides, cermets.

Reference &Text Books:

1. Powder metallurgy science – **R M German**
2. Powder metallurgy science,technology & applications – **PC Angelo & RSubramanian**
3. Powder metallurgy- Science, Technology and Materials by **Anish Upadhyaya and G. S. Upadhyaya**

Video Reference: Manufacturing Processes-1: Source: NPTEL Link: http://nptel.ac.in/courses/112107145/

Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MM3282	**Computational Materials Engineering Laboratory**	**PCC**	**0-0-3**	**1.5**

List of Experiments

Development and execution of illustrative computer programs pertaining to the following topics.

1. Computation of phase diagrams and property diagrams.
2. Finite difference method for heat conduction and solidification.
3. Finite element method for elasto-plastic deformation.
4. Simulated annealing for finding global minimum of a function.
5. Genetic algorithms for steel making processes and optimization.
6. Artificial Neural networks for steel making processes and optimization.
7. First-principles calculation of enthalpies of elements.
8. Monte Carlo simulations.
9.

Assessment Method

Assessment Tool	**Experiments**	**Record**	**Viva-Voce/ Quiz/ MCQ/Lab project**	**Total**
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**

20MMXX06	Nano materials	OEC	3-0-0	3

Course Content:

Unit - 1

Introduction to nanomaterials and nanostructures including both inorganic and organic materials, Top & Bottom up approaches, Challenges in Nanotechnology, Physical Chemistry of solid surfaces- Surface energy, Electrostatic-Van der Waals attraction potential, Interactions between two particles (DLVO theory), and Steric stabilizationInteractions between polymer layers, Mixed steric and electric interactions.

Unit - 2 Zero-Dimensional Nanostructures/Nanoparticles, Homogeneous nucleation and subsequent growth, synthesis of oxide nanoparticles, Synthesis of metallic and semiconductor nanoparticles - Influences of reduction reagents, Influences of polymer stabilizer, Solgel, Hydrolysis, vapor phase reactions, Solid state phase segregation.

Unit - 3

Fundamentals of heterogeneous nucleation, Heterogeneous nucleation and subsequent growth, Nanoparticles through Heterogeneous Nucleation, kinetically confined synthesis of nanoparticles – Aerosol synthesis, Spray paralysis, Template Based synthesis, and Growth termination processes.

Unit - 4 One dimensional nanostructures: Spontaneous growth, Evaporation- Condensation growth, Dissolution- Condensation growth, Vapor (or solution)-liquid-solid (VLS or SLS) growth, Template-Based Synthesis- Electrochemical deposition, Electrophoretic deposition, Template filling, Electrospinning, Lithography.

Unit - 5

Two dimensional nanostructures: Fundamentals of Film Growth, Physical Vapor Deposition (PVD)- Evaporation, sputtering, the comparison between evaporation and sputtering, Chemical Vapor deposition (CVD) - Typical chemical reactions, Reaction kinetics, CVD methods, Atomic Layer Deposition (ALD), Super lattices, self assembly, Electrochemical deposition, Solgel films.

Unit - 6

Carbon-based nanomaterials-Carbon Fullerenes and Nanotubes, Characterization of nanomaterials - Structural Characterization, Chemical Characterization, Physical
Properties of Nanomaterials, Electrical conductivity, applications of nanomaterials

Learning resources

Reference Books:

1. Nanostructures and Nanomaterials –Sysnthesis, Properties and Applications, Cao Guozhong and Wang Ying, World Scientific Publishing.
2. Nanomaterials: An Introduction to Synthesis, Properties and Applications, Dieter Vollath, Wiley, 2008
3. Nanoscale Materials in Chemistry, edited by Kenneth J. Klabunde & Ryan Richards, John Wiley & Sons, 2nd edition, 2009.
4. "No Small Matter: Science on the Nanoscale": Felice C. Frankel and George M. Whitesides, The Belknap Press of Harvard University Press, 2009

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits

MMXX30	Non-destructive testing	PEC	3-0-0	3

Course Objectives:

1. To provide a brief knowledge about the basics of NDT and itsclassification.
2. To learn the liquid penetrant inspection and the characteristics of penetrants and developers.
3. To learn about the principles of magnetic particle inspection and evaluation of indicationstandards.
4. To study the eddy current testing and the factors that effect the eddy currentresponse.
5. To understand x-ray radiography testing and the phenomena of radiographyimage.
6. To obtain knowledge about the principles of ultrasonic inspection and the applications of NDT techniques.

Course Content:

Unit -1: (10Hrs)

Scope and advantages of NDT,Comparison of NDT with DT. Classification of different NDT techniques. Visual InspectionEquipment used for visual inspection – Magnifying Glass Magnifying Mirror,Microscope Borescope, endoscopes or endoprobes Flexible Fiber Optic Borescope, Video Imagescope. Role of NDT in quality control

Unit-II: (8Hrs)

Liquid penetration testing – Introduction, Principle, Equipment, Procedures. Characteristicsof penetrants – developers – Evaluation. Hazards Precautions, advantages, limitations and Applications

Unit-III: (10Hrs)

Principle of Magnetic Particle Testing – different methods to generate magnetic fields.Magnetic Particle Testing Equipment – Magnetic Particle Testing Procedures Method of Demagnetization-magnetic Particle Medium. Evaluation of Indications of Acceptance Standars
– magnetic particle test – applications, advantages and limitations.

Unit-IV: (12Hrs)

Eddy Current Testing – Principles, equipment,advantages, and disadvantages. Factors Affecting Eddy Current Response-Material. Different types of the testing equipments. Conductivity

Permeability – Frequency-Geometry-Proximity (Lift off). Typical Applications, limitations, Types of Probes.

Unit-V: (10Hrs)

X-ray radiography: its principles, equipment, advantages, limitations and applications. Radiographic Procedure – Radiograph Interpretation, Radography Image Quality Indicators. Techiques – Film Processing-Methods of Viewing Radiographs. Radiographic Testing Procedures for welds. Precautions against radiation hazards.

Unit-VI:UltrasonicInspection *(10 Hrs)*

Introduction, Principle of operation Type of Ultrasonic Propagation- Ultrasonic probes. Types of Transducers – Ultrasonic Testing Techniques. Method for Evaluation Discontinuities- Ultrasonic Testing Procedures for different component – applications, advantages and limitations. Applications in inspection of castings, forgings, Extruded steel parts, bars, pipes, rails and dimensionsmeasurement.

Text book

1. "Non Destructive Evaluation and Quality Control", Metals Handbook, Vol. 17, 9th Ed., ASM, 1989

Reference Books

1. Baldev Raj, Jayakumar T, Thavasimuthu M, Practical Non-Destructive Testing, 3rd Ed., Narosa,2009
2. Srivastava, K.C., "Handbook of Magnetic Particle Testing", Oscar Publications,1998

Course outcomes:

1. Recognize the importance of Non destructive testing in the inpection and quality control.
2. Explain the principles and procedures of the liquid penetrantinspection.
3. Able to understand the magnetic field generations and application of Magnetic particletesting.
4. Perform Eddy current inspection for the flawdetections.
5. Discuss the x-ray radiography and the phenomenon of imagegeneration.
6. Determine the Ultrasonic inspection in different types of fabricationtechniques.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Coursecode	**CourseCategory**	**L-T-P**	**Credits**
20EE2202	**ElectricalMachines-IILaboratory**	**0-0-3**	**1.5**

CourseLearningObjectives:

1. TomakeunderstandtheconceptofInductionmotorsinreal-time
2. TomakeunderstandtheconceptofthespeedcontroloftheInductionmotor
3. TounderstandtheconceptofvoltageregulationofAlternator inreal-time
4. Togetknowledgeabout theoperationofSynchronousandinductionmachines
5. Toget familiar withAC electricalMachines

ListofExperiments:

1. Torque-speedcharacteristicsofsquirrelcageInductionMotor

2. SpeedControlofwoundrotorInductionmotorusingrotorresistancecontrol
3. ParameterestimationofsquirrelcageInductionmotor usingBlockedrotor &No-loadtest
4. DeterminationofvoltageregulationofSynchronous generator usingEMF&MMFmethod.
5. VandinvertedVcurvesofSynchronousmotor.
6. VandinvertedVcurvesofsynchronousgenerator.
7. SpeedControlofInductionmotorusingrotorusingV/fcontrolmethod
8. DeterminationofvoltageregulationofSynchronousgeneratorusingASAmethod.
9. Equivalentcircuit diagramof1-phaseInductionmotor
10. ParalleloperationofAlternators

CourseOutcomes Attheendofthecourse: Thestudentwill beableto

CO1	AnalyzeTorque-speedcharacteristicsofinductionmotor
CO2	Analyzeno-load,blockedrotor,andspeedcontrolof inductionmotor
CO3	Analyzethevoltageregulationof Alternators
CO4	AnalyzetheParalleloperationof Alternators
CO5	UnderstandtheprincipleofoperationofACmachines
CO6	UnderstandthePhasor andequivalentcircuitdiagrams ofinductionmotorandAlternators

Coursecode	**CourseCategory**	**L-T-P**	**Credits**
20EE2201	**ElectricalMachines-II**	**3-1-0**	**4credits**

CourseLearningObjectives

5. TomakeunderstandtheconceptofACrotatingmachines.
6. TomakeunderstandtheconceptoftheInductionmotor
7. Tounderstandtheconceptofsynchronousgeneratorandmotor
8. Toget knowledgeaboutapplicationsofinductionandsynchronousmachines

UNITI:Three-phaseInductionmotor

(10hours
)
Polyphase Induction Motors-Construction Details of Cage and Wound Rotor Machines Production of a RotatingMagneticField-PrincipleofOperation-RotorEmfandRotorFrequency-RotorReactance,RotorCurrentandPfatStandstillandDuringOperation.

UNITII:ThreephaseInductionmotorcharacteristics

(10hours) Rotor Power Input, Rotor Copper Loss and Mechanical Power Developed and Their Inter Relation-Torque Equation-DeductionFromTorqueEquation-ExpressionsforMaximumTorqueandStartingTorque-TorqueSlipCharacteristic – GeneratorOperation - Double Cage and Deep BarRotors - Equivalent Circuit- PhasorDi- agram - CrawlingandCogging -CircleDiagram-NoLoad andBlocked RotorTests-PredeterminationofPerformance

UNIT III: Starting and speed control of Induction motor & Single Phase Induction Motor (10 hours) StartingMethodsandStartingCurrentandTorqueCalculations,SpeedControl-ChangeofFrequency;PoleChangingand Methodsof Consequent Poles; Cascade Connection. Injection of an Emf.Single Phase InductionMotors: Sin-gle phase induction motor – Constructional features - Double revolving field theory – Elementary idea of cross-fieldtheory–split-phase motors–starting methodsofsingle-phaseinduction motors.

UNITIV:SynchronousMachines&CharacteristicsofSynchronousGenerators

(10Hours) Constructional Featuresof the round rotorand salientpole machines – Armaturewindings–Integral slot andfractional slot windings; Distributed and concentrated windings – distribution, pitch and winding factors – E.M.FEquation - Harmonics in generated e.m.f. – suppression of harmonics – armature reaction – leakage reactance –synchronous reactanceandimpedance–experimentaldetermination-phasordiagram– loadcharacteristics.

UNITV:Regulation&Paralleloperationofsynchronous generators

(10 hours) Pre determination of Regulation by synchronous impedance method, Z.P.F method, M.M.F method. two reactionanalysis–determinationofXdandXq(Sliptest)Phasordiagrams–Regulation.Synchronizationofalternatorswithinfinitebusbar–synchronizingpower,synchronizingtorque–paralleloperationandloadsharing-Effectofchangeofexcitationandmechanicalpowerinput.

UNITVI:Synchronousmotors (10Hours)

Principle of operation – phasor diagram – Variation of current and power factor with excitation – V and Inverted VCurves - Power developed – Synchronous Condensers - Excitation and power circles – hunting and its suppression –Methods ofstarting– synchronousmotor.

LearningResources:

TextBooks:

1. IJNagrathandDPKothari,“ElectricMachines”, McGrawHillEducation,ThirdEdition,2004.
2. PSBimbhra,“ElectricalMachinery”, KhannaPublishers,SeventhEdition,2011.

ReferenceBooks:

4. MGSay,“PerformanceanddesignofACmachines”, CBSPublishers,ThirdEdition, 2002.
5. AEFitzgeraldandCKingsley, "ElectricMachinery”,McGrawHillEducation,SeventhEdition,2020.
6. JBGupta“TheoryandperformanceofElectricalMachines”,S.K.Kataria&SonsPublishers14th Edition,2009.

Webresources:

3. Prof.P.SasidharaRao,NPTEL,IIT-Madras,ElectricalMachines-IIhttps://nptel.ac.in/courses/108/106/108106072/
4. Prof.TapasKumarBhattacharyaNPTEL,IIT-Khragpur,ElectricalMachines-II,https://nptel.ac.in/courses/108/105/108105131/

CourseOutcomes:

Atthe end ofthecoursethestudentwillbeableto

CO1	UnderstandInductionmotoroperation,construction,andapplications
CO2	Understandthestartingandspeedcontroltechniquesforinductionmotors
CO3	UnderstandSynchronousgeneratoroperation,construction,andapplications
CO4	Analyzetheparalleloperationofalternators
CO5	UnderstandtheprincipleofoperationofSynchronousmotor
CO6	UnderstandtheapplicationsandstartingmethodsofSynchronousmotor

S.No	UnitNumber	Number ofHours		Totalnumber ofclasshours
		Lecturehours(L)	Tutorialhours(T)	
1	UnitI	8	2	10
2	Unit II	8	2	10
3	UnitIII	8	2	10
4	UnitIV	8	2	10
5	Unit V	8	2	10

6	UnitVI	8	2	10
Totalhours		48	12	60

20EE3101	PowerElectronics	PCC	3L:1T:0P	4credits

CourseLearningObjectives:

1. Tointroducetheconceptofsemiconductorsdevicesforhighpowersupplyandtheirapp lications.
2. TounderstandtheneedforPowerElectronicsDevicesandCircuitsandtheirbasicoperation.

Coursecontent

Unit-I:Introduction **(10hours)**

Introduction to Power Electronics, Power Semi-Conductor Devices: Power Diodes, power Tran-sistors, power MOSFETs, IGBTs, GTOs, Thyristors, Basic theory of operation, characteristics,Ratings,Protectionandcooling,linecommutationandforced commutationcircuits.

UnitII:Converters **(10hours)**

Power Electronic converters: 1-phase / 3 phase rectifier circuits, 1-phase / 3 phase phase-con-trolled converters (Semi-converters, full–converters and Dual converters) using IGBT. Analysisand performance with passive and active load, Harmonics and power factor, Introduction topowerquality.

UnitIII:D.Cconverters **(6hours)**

D.C-to-D.C converters (choppers): Buck, Boost and Buck-Boost type and various chopper con-figurations.

UnitIV:A.Cconverters **(8hours)**

A.C-to-A.C converters: A.C voltage controllers, Cyclo-converters, Introduction to matrix con-verters

UnitV:Inverters **(10hours)**

D.C–to-A.C converters (Inverters): 1-phase VSI in half bridge and full bridge configuration,CSI,Frequencyandvoltagecontrol,Line-commutatedinverters (LCIs).

Unit-VI:APPLICATIONS **(8hours)**

Power system applications- Static AC circuitbreaker, interconnection of renewableenergysources and energy storage systems to the utility, Industrial applications - Switch mode welder,Voltage source series resonant inverters in induction heating, solid state relay. Applicatons forDC-DCconverters,fullyintegratedvoltageregulators.

Learning ResourcesTextBooks

1. DanielWHart, *PowerElectronics*TataMcGrawHill

2. IssahBatterseh,*PowerElectronicCircuits*, Wiley.

3. N.Mohan,T.M.Undeland&W.P.Robbins,*PowerElectronics:Converter,Applications&Design*,JohnWiley&Sons,1989

4. MuhammadH.Rashid,*Power Electronics:Circuits,Devices,and Applications*, Pearson,2009

ReferenceBooks

2. BimalKBose,*ModernPowerElectronicsandACmotorDrives*,PearsonPublishers.

3. JoeH.Chow,AlexM.Stankovic,DavidJ.Hill,*PowerElectronicsandPowerSystems* SpringerPublications.

WebResources:

2. Prof.G.Bhuvaneshwari,NPTEL-IIT-Delhi,PowerElectronics.
URL:https://archive.nptel.ac.in/courses/108/102/108102145/

Courseoutcomes: Attheendofthecourse,thestudentswillbeableto

CO1	UnderstandtheneedforPowerElectronicsDevicesandCircuitsandtheirbasicopera-tion.
CO2	Perform an analysis of driving and control and triggering circuits for Power Electronicconverters
CO3	Perform an analysis of AC to DC converters (Single phase and three phase, controlledand uncontrolled), A.C Voltage controllers, DC to DC converters(choppers), and singlephaseD.CtoA.C converters (Inverters)insquare wavemode.
CO4	Perform Fourier analysis and knowledge of Power Quality issues associated withpowerelectroniccircuits.
CO5	Understand differentapplicationsofpowerelectronics.

20EE3103	**ControlSystems**	**PCC**	**4L:0T:0P**	**4**

CourseLearningObjective

1. Toexplorethe modelingoflineardynamicsystemsviadifferentialequationsandtransferfunctionsutilizingstate-paceandinput-outputrepresentations.
2. Analysisofcontrolsystemsinthetimeandfrequencydomainsandusingtransferfunctionandstate-spacemethods.
3. Studyoftheclassicalstabilitytests,suchastheRouth-HurwitzandNyquistcriterions,anddesignmethods usingroot-locusplots andBodeplots.

Coursecontent

Unit-I:Introduction **(6hours)**

Introduction-Openloopandclosedloopcontrolsystems-Transferfunctions-Blockdiagramsandtheirreduction-Signalflowgraphs-formula.

Unit-II:Mathematicalmodeling **(6 hours)**

Mathemat-ical modeling and transfer functionsof electrical circuitsandmechanical systems.PrincipleandoperationofServomotors andSteppermotors.

Unit-III:Timeresponseanalysis **(10hours)**

Standard test signals, step response of first and second order systems Time response specifica-tions stea~~d~~y state error static ~~e~~rror and generalized error coefficients response~~-w~~ith proportional,derivativeandintegralcontrollers.DesignofK_p,K_i,$k_v$parameters.

Unit-IV:Stabilityanalysis **(6hours)**

Stability concept, characteristic equation, location of roots in the s-plane for stability Routh-Hurwitz criterion, Root locus rules for the construction of root locus- construction of root locususingMATLAB/SIMULINK.

Unit-V:Stabilityanalysiscntd. **(8hours)**

Introduction-Bode Plots Gain margin and Phase margin - Polar plots - Nyquist stability criterionNeedfor compensators.IntroductiontoLagandleadcompensatorsin frequencydomain.

Unit-VIStatespaceAnalysis **(10hours)**

Concepts of state, state variables and state model, derivation of State models from block diagrams, Diagonalization, Solving the Time invariant state Equation,state transition Matrix anditsProperties ConceptsofControllabilityandObservability.

Learning ResourcesText Books:

3. B.C.Kuo,*Automaticcontrolsystems*,JohnWileyandSons, 8th edition,2003.
4. K.Ogata,*Moderncontrolsystems*,PrenticeHallofIndiaPvt.Ltd.,5th edition,2010.

References

3. I.J.NagrathandM.Gopal,*ControlSystemEngineering*,NewAgeInternational(P)LimitedPublishers,5thedition,2007.
4. NormanS.Nise,*ControlSystemEngineering*,WileyIndia,5th edition2000.

WebResources:

2. Prof.C.S.ShankarRam,NPTEL,IIT-Madras,ControlSystems.URL:https://archive.nptel.ac.in/courses/107/106/107106081/

Course outcomes: Attheendofthe course,thestudents willbeable to

CO1	Analyzecontrollabilityandobservabilityof linearsystems.
CO2	Designstate-spacecontrollerandappropriate(deterministic)observer.
CO3	Designcontrollerwithfrequencydesignmethods.
CO4	Applyroot-locusmethodfor analysisandsynthesis.
CO5	Applypoleplacementcontrollerdesign approach.
CO6	Designlinearquadraticregulatorfordiscrete-timesystems.

20ECXY53	IntroductiontoMachineLearning	PEC	3L:1T:0P	3credits

CourseLearningObjectives

1. To provide abroad survey of approaches and techniques in machine learning.2.Todevelopadeeperunderstandingofseveralmajortopicsinmachinelearning.3.Todevelopthebasicskillsnecessarytopursueresearchinmachinelearning.

CourseContent:

Unit-I:Introduction (6hours)

Introduction, Different types of Learning, Hypothesis space and Cross-Validation, LinearRegression, Introduction to decision trees, learning decision trees, over fitting, Python ex-erciseondecisiontreesandlinearregression

Unit-II:KNN (7hours)

K-Nearest neighbor, feature selection, feature extraction, collaborative filtering, pythonexerciseonKNNandPCA.

Unit-III:BayesianLearning (8hours)

BayesianLearning, NaïveBayes,BayesianNetwork,PythonexerciseonNaïveBayes

Unit-IV:SVM (8hours)

Logistic regression, Introduction to Support Vector Machine, SVM: The Dual formation,SVM: maximum margin with noise, nonlinear SVM and Kennel function, SVM: solutionstothedualproblem,Pythonexercise onSVM.

Unit-V:MLP (8hours)

Multilayer Neural network, neural network and back propagation algorithm, deep neuralnetwork,pythonexerciseonneuralnetwork.

Unit-VI:Clustering (8hours)

Introduction to computational learning theory, sample complexity: finite hypothesis space,VC Dimension, Introduction to Ensembles, Bagging and Boosting, Clustering, means clus-tering,agglomerativehierarchicalclustering,pythonexerciseonclustering.

LearningResources:

TextBooks:

1. TomMitchell,IntroductiontoMachineLearning,TMH2ndEdition.

2. EthemAlpaydin,IntroductiontoMachine Learning,PHI,2nd Edition.

ReferenceBooks:

1. AndreasC.Müller,SarahGuido,IntroductiontoMachineLearningwithPythonO' ReillyMedia,Inc.FirstEdition.

Webresources:

1. Prof.SudeshnaSarkar,NPTE-IT-Kharagpur,IntroductiontoMachineLearningURL:http://nptel.ac.in/courses/106105152/

CourseOutcomes: Attheendofthecourse,thestudentwillbeable to

CO1	Understandthefundamentalissuesandchallengesofmachinelearninglikeda-ta,modelselection,andmodelcomplexity.
CO2	Understand strengths And Weaknesses of many Popular machine learning approaches.
CO3	Designandimplementvariousmachinelearningalgorithmsinarangeofrealworld applications.

20ECXY26	**EmbeddedSystems**	**PEC**	**3L:0T:0P**	**3credits**

CourseLearningObjectives:

1. Studentsshalllearnaboutevaluationofembeddedsystems
2. StudentsshalllearnaboutPICUnit
3. StudentsshalllearnaboutARMprocessors
4. StudentsshalllearnaboutDSP processors
5. Studentsshalllearnaboutsoftwarelimitationsinembedded systems
6. Studentsshalllearnaboutnetworkingofembeddedsystems

CourseContent

UnitI:OverviewofEmbeddedSystems (6hours)

Overview of Embedded Systems, Embedded System Architecture, Processor examples: ARM,PIC etc, Introduction to Embedded Hardware, Overview of micro controller and micro-proces-sor, Von Neumann Architecture, Harvard Architecture, Advanced Harvard Architecture, Intro-ductiontoPIC microcontroller.

Unit-II:Instruction set (10hours)

Instruction format, Addressing modes, Instructions, Data transfer instructions, Arithmetic andLogical instructions, Bit oriented instructions, Control instructions, Assembly language pro-gramming, Interrupts in PIC, Interrupts timing, PIC input output pins, PIC timers, Watchdogtimer,PWMmodeinPIC,PICperipherals,PICexamples.

Unit-III:ARM (10hours)

History, ARM Architecture and its versions, Basic ARM organization, Registers and its organi-zation, Processor modes, Memory Organization, ARM Instruction set, ARM Data types, ARMinterrupt processing, Stack organization, ARM input output system, Pipeline operation in ARM,SimpleARMbasedsystems.

Unit-IV: DSP (8hours)

Features of digital signal processors, DSP applications and DSP algorithms, DSP memory, In-struction sets and parallel instructions, System on chip, Memory, Memory organization, Virtualmemory, Memory management Unit, BUS structure, Serial interfaces, Power aware architec-ture.

Unit-V:Softwareforembeddedsystems **(6 hours)** Re-quirementandfeaturesof softwareforembeddedsystems,Usage of Candjavaanditslimitations,Fundamentalsofembeddedoperatingsystems, Scheduling policies,Resourcemanagement,EmbeddedOS.

Unit-VI:Networkembedded systems **(5 hours)** Net-work embedded systems, Distributed embedded systems andits Architecture,Multi-proces-sornetworks,Ethernetandits features,Hardware modules,Protocols.

LearningResources:

Textbooks

1. WayneWolf,'Computersascomponents:PrinciplesofEmbeddedComputingSystemDesign',MorganKaufmanpublication,2000.
2. A.K.RayandK.M.Bhurchandani,AdvancedMicroprocessorsandPeripherals, TMH,2nd Edition2006

Referencebooks:

1. MicroprocessorsandInterfacing,D.V.Hall,TMH,2nd Edition2006.

Webresources:

1. Dr.SantanuChaudhury,NPTEL-IITDelhi,'EmbeddedSystems',URL:URL:https://nptel.ac.in/courses/108102045/

Course outcomes: Attheendofthecourse,thestudentwillbeableto

CO1	Understandevaluationofembeddedsystems
CO2	AnalysethePICUnit
CO3	AnalysetheARMprocessors
CO4	AnalysetheDSPprocessors
CO5	Understandthesoftwarelimitationsinembeddedsystems
CO6	Understandthenetworkingofembeddedsystems

22EE3190	Mini Project -1 (Socially RelevantProject)	PROJ	0L: 0T: 3P	1 credits

Course Learning Objective

- To introduce the student to the existing real-time societalproblems
- To make the student to identify a problem with the help of staffmembers
- To see that students can propose elaborately and try attempting to solve the problem togreat extent.

List of Experiments

1. Identifying real-time societalproblems
2. Idea proposal of multiple-solutions for the problem identified anddiscussion
3. Prototype design for an optimalsolution

Note: The student is supposed to use the latest advancements of IOT/AI and general understanding on science and technology for identifying solution to a problem

Course outcome: After the completion of this Laboratory course, the student will be able to

CO 1	To understand the problems the society facing at present specifically at university/institute/ locality etc level.
CO 2	Shortlist some of the problems and do an exercise to choose a problem to solve
CO 3	Form a group with classmates and peers (worldwide), local authoritiesand understand deeply the roots of the problem and start initiation of solvingit.
CO 4	Propose a solution method and prepare either hardware or software models depending upon the problem demands
CO 5	See his/her solution impact on the society and see or submit/suggest the models to the authorities for further implementation after approval satisfying he IP rights of RGUKT.

Assessment Method

Assessment Tool	Literature survey (Internal)	Seminar on observed case- studies (Internal)	Hardware/Software prototype development for identified problem (External)	Final Presentation and Viva-Voce (External)
Weightage (%)	20 %	20%	40%	20%

22EG1281	**English-I Laboratory**	**HSC**	**0L : 1T : 3P**	**2.5 credits**

Course objectives:

- To facilitate computer-aided multi-media instruction enabling individualized andindependent language learning
- To sensitize the students to the nuances of English speech sounds, word accent,intonation andrhythm
- To provide opportunities for practice in using English in day to daysituations
- To improve the fluency in spoken English and neutralize mother tongueinfluence
- To train students to use language appropriately for debate, group discussion andpublic speaking

Course Content:

UNIT-I: (06 ContactHours)

Theory: An Ideal Family by Katherine Mansfield

Spoken Skills: Situational Dialogues – Role-play – Expressions in various situations – Self Introduction – Introducing others – Greetings – Apologies – Requests – Giving directions

UNIT-II: (06 ContactHours)

Theory: Energy -Alternative sources of Energy

Panel Debate on "On-grid & off-grid support to public participation in the production of solar energy in India", Reading the Wikipedia content on "The Green New Deal". Reflective session on the prospects of "The Green New Deal in India"

Writing Skills: Letter Writing (Formal & Informal) and Hands on Session on Letter Writing

UNIT-III: (06 ContactHours)

Theory: Transport - Problems & solutions

Group Discussion on "The Future of Bullet Trains in India"

PPT on "The Dedicated Freight Corridors & the Future of Indian Economy" – Introduction to Speech

Spoken Skills: Sounds – Vowels, Consonants and Diphthongs – Pronunciation Exercises (Basic Level)

UNIT-IV: (06 ContactHours)

Theory: Technology - Evaluating technology

PPT on "3R: Reduce, Recycle, Reuse" - Solo Debate on "Can Block Chain Technology Mitigate the Issue of Cyber Crimes and Hacking?"

Presentation Skills: JAM –Description of Pictures, Photographs, Process, Talking about wishes, Information Transfer

UNIT-V: (06 ContactHours)

Theory: Environment - Ecology versus Development

Listening Skills: Listening Activity on YouTube video on “Greening the Deserts” - Students’ seminar on “Waste to Wealth: Examples from around the Globe”.

UNIT-VI: (06 ContactHours)

Theory: Industry - Selling products

Reading Skills: Reading the material on “4Ps: Product, Price, Place, and Promotion” Role play on “How to sell your product and services”

References:

Non – Detailed Text Book: Panorama – A Course on Reading published by Oxford University Press, India

English for engineers and technologists by Orient Black Swan

A Textbook of English Phonetics for Indian Students 2nd Ed T. Balasubramanian. (Macmillan), 2012.

Speaking English Effectively, 2nd Edition Krishna Mohan & NP Singh, 2011. (Macmillan).

A Hand book for English Laboratories, E.Suresh Kumar, P.Sreehari, Foundation Books,2011

English Pronunciation in Use. Intermediate & Advanced, Hancock, M. 2009. CUP

Basics of Communication in English, Soundararaj, Francis. 2012.. *New Delhi: Macmillan*

EnglishPronouncing Dictionary, DanielJones CurrentEdition with CD.Cambridge, 17th edition, 2011.

Courseoutcomes*:* At the end of the course, the student will be able to

CO 1	Understand the issues affecting the economy and environment in India and across the globe
CO 2	Develop the instinct for problem solution
CO 3	Develop the ability to collect materials on various socio-economic-technological issues and prepare PPT for presentation
CO 4	Improving listening skills
CO 5	Inculcate speaking as a behaviour by repeated practice and exposure

Course Nature: THEORY + LABORATORY

Internal Assessment (40 Marks)	**External Assessment** (60 Marks)
Record Writing– 10 Marks	ReadingComprehension 15 Marks
Attendance – 10Marks	Writing3 0 Marks

Continuous Assessment (Listening – 10 Marks + Oral Presentations – 10 Marks)	Speaking (Viva-Voce) 15 Marks

22EG3183	**English-II Laboratory**	**HSC**	**0L: 0T: 3 P**	**1.5 credits**

Course objectives:

- To improve group discussion skills of thestudents
- To help the students to write their CV and Internshipapplication
- To improve the telephonic etiquettes of thestudents
- To help the students to take decision on theircareer

Course Content

UNIT-I: (06 ContactHours)
Group Discussion - How to think and analyze - How to initiate a topic - How to continue a topic - How to support or reject a point-of-view - How to defend your position - Managing distractions and mediating between contenders - How to summarize & conclude

UNIT-II: (06 ContactHours)
Telephonic conversation & Etiquettes - How to introduce oneself - How to introduce the main issue - How to keep the other person engaged - How to convince the other person - How to complain without irritating. - Giving assurance and asking for clarification - How to end a formal telephonic conversation

UNIT-III: (06 ContactHours)
Career Planning & Job-Skill Analysis - ASK: Talking about one's Attitudes, Knowledge, & Skills - SMART goals - Reading & Analysis of JobAdvertisements

UNIT-IV: (06ContactHours)
CV & Resume Writing - Difference between CV & Resume - Writing CV - Writing Resume - Writing Cover Letter

UNIT-V: (06 ContactHours)
Application for Internship - Application for internship in Academic Labs - Application for internship in Industries - Follow up the Application with reminders and requests

UNIT-VI: (06 Contact Hours)
Interview Skills - Preparation for the Interview - Frequently asked questions - Dress Codes, Appearance, and Etiquettes. 6.4 Facing the Interview

References:

Business Communication Today, 12th Edition, Courtland L Bovee & John Thill, Pearson
British Council Material on Career Planning & Interviews
Master the Group Discussion & Personal Interview - Complete Discussion on the topics asked by reputed B-schools & IIMs by Sheetal Desarda, Notion Press
Group Discussion and Interview Skills by Priyadarshi Patnaik , Cambridge University Press India
The Ultimate Guide to Internships: 100 Steps to Get a Great Internship and Thrive in It
by Eric Woodard
Telephone Etiquette by Robert DeGroot

Courseoutcomes: At the end of the course, the student will be ableto

CO 1	Get used to a variety of GDs to understand the principles, finer nuances, and intricacies of the art
CO 2	Get exhaustive information on how to prepare for internship and interview
CO 3	Write his/her CV to remain well-prepared for the interviews
CO 4	Take decision on his/her career goals and plans
CO 5	Attain professional speaking skills To Enhance his/her employability skills.

<u>Assessment Method:</u>

Course Nature: LABORATORY

Internal Assessment (40 Marks)	External Assessment (60 Marks)
Record Writing– 10 Marks	ReadingComprehension – 15Marks
Attendance – 10Marks	Writing– 30 Marks
Continuous Assessment (Listening – 10 Marks + Oral Presentations – 10 Marks)	Speaking (Viva-Voce) – 15 Marks

22EG3183	**English-II Laboratory**	**HSC**	**0L: 0T: 3 P**	**1.5 credits**

Course objectives:

- To improve group discussion skills of thestudents
- To help the students to write their CV and Internshipapplication
- To improve the telephonic etiquettes of thestudents
- To help the students to take decision on theircareer

Course Content

UNIT-I: (06 ContactHours)

Group Discussion - How to think and analyze - How to initiate a topic - How to continue a topic - How to support or reject a point-of-view - How to defend your position - Managing distractions and mediating between contenders - How to summarize & conclude

UNIT-II: (06 ContactHours)

Telephonic conversation & Etiquettes - How to introduce oneself - How to introduce the main issue - How to keep the other person engaged - How to convince the other person - How to complain without irritating. - Giving assurance and asking for clarification - How to end a formal telephonic conversation

UNIT-III: (06 ContactHours)

Career Planning & Job-Skill Analysis - ASK: Talking about one's Attitudes, Knowledge, & Skills - SMART goals - Reading & Analysis of JobAdvertisements

UNIT-IV: (06ContactHours)

CV & Resume Writing - Difference between CV & Resume - Writing CV - Writing Resume - Writing Cover Letter

UNIT-V: (06 ContactHours)

Application for Internship - Application for internship in Academic Labs - Application for internship in Industries - Follow up the Application with reminders and requests

UNIT-VI: (06 Contact Hours)

Interview Skills - Preparation for the Interview - Frequently asked questions - Dress Codes, Appearance, and Etiquettes. 6.4 Facing the Interview

References:

Business Communication Today, 12th Edition, Courtland L Bovee & John Thill, Pearson
British Council Material on Career Planning & Interviews
Master the Group Discussion & Personal Interview - Complete Discussion on the topics asked by reputed B-schools & IIMs by Sheetal Desarda, Notion Press
Group Discussion and Interview Skills by Priyadarshi Patnaik , Cambridge University Press India
The Ultimate Guide to Internships: 100 Steps to Get a Great Internship and Thrive in It by Eric Woodard
Telephone Etiquette by Robert DeGroot

Courseoutcomes: At the end of the course, the student will be ableto

CO 1	Get used to a variety of GDs to understand the principles, finer nuances, and intricacies of the art
CO 2	Get exhaustive information on how to prepare for internship and interview
CO 3	Write his/her CV to remain well-prepared for the interviews
CO 4	Take decision on his/her career goals and plans
CO 5	Attain professional speaking skills To Enhance his/her employability skills.

<u>Assessment Method:</u>

Course Nature: LABORATORY

Internal Assessment (40 Marks)	External Assessment (60 Marks)
Record Writing– 10 Marks	ReadingComprehension – 15Marks
Attendance – 10Marks	Writing– 30 Marks
Continuous Assessment (Listening – 10 Marks + Oral Presentations – 10 Marks)	Speaking (Viva-Voce) – 15 Marks

22EG3283	**English-III Laboratory**	**HSC**	**0L: 0T: 3 P**	**1.5 credits**

Course objectives:

- To improve interpersonal skills of thestudents
- To help the students to write professional letters andreports
- To practice the etiquettes to be used atworkplace
- To reward hands on experience on managingmeetings
- To imbibe leadership qualities in thestudents

Course Content

UNIT-I: (06 Contact Hours)

Professional Presentation - Collecting & Reading the materials to be presented - Analyzing the main points - Summarizing & concluding - Developing PPT - Delivery of the Presentation

UNIT-II: (06 Contact Hours)

Report Writing & Writing Professional Emails & Applications – Routine Reports – Investigative Reports - Professional Emails - Formal Letters and Applications

UNIT-III: (06 ContactHours)

Agenda, Meetings, & Minutes - Setting the agenda for a meeting - Managing a meeting - Keynote address & vote of thanks - Publishing the minutes

UNIT-IV: (06 Contact Hours)

People skills and small talks (2 minutes) - Talking to professional executives - Talking to colleagues - Talking to the boss - Talking to your team - Talking to the mediadelegates

UNIT-V: (06 ContactHours)

Corporate Etiquettes - How to introduce & greet - How to raise a question - How to clarify a doubt - How to say “yes” or “no” - Rapport building - Dining & winning - Counseling somebody - How to influence & motivate

UNIT-VI: (06 Contact Hours)

Life Skills - Leadership communication - Interpersonal communication - Stress management - Time Managemen

References:

***Business Communication Today*, 12th Edition, Courtland L Bovee & John Thill, Pearson**
British Council Material on communication
Training in Interpersonal Skills: Tips f: Tips for Managing People at Work by **Robbins andHunsaker**
Soft Skills for Everyone, with CD Paperback –by Jeff Butterfield
Communication for business by Shirley Taylor, Pearson

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

CO 1	The art of professional presentation
CO 2	Write professional reports and letters
CO 3	Conduct a formal meeting
CO 4	Develop people skills and corporate etiquettes
CO 5	Gain the basic knowledge about leadership communication, stress management and timemanagement

Assessment Method:

Course Nature: LABORATORY

Internal Assessment (40 Marks)	**External Assessment** (60 Marks)
Record Writing10 Marks	ReadingComprehension – 15 Marks
Attendance 10 Marks	Writing– 30 Marks
Continuous Assessment (Listening – 10 Marks + Oral Presentations – 10 Marks)	Speaking (Viva-Voce) – 15 Marks

22HS3101	Constitution of India	MC	1L: 0T: 0P	0 credits

Course Learning Objectives

7. The basic objective of the course is to provide knowledge aboutinstitutions
8. It help to understands the processes to governing the society in a systematicway.
9. It helps to establish social Justice, Liberty, Equity andFraternity.
10. The course will introduce the idea of political system ingeneral
11. It provides idea about working process of constitutionalinstitutions.
12. To create awareness about the functioning of the judicial system inIndia.

Course Contents

Unit-I **(2hours)**

Introduction-Constitution' meaning of the term, Indian constitution sources and constitutional history, Features: Citizenship, Preamble, Fundamental Rights and duties, Directive Principles of State Policy.

Unit-II ***(3hours)***

Union Government and its Administration-Structure of the Indian Union: Federalism, centre-state relationship, President: Role, power and position, PM and Council of ministers, Cabinet and Central Secretariat, Lok sabha, Rajya sabha.

Unit-III ***(2hours)***

Election commission- Election commission: Role and functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and functioning, Institute and Bodies for the welfare of SC/ST/OBC and women.

Unit-IV ***(2hours)***

State Government and its Administration- Governor: Role and position, CM and Council of ministers, state secretariat: Organization, structure and functions.

Unit-V ***(3hours)***

Local Administration-District's Administration head: Role and importance, Municipalities: Introduction, Mayor and role of Elected Representatives, CEO of Municipal Corporation, Panchayati raj: Introduction, PRI: Zilla Panchayat, Elected officials and their roles, CEO Zilla Panchayat: Position and role, Block level: Organizational Hierarchy (different departments), Village level: Role of elected and appointed officials, Importance of grass root democracy.

Unit-VI ***(3hours)***

Union Judiciary-Establishment and constitution of Supreme court, Appointment of Judges, Establishment of State High court, Establishment of common High court for 2 or more states, WRITS, PIL(Public Interest Litigation).

Learning resources
Text books

1. Durga Das Basu, *Constitutions of India*, 23rd ed, LexisNexis Publication.

Reference Books

Indian Polity by Laxmikanth
Indian Administration by Subhash Kashyap
Indian Administration by Avasti and Avasti
Government and Politics of India by W.H.Mrrison Jones
Constitution of India by J.C.Johari

Web Resources

2. https://unacademy.com/

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

CO 1	The students will understand their fundamental rules and duties.
CO 2	The students will learn the political system and the system of elections in India.
CO 3	It is to provide the students the institutions and processes to govern themselves in the manner they prefer.
CO 4	Students can also be able to utilize the laws and facilities provided by constution
CO 5	It will provide over all idea about our legal system.
CO 6	It will enable students more strong in terms of law and practice in day to day life.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	0	0	100%	%100

Coursecode	CourseName	Course Category	L-T-P	Credits
20MA2109	**Mathematics-III**	**BSC**	**3-1-0**	**4**

CourseLearningObjectives:

1. Toenablethestudentstounderstandthemathematicalconceptsofthecomplexvariablesandtheirapplicationsinscienceandengineering.
2. ApplyCauchyintegralformula.

3. Toevaluatetheintegralsusingresidues.
4. Providingstudentswithaformaltreatment ofprobabilitytheory.
5. Tointroduceprobabilitydistributionsandthecumulativedistributionfunctions.

CourseContent:

Unit-IFunctionsofcomplexvariables (10 hours)

Regions in the complex plane, limit, continuity, elementary functions, differentiability and analyticity of functions,Cauchy-Riemann equations, harmonic functions and harmonic conjugates, Conformal mappings-transformationofe^z,□,□^{2},□□□□,□□□□,-imagesundertransformation-bileneartransformation.

Unit-IIComplexintegration (10hours)

Lineintegralsincomplexplane,Cauchy’sintegral theorem,independenceofpaths,existenceofindefinitein-tegral,Cauchy’s integralformula, andderivativesof analyticfunctions.

Unit–IIIResidueandapplications (10hours)

Taylor’sseries,Laurent’sseries,Zerosandsingularities,Residuetheoremanditsapplications,evaluationofin-tegralsusingresidues.

Unit–IVIntroductiontoProbability (10hours)

Introduction to probability, experiments and sample spaces, discrete and continuous sample spaces, events,ax-iomsofprobability,conditionalprobability,Bayes’ theorem,and independentevents.

Unit–VRandomVariables (10hours)

Random variables, probability mass function and density function, mathematical expectation, and variance. Discretedistributions: Bernoulli, Binomial, Poisson, Negative Binomial, Geometric, and hypergeometric distributions. Con-tinuousdistributions: Uniform, Exponential,Normaldistributions.

Unit–VIJointProbabilityDistributions (10hours)

Bivariate random variable and joint probability functions. Functions of random variables, correlation coefficient,andbivariatenormaldistribution.

Learning re-
sou
rce
s **Text-book:**

1. ErwinKreyszig,**‘***AdvancedEngineeringMathematics’*,Wiley-India,9th Edition.

2. PeytonPeebles,‘Probability,RandomVariablesandRandomSignalPrinciples’,McGrawHillEducation;4thedition.

ReferenceBooks:

1. B.S.Grewal,‘*HigherEngineeringMathematics*,KhannaPublishers,42ndEdition.
2. SheldonRoss, ‘*AFirstCourseinProbability*,PearsonPublications,9thEdition.
3. A.Papoulis,‘Probability,randomvariables,andstochasticprocesses’,McGraw-Hill,FourthEdition.

Webresources:

1. https://mathworld.wolfram.com/ComplexAnalysis.html
2. https://ntpel.ac.in/courses/15101003/downloads/modu21/lecture23.pdf
3. https://nptel.ac.in/courses/117105085/
4. https://nptel.ac.in/courses/111106112/
5. https://nptel.ac.in/courses/111102111/

Courseoutcomes: Attheend ofthecourse,thestudentwillbeableto

CO1	Familiarwithelementaryfunctionandtheirproperties.
CO2	Checktheanalyticityofthecomplex variablefunctions.
CO3	Useresiduestoevaluateintegrals.
CO4	ApplyProbabilitytheoryviaBayes’Rule.
CO5	DescribethepropertiesofDiscreteandContinuousdistributions.
CO6	Applyselectedprobabilitydistributionstosolveproblems.

Coursecode	Coursename	Course Category	L-T-P	Credits
20CS2102	**DatabaseManagementSystems**	**PCC**	**3-0-0**	**3**

CourseLearningObjectives:

1. ToUnderstand the roleof adatabasemanagementsystem inan organization.
2. ToUnderstandthebasicsofERDiagram,Relationalmodel,RelationalAlgebraandRelationalCalculus.

1. ToUnderstandbasicdatabaseconcepts,includingthestructureandoperationoftherelationaldata model.
2. ToConstructsimpleandmoderatelyadvanceddatabasequeriesusingStructuredQueryLanguage (SQL).
3. ToUnderstandandsuccessfullyapplylogicaldatabasedesignprinciples,includingE-Rdiagramsanddatabasenormalization.
4. ToUnderstandtheconceptofadatabase transactionandrelateddatabasefacilitiesandindexingtechniques.

CourseContent:

UnitI **(8Contactshours)**

Introductiontodatabasesystems,FileSystemvs.DatabaseSystems,Databasesystemstructure ,Viewsofdata inadatabasesystem,Data models and Databaselanguages.

IntroductiontoEntity-Relationshipdatamodel,ElementsofanERmodel,ConstructingERdiagrams,Modelling ofconstraints,Reduction ofER diagramsto relational tables.

UnitII *(6Contact hours)*

Basics of relational model, ER diagrams to relational design, Relational algebra: Simple operationsand extended operations, writing relational algebra expressions for queries, Introduction to tuplerelationalcalculus and writing basic queries usingtuplecalculus

UnitIII *(9Contact Hours)*

Basic structure of SQL queries, Writing simple queries, Complex queries and nested Subqueries inSQL, Aggregate functions in SQL, Effect of NULL values on result, Defining a Relational Schema,Viewdefinitions and constraints, types of keys.

UnitIV *(7Contact hours)*

FeaturesofGoodRelationalDesigns,AtomicDomainsandFirstNormalForm,Problemsencountered in bad schema design, Motivation for normal forms, Dependency theory-functionaldependencies, Armstrong's Axioms for FD, Closure of a set of FD's, Minimal Cover, Definition of1NF,2NF, 3NFand BCNF,Decomposition and desirable properties ofthem.

UnitV *(6Contacthours)*

Storing data in disk and files and the memory hierarchy, RAID, File organization and indexes,ISAMTree, B+Tree, Linear Hashingand ExtendibleHashing

UnitVI *(9 Hours)*

Transaction concept, ACID properties, Concurrency in a DBMS, Serializability and Recoverability,Concurrencycontrol Protocols (lock-based and time-stamp based)

TextBooks

A.Silberschatatz,H.F.KorthandS.Sudarshan,DatabaseSystemConcepts,5/e,McGrawHill ,2006

R.RamakrishnanandJ. Gehrke,DatabaseSystemConcepts,3/e,McGrawHill,2003

WilfriedLemahieu,SeppeVandenBrouckeandBartbaesensPrinciplesofDatabaseManagementSystems, 1/e Cambridge2018

ReferenceBooks

Ramez Elmasri, Shamkant B.Navathe , Fundamentals of Database (7th Edition), Paperback, 2007TheoreyT J,DatabaseModeling &Design, 2/e, MorganKaufmann Publishers, 1994.

H.GarciaMolina,J.D.UllmanandJ.Widom,DatabaseSystemsTheCompleteBook,1/e,PearsonEducation,2007

Webresources:

Department of CS&E, IIT M, "Introduction to Database Sytems and Design",https://nptel.ac.in/courses/106106095/

Indian Institute of Technology, Kharagpur, " Database Management Systems",https://nptel.ac.in/courses/106105175/

Courseoutcomes: Attheend ofthecourse, thestudent willbe able to

CO1	Demonstratethebasic elementsof arelational databasemanagement system,
CO2	Abilityto identify thedatamodels forrelevant problems.
CO3	AbilitytodesignentityrelationshipandconvertentityrelationshipdiagramsintoRDBMSandformulate SQL querieson therespectdata.
CO4	Applynormalizationfor thedevelopmentofapplicationsoftware
CO5	AbilitytolearnaboutDiskManagement,Buffermanagement
CO6	Abilitylearnabouttransactionmanagement

ForTheorycoursesonly:

CourseNature		**Theory**		
AssessmentMethod				
Assessment Tool	Weeklytests	Monthlytests	EndSemesterTest	Total
Weightage(%)	10%	30%	60%	100%

Coursecode	**Coursename**	**Coursecategory**	**L-T-P**	**Credits**
20CS2181	Design&Analysisof AlgorithmsLab	PCC	0-0-3	1.5

CourseLearningObjective:

1. Thispractical courseshould enablethestudentsto
2. Learhowtoanalyzeaproblem anddesign thesolution fortheproblem
3. Designand Implementefficientalgorithmsforaspecifiedapplication
4. Strengthentheabilitytoidentifyandapplythesuitablealgorithmforagivenrealworldproblem.
5. Tounderstandvarious graphalgorithms

ListofExperiments:

1. LabNo1:ImplementationandAnalysisofSortingAlgorithms–QuickSort,MergeSort&HeapSort
2. LabNo2:WarshallsAlgorithms–ApplyingtoTopologicalOrderingofverticesinagivendigraphand computing thetransitiveclosureof given directed graph

3. LabNo3:Implement0/1KnapsackProblemusingDynamicProgramming

4. **4.** LabNo4:ShortestPaths Algorithms:AllPairShortestPathalgorithms–FloydsAlgorithmandotheralgorithms
5. **5.** LabNo5:ImplementanyschemetofindtheoptimalsolutionfortheTravellingSalesmanProblem
6. **6.** Lab No 6: ImplementMinimumSpanning Tree Algorithms–Prims AlgorithmsandKruskalAlgorithm
7. **7.** LabNo7:SingleSourceShortestPathAlgorithmsandotherGraphAlgorithmslikeconnected components
8. **8.** LabNo8:ImplementtheSumofSubsetsProblem
9. **9.** LabNo9:ImplementationofanyschemetosolvetheSUDOKUpuzzle
10. **10.** LabNo10: ImplementN QueensProblemusingtheBackTrackin

CourseOutcomes

Attheend ofthe course,thestudent willbe ableto

CO1	Toanalyzeasymptoticnotationand worst,averageandbestcaseanalysisusingsuitablemathematical tools.
CO2	Todesignefficientalgorithmsforcomputationalproblemsusingappropriatealgorithmicparadigm.
CO3	Tounderstanddifferentgraphalgorithmsandtraversalproblems.
CO4	Toanalyzethecomplexity ofdifferent class of problems.
CO5	Toexplaintheroleofrandomizationandapproximation incomputation

AssessmentMethod

CourseNature		**Practical**		
AssessmentMethod				
AssessmentTool	Experiments	Record	Viva-Voce/Quiz/MCQ/Labproject	Total
Weightage(%)	25%	5%	10%	40%
		EndSemesterExaminationweightage(%)		60%

CourseNature		**Practical**		
AssessmentMethod				
AssessmentTool	Experiments	Record	Viva-Voce/Quiz/MCQ/Labproject	Total
Weightage(%)	25%	5%	10%	40%
		EndSemesterExaminationweightage(%)		60%

Course code	Coursename	Course Category	L-T-P	Credits
20CS2182	**DatabaseManagementSystems Laboratory**	**PCC**	**0-0-3**	**1.5**

CourseObjectives:

1. Analyzetheproblemand identify theEntitiesandRelationships, keysforgivendatabase.
2. Design,developandqueryadatabase.

3. Abletoconstruct queriesandmaintain asimpledatabaseusingMySQL.
4. Normalizationofdatapresentindatabasetables.
5. DeveloptriggersprogramsusingPL/SQL.

ListofExperiments:

1. DesigningtheDatabasethrough IdentifyingEntities,RelationshipAttributes.

MySQL

1. Queries to facilitate acquaintance of Built-In Functions, String Functions, NumericFunctions,
2. QueriestofacilitateacquaintanceofDate FunctionsandConversionFunctions.
3. QueriesforCreating,Dropping,andAlteringTables
4. Queriesusingoperators inSQL
5. QueriestoRetrieveand ChangeData:Select,Insert,Delete, andUpdate
6. QueriesusingGroupBy, OrderBy,andHavingClauses
7. QueriesonControllingData:Commit,Rollback,andSavepoint
8. QueriesforcreatingViews,andConstraints
9. QueriesonJoins(OuterandInnerjoins)
10. QueriesonCorrelatedSub-Queries

PL/SQL

1. WriteaPL/SQLCodeusingBasicVariable,AnchoredDeclarations,andUsageofAssi gnmentOperation
2. WriteaPL/SQLblock usingSQLandControl Structuresin PL/SQL
3. WriteaPL/SQLCodeusingCursors,Exceptionsand CompositeDataTypes
4. WriteaPL/SQLCodeusingProcedures, Functions,andPackagesFORMS

CourseOutcomes:

Aftercompletingthis coursethestudent mustdemonstrate theknowledge and abilityto:

CO1	Identifytheentities,attributes,relationships,keysforgiven database.
CO2	Designadatabaseschemaforgivenproblem.
CO3	FormulatequeriesusingMySQLDML, DDLcommands.

CO4	FormulateSQLqueriesusingconstraintsandsetcomparisonoperators.
CO5	Applythenormalizationtechniquesfordevelopmentofapplicationsoftware torealisticproblems.
CO6	DevelopPL/SQLprogramsusingtriggers,procedures
CO7	Abilitytodesignandimplementgivencasestudy.

CourseNature		**Practical**		
AssessmentMethod				
AssessmentTool	Experiments	Record	Viva-Voce/Quiz/MCQ/Labproject	Total
Weightage(%)	25%	5%	10%	40%
			EndSemesterExaminationweightage(%)	60%

Course code	**Coursename**	**Course Category**	**L-T-P**	**Credits**
20CS2201	**COMPUTERORGANIZATION ANDARCHITECTURE**	**PCC**	**3-0-0**	**3**

CourseLearningObjectives:

1. To conceptualize the basics of organizational and architectural issues of a digitalcomputer.
2. To analyze performance issues in processor and memory design of a digitalcomputer.
3. Tounderstandvariousdatatransfertechniquesindigitalcomputer.
4. Toanalyzeprocessorperformanceimprovementusinginstructionlevelparallelism

Coursecontent:

UNIT-I

Basic Functional blocks of a computer: CPU, memory, input -output subsystems, control unit.**DataRepresentation**:Numbersystems,signednumberrepresentation,fixedandfloating pointrepresentations,characterrepresentation.

UNIT-II

ALU: Computer Integer Arithmetic: addition, subtraction, multiplication, division, floating pointarithmetic:Addition, subtraction, multiplication, division.

Instruction set architecture of a CPU registers, instruction execution cycle, RTL interpretation ofinstructions, addressing modes, instruction set. RISC and CISC architecture. Case study instructionsetsof somecommon CPUs.

UNIT-III

CPUcontrolunitdesign:IntroductiontoCPUdesign,ProcessorOrganization,ExecutionofComplete Execution,Designof ControlUnit: hardwiredandmicro-programmedcontrol,Casestudydesign of asimple hypothetical CPU.

UNIT-IV

Memory system design: Concept of memory: Memory hierarchy, SRAM vs DRAM ,Internalorganizationofmemorychips,cachememory:Mappingfunctions,replacementalgorithms,Memorymanagement, virtual memory.

UNIT-V

Input -output subsystems, I/O transfers: programmed I/O, interrupt driven and DMA.I/OBuses, Peripheraldevicesand their characteristics, DiskPerformance

UNIT-VI

Performance enhancement techniques: Pipelining: Basic concepts of pipelining,Throughput and speedup, pipeline hazards.
Parallelprocessing:Introductiontoparallelprocessing,IntroductiontoNetwork,Cachecoherence

TextBooks:

V. C. Hamacher, Z. G. Vranesic and S. G. Zaky, *"Computer Organization,"* 5/e, McGraw Hill,2002.
William Stallings, *"Computer Organization and Architecture"*: Designing for Performance, 8/e,PearsonEducation India.2010.
MorrisMano,"ComputerSystemArchitecture",PearsonEducationIndia,Thirdedition.

References:

A. S. Tanenbaum, "*Structured Computer Organization*", 5/e, Prentice Hall of India,2009.
D. A. Patterson and J. L. Hennessy, *"Computer Organization and Design,"* 4/e,MorganKaufmann, 2008.
J. L. Hennessy and D. A. Patterson," *Computer Architecture: A QuantitativeApproach",*4/e,MorganKaufmann, 2006.
D.V.Hall,"*MicroprocessorsandInterfacing"*,2/e,McGrawHall,2006
*"8086AssemblerTutorialforBeginners"*ByProf.EmersonGiovaniCarati.
Web refereneces:https://en.wikibooks.org/wiki/IB/Group_4/Computer_Science/Computer_Organisationhttp://www.cs.uwm.edu/classes/cs458/Lecture/HTML/ch05.htmlhttp://www.cse.iitm.ac.in/~vplab/courses/comp_org.htm
OAIIT-GuwahatiPdf

Courseoutcomes: At theendofthecourse, thestudent will be able to

CO1	Understandthebasicorganizationofcomputeranddifferentinstructionformatsandaddressing modes.
CO2	Analyzethe concept ofpipelining,segment registersandpin diagramofCPU.
CO3	Understandand analyze variousissuesrelatedtomemory hierarchy.
CO4	Evaluatevariousmodesofdatatransferbetween CPUandI/Odevices.
CO5	Examinevariousinter connectionstructuresofmultiprocessors.

ForTheorycoursesonly:

CourseNature	**Theory**			
AssessmentMethod				
AssessmentTool	Weeklytests	Monthlytests	EndSemesterTest	Total
Weightage(%)	10%	30%	60%	100%

CourseCode	**CourseName**	**CourseCategory**	**L-T-P**	**Credits**
20CS2204	**CompilerDesign**	**PCC**	**3-0-0**	**3**

CourseLearningObjectives:

1. Toimplementtheconceptlearnedinautomatatheoryandlanguagestothefieldofcomp uterScience.
2. Analyzethe basicsteps involved inconverting asourcelanguagetotargetcode.
3. Understandstheconceptsofparsersandcanwritesolutionsforvariousgrammarsbyusingtools,and alsoanalyzes different storagetechniques, errorrecoverystrategies
4. Gaintheknowledgetowriteacompilerprogramor can abletobuild a compiler.

CourseContent:

UnitI

IntroductiontoCompilers *(6Contacthours)*

Introduction tocompilers,Phasesof compiler, LexicalAnalyzer, The role of the lexicalanalyzer,inputbuffering, specification oftokens, Recognition of tokens.

UnitII

SyntaxAnalysis -I **(9Contacthours)**

Roleoftheparser,writinggrammarsandcontextfreegrammars,Topdownparsing,Brute-forceapproach,Recursivedescent parsing,Predictiveparsing, FIRSTandFOLLOWconstructs.

UnitIII

SyntaxAnalysis -II **(8Contacthours)**

Bottom-upparsing,shift-reduceparsing,operatorprecedenceparsing,LRparsers,SLRparser,canonicalLR parser, LALR parser.

UnitIV

SemanticAnalysis **(8Contacthours)**

Syntaxdirectedtranslations,applicationsofsyntaxdirectedtranslations,Syntaxdirecteddefinitions,constructionofsyntaxtree,Bottom-upevaluationofS-attributeddefinitions,L-attributeddefinitions.

UnitV

IntermediateCodeGenerationandCodeOptimization **(8 Contact hours)**Intermediate languages, Declarations, Assignment statements, Boolean

UnitVI

Codegeneration **(6Contacthours)**

Issuesinthedesignofcodegenerator,thetargetmachine,runtimestoragemanagement,peepholeoptimization.

Learning resourcesTextbook:

1. AlfredVAho,MonicaSLam,RaviSethi,JeffreyDUllman,*"Compilers:PrinciplesTechniques& Tools"*, Pearson Education,2nd Edition 2013.

ReferenceBooks:

1. KennethCLouden,*"CompilerConstruction:PrinciplesandPractice*",CengageLearning.Lex&Yacc, John R Levine, Oreilly Publishers.
2. KeithDCooper&LindaTarezon*, "EngineeringaCompiler*",MorganKafman,Seconedition.Lex &Yacc, John R Levine,Tony Mason, Doug Brown, ShroffPublishers.
3. Muchnik,"*AdvancedCompilerDesignandImplementation*",Kauffman(1998)

Courseoutcomes:

CO	Identifythebasicconceptsneededforthedevelopmentofacompiler

1	
CO 2	Analyzethe various phasesand Tools ofaCompiler
CO 3	DescribethedifferencesbetweenTop-DownandBottom-UpParsersandapply parsingmethodsforvariousgrammars.
CO 4	CompareandContrastSymboltableorganizationforBlockStructuredandNon-BlockStructuredlanguages.
CO 5	AnalyzetheconceptsinvolvedinIntermediate,CodeGenerationandCode OptimizationProcess.
CO 6	Recognizethevarioustypesoferrorsanderrorrecoverystrategiesinphasesof Compilation

AssessmentMethod:

CourseNature		**Theory**		
AssessmentMethod				
Assessment Tool	Weeklytests (Insemester)	Monthlytests (Insemester)	EndSemesterTest	Total
Weightage(%)	10%	30%	60%	100%

CourseCode	CourseName	CourseCategory	L-T-P	Credits
20CS2203	**WebTechnologies**	**PCC**	**3-0-0**	**3**

CourseLearningObjectives:

1. Todemonstratebasicskills inanalysingthe usabilityofawebsite.
2. Toidentifyhowtoplanuser researchrelatedtowebdesign.
3. ToLearnhow todesign,addclientsidescriptandpublishweb page
4. ToLearn about serversideprogramming anddeploy theappinto aserver
5. ToLearnaboutstoringthe datainto SQLand NoSQL
6. ToLearn aboutFront-EndWebUIFrameworks andGITrepositoryTools
7. Tolearnthelanguageof theWeb:jQueryFrontenddesignandBootstrap
8. Tolearnthelanguageof Web:NodeJS

UNITI *(10Contacthours)*

IntroductiontoWebWorld: RecaponHTML,insertingFramesandframesets,insertinghyperlinks,lists, tables and images,

JavaScript : Clientsidescripting withJavaScript,variables,functions, conditions,loopsandrepetition,Pop up boxes, objects,HTML DOM and web, Browser environments, form validation,Eventsand Event Listeners

UNITII *(10Contacthours)*

ServerProgramming:PHPbasics:PHPSyntax,variables,constants,DataTypes,Strings,ConditionalandControlStructures.PHPGETandPOST.PHPAdvanced:includefiles,Filesystem,parsingdirectories, fileupload anddownload, Sessions,Form handling,JSONParsing

UNIT-III *(10Contacthours)*

DatabaseConnectivity:IntroductiontoSQL:Connect,createdatabase,createtable,insert,prepared statements. Use of NoSQL: Introduction to NoSQL, Difference between SQL and NoSQL,Typesof NoSQLDatabases, Query mechanism tools forNoSQL.

Authentication: Google OAuth: Basic Steps. Access to Google APIs: For Server-side Web apps,forJavaScript Web apps, forMobile & Desktop apps

UNITIV *(10Contacthours)*

Front-End Web UI Frameworks and Tools: Bootstrap, Full-Stack Web Development, Setting upGit,BasicGitcommands,OnlineGitRepositories,Node.jsandNPM,Front-endWebUIFrameworks.

jQuery: Introduction, Selectors, Attributes, Event Handlers, Style Methods, Traversing the DOM,Effects,andIntroductionto jQuery Plugins

UNITV *(7Contacthours)*

Bootstrap: Introduction to Bootstrap, Responsive Design, Bootstrap Grid system, Navigation andNavigation Bar, Icon Fonts, User Inputs, Bootstrap CSS Components, Bootstrap and JavaScriptComponents,Bootstrap andJQuery, Buildingand Deployment,NPM Scripts,Task Runners

UNITVI *(7Contacthours)*

NodeJs: Introduction,EnvironmentSetup,FirstApplication,REPLTerminal,NativePackageManager(NPM),Web Module, Express Framework, RESTFul API

Learningresources:

TextBooks

1. RalphMoseleyandM.T.Savaliya,WileyIndia "*DevelopingWebApplications*"
2. Jeffrey C.Jackson,"*Web Technologies--A Computer Science Perspective*",PearsonEducation,
3. DreamtechPress"*WebTechnologiesBlackBook*,"HTML5,
4. WebTechnologies:HTML,JAVASCRIPT,PHP,JAVA,JSP,XMLandAJAX,Black BookKindle Edition byKogent Learning Solutions Inc. (Author)
5. O'Reilly-HeadFirstServletsandJSP,2ndEdition
6. Node.jsWebDevelopment:Createreal-timeserver-sideapplicationswiththispractical,step-by-stepguide, 3rdEdition
7. Bootstrap:ResponsiveWebDevelopmentBookbyJakeSpurlock

ReferenceBooks

1. JoelSklar,Cengage"*WebDesign*",Learning
2. Robert. W. Sebesta, "*Programming the World Wide Web*", Fourth Edition,PearsonEducation
3. P.J.Deitel&H.M.Deitel"*InternetandWorldWideWebHowtoprogram*",Pearson

Web Resourceshttps://www.w3schools.com/
https://www.tutorialspoint.com/web_development_tutorials.htm
https://html.com/
https://www.coursera.org/learn/bootstrap-4https://www.tutorialspoint.com/jquery/index.htmhttps://www.tutorialspoint.com/nodejs/http://www.ntu.edu.sg/home/ehchua/programming/java/javaservlets.htmlhttp://wiki.lib.sun.ac.za/images/0/07/Bootstrap-tutorial.pdfhttps://media.readthedocs.org/pdf/htmlguide/latest/htmlguide.pdf

Courseoutcomes: Attheend ofthecourse, thestudent willbe able to

CO1	Learnhowtodesign, addclientsidescript andpublishwebpage

CO2	Learnhowto writeserver sideprogramming and deploytheappinto aserver.
CO3	Learnhow tostoredatainto databaseandNoSQL.
CO4	LearnaboutFront-End WebUIFrameworksand GITrepositoryTools.
CO5	LearnaboutresponsiveWebdesign.
CO6	LearnaboutPackagemanagerandWebmodules.

Course Code	Course Name	Course Category	L-T-P	Credits
21AM1101	Symmetry and Properties of Materials	PCC	3-1-0	3
Course Content				
Unit-1:				
Introduction: Symmetries in 1D, 2D and 3D - Examples of patterns showing various symmetries; Symmetries and Lattices in 2D space: - Operations of Translation, Rotation and Reflection, standard symbols - Lattices and Unit Cells - Permissible rotational symmetries - Derivation of lattices: oblique, rectangular, centred rectangular, square, hexagonal.				
Unit-2:				
Point Groups in 2D: - Set of symmetry operations- Group Theory Essentials- Evolution of 2D crystallographic point groups; 2D Space Groups (Plane Groups): - Glide Planes: combination of lattice translation and reflection- Derivation of all the 17 plane groups - Understanding the Plane Group entries in the International Tables of Crystallography; 3D Point Groups: - Combination of rotation axes in 3D, - Development of the 32-point groups- Laue Groups;				
Unit-3:				
3D Bravais Lattices: - Addition of a third translation to the plane groups - Derivation of Bravais Lattices; 3D Space Groups: - Screw Axes: combination of lattice translation and rotation - Development of the 230 space groups - Understanding the Space Groups entries in the International Tables of Crystallography; Quasi-crystals				
Unit-4:				
Tensors and Physical Properties: - Definition of a tensor, rank of tensor - Transformation laws for tensors- Transformation operators for the crystallographic symmetry elements- Tensor description of physical properties of crystals.				
Unit-5:				
Dielectric Constant (Second rank property tensors) - Stress and strain (Second rank tensors) - Piezoelectricity (Third rank property tensors) - Matrix transformation and Neumann's Law.				
Unit-6:				
Elasticity (Fourth rank property tensors) - Thermal expansion of crystals - Generalized Hooke's Law - Stiffness and Compliance Tensors (fourth rank): inherent symmetry - Tensor and Matrix coefficients - Tensor and Matrix transformations - Effect of crystal symmetry; Generalized approach to other symmetry dependent tensor properties - Optical properties, conductivity, ferroelectricity, etc.				
Reference Books				
1. Marc De Graef, Michael E. McHenry, "Structure of Materials: An Introduction to Crystallography, Diffraction and Symmetry", Cambridge University Press, 2nd edition, 2012. 2. Martin J. Buerger, "Elementary Crystallography", John Wiley & Sons Inc, 1963. 3. Christopher Hammond, "The Basics of Crystallography and Diffraction", Oxford University Press, 2015 4. Robert E. Newnham, "Properties of Materials: Anisotropy, Symmetry, Structure", Oxford University Press, 2004.				

Course Code	Course Name	Course Category	L-T-P	Credits
21AM1102	Phase Diagrams and Phase Transformations	PCC	3-1-0	3

Course Content

Unit-1:

Introduction: Gibb's phase rule, phases, component & degree of freedom, various types of phase diagram (Unary, Binary phase diagram), determination of phase fraction by using Lever rule, uses of phase diagrams, determination of phase diagrams.

Unit-2:

Thermodynamics related to phase diagrams-Gibb`s free energy for single and Binary solutions. Variation of free energy with temperature, Ideal and Regular solutions, chemical potential of a solution. Ordered and intermediate phases.

Unit-3:

Diffusion, Atomic mechanism of diffusion, interstitial & substitutional (self and vacancy) diffusion Fick`s law of diffusions, determination of diffusion coefficient, effect of temperature on diffusion coefficient, Kirkendal effect, Darken's equation, application of diffusion in some metallurgical processes like carburizing & nitriding of steels.

Unit-4:

Theory of phase transformation: nucleation and growth mechanism, homogeneous and heterogeneous nucleation. Diffusion Controlled Phase Transformations: General considerations in phase transformation, concept of activation energy and arrhenius equation-examples. isothermal transformations. growth of pearlite. T-T-T diagrams- construction and use in heat treatment (annealing, normalizing, hardening, austempering and martempering). CCT diagrams. Johnson-Mehl-Avrami equation-numerical problems. spinodal decomposition-concept of uphill diffusion-order-disorder transformations. examples from metallic systems.

Unit-5:

Diffusionless Transformations: Martensitic transformation-definition, characteristic features of martensitic transformation in steels, morphology of martensite-lath and acicular martensites, crystallography of martensitic transformation, martensite in non-Ferrous systems-thermoelastic martensite and shape memory effect-examples and applications of shape memory alloys.

Unit-6:

Advanced Phase transformations: Carbides, Intermetallic, TCP phases and phase transformation in amorphous soilds.

Reference Books

1. David A. Porter, K. E. Easterling and Md. Y. Sherif,, "Phase Transformations in Metals and Alloys" , CRC press, 3rd edition, 2009
2. Robert E. Reed hill, Reza Abbaschian, Lara Abbaschian, "Physical Metallurgy Principles", Wadsworth Publishing Co Inc, 4th edition, 2009.
3. Raghavan V, "Solid State Phase Transformations", PHI Learning, 1987
4. R. C. Sharma, "Phase Transformations in Materials", CBS Publishers, 2017

Course Code	Course Name	Course Category	L-T-P	Credits
21AM1103	**Advanced Materials Characterizations**	PCC	3-1-0	3

Course Content

Unit-1:

Introduction, concept of resolution, Airy rings, numerical aperture, magnification, depth of field, depth of focus, lens defects and their corrections, principles of phase contrast – bright field and dark-field contrast, polarized light microscopy, Quantitative microscopy, estimation of grain size, grain boundary area, relevance of light microscopy ideas to electron microscopy.

Unit-2:

Introduction, crystal geometry, lattice directions and planes, zone axis, interplaner spacing and angle, Stereographic projection, Bragg's condition of diffraction, X-ray scattering, application of X-ray diffraction – phase identification, estimation of grain size, particle size, residual stress.

Unit-3:

Principle, construction and operation of TEM, Interaction of electrons with specimen, reciprocal space and lattice, Ewald sphere, diffraction from finite crystal, preparation of specimens, bright and dark field imaging, selected area diffraction, indexing of diffraction patterns.

Unit-4:

Construction and working principle of SEM. Resolving power, magnification, depth of field, depth of focus, image contrast, Secondary electron, back scattered mode of imaging and energy dispersive analysis of x-rays, Sample preparation techniques. Introduction to transmission electron microscopy

Unit-5:

Scanning Tunneling Microscopy (STM) & Atom Force Microscopy (AFM), Scanning Transmission electron Microscopy (STEM)

Unit-6:

Principles of differential scanning calorimetry (DSC), differential thermal analysis (DTA), Dilatometry, Thermogravimetric analysis (TGA), Dynamic mechanical anaylsis, ThermoMechanical Anaylsis.

Reference Books

1. P. J. Goodhew, J. Humphreys, R. Beanland, "Electron microscopy and analysis", CRC Press, 3rd edition, 2000.
2. B.D. Cullity, S.R. Stock, "Elements of X-Ray Diffraction", Pearson; 3 edition, 2001.
3. Brown, M.E., "Introduction to Thermal Analysis: Techniques and Applications",Springer-Verlag New York Inc.; 2nd edition, 2001
4. P.J. Grundy and G.A. Jones, "Electron Microscopy in the Study of Materials", Hodder & Stoughton Educational, 1976.
5. D.B. Williams and C.B. Carter, "Transmission Electron Microscopy", Springer; 2nd edition, 2009.
6. C.S. Suryanarayana, and M. Grant Norton, "X-ray Diffraction: A Practical Approach", Springer, 2013.
7. D.A. Skoog, F.J. Holler and S.R. Crouch, "Principles of Instrumental Analysis", Thomas Brookes/Cole, 6th Edition, 2007

Course Code	Course Name	Course Category	L-T-P	Credits
21AM1104	**Mechanical Behaviour and Testing of Materials**	PCC	3-1-0	3

Course Content

Unit-1:

Elastic constants (atomistic origin), State of stress in 2D/3D, Transformation of stress, Principal stresses, Mohr Circle, Stress-strain relationships in isotropic and anisotropic materials

Unit-2:

Plasticity Theory: Yield Criteria – Yield Locus – Yield Surface and Normality – Plastic Stress Strain Relations

Unit-3:

Plastic Deformation in Metals and Alloys: Critical resolved shear stress. Defects in crystalline materials Point defects and line defects. The concept of dislocation - Edge dislocation and screw dislocation. Interaction between dislocations, sessile dislocation, glissile dislocation, dislocation climb, Jogs, Forces on dislocations Energy of a dislocation. Frank Reed source, slip and twinning.

Unit-4:

Strengthening mechanisms: solid solution strengthening - strain hardening- Martensitic strengthening, precipitation hardening - dispersion strengthening- fiber strengthening; Fracture: Elementary theories of fracture, Griffith’s theory of brittle fracture, Ductile Fracture, Notch sensitivity.

Unit-5:

Tension Test: Engineering stress-strain and True stress-strain curves. Tensile properties, conditions for necking. Stress-Strain diagrams for Steel, Aluminum and Cast Iron. Hardness Testing: Brinell, Rockwell, Vickers, and Nanoindentation. Impact Testing: Principle, Izod and Charpy Impacts tests, Ductile to Brittle Transition Temperature (DBTT), Factors affecting DBTT.

Unit-6:

Fatigue Testing: Introduction, Stress Cycles, The S-N Curve, mechanism - factor affecting fatigue; Creep test: The High-Temperature Materials Problem, The Creep Curve, Structural Changes During Creep, Mechanisms of Creep Deformation, Deformation Mechanism Maps.

Reference Books

1. George E Dieter, “Mechanical Metallurgy", McGraw Hill Education, Third edition, 2017.
2. Thomas H.Courtney, “Mechanical Behaviour of Materials”, McGraw-Hilll, Boston, 2nd edition, 2000.
3. A .K. Bhargava, C. P. Sharma, “Mechanical behaviour and testing of materials”, PHI Learning, First edition, 2011.
4. Suryanarayana, A. V. K., “Testing of Metallic Materials”, Prentice Hall India, New Delhi, 1979
5. Marc A. Meyers, Krishan Kumar Chawla “Mechanical Behavior of Materials” Cambridge University Press, 2008

Course Code	Course Name	Course Category	L-T-P	Credits
21AM1181	Advanced Materials Characterization Laboratory	PLC	0-0-3	1.5

List of Experiments

1. Quantitative image analysis of phase fraction, grain size, nodularity and nodule count.
2. Calculation of structure factor of different crystal structures.
3. Determination of crystal structure by X-ray Diffraction (XRD)
4. Determination of lattice parameter by XRD
5. Determination of crystallite size by XRD
6. Determination of lattice strain of a deformed sample using XRD
7. Fractography analysis using Scanning electron microscopy (SEM)
8. Determination of interlamellar spacing of pearlite using SEM
9. Chemical analysis using energy dispersive X-ray analysis in SEM (spot and line analysis).
10. Study of Wulff net diagram, Stereographic projection & Pole Figures
11. Study of DSC, TGA and FTIR.

Course Code	Course Name	Course Category	L-T-P	Credits
21AM1201	Science and technology of Ceramics, Semiconductors and Polymers	PCC	3-1-0	3

Course Content

Unit-1:

Introduction to ceramics, classification of ceramics, oxide and non-oxide ceramics, their chemical formulae, Rules for structure formation in oxides/ionic solids, Crystallography: structures and structure determination, Atomic structure and bonding in materials. Review of Bonding Characteristics of Ceramics Crystal structure of materials.

Unit-2:

Defects and dislocations in ceramics, non-stoichiometry and typical properties, Defects equilibrium, Defects diffusion, Ionic and defect conductivity, Electronic properties of ceramics, Ceramics for energy and environment technologies -fuel cell, lithium battery

Unit-3:

Introduction to semiconductors, Introduction to chemical bonding and development of band gap, Types of semiconductors. Explanation of density of states, Fermi energy, and band occupancy, related problems. Intrinsic and extrinsic semiconductors, carrier concentration, mobility, temperature dependence, related problems,

Unit-4:

Metal-semiconductor junctions, Schottky vs Ohmic junctions, Band gap diagrams. I-V characteristics, related problems. p-n junctions, equilibrium and under bias (forward and reverse), Band diagrams. I-V characteristics, Junction breakdown, Juntion diode types, related problems

Unit-5:

Introduction to polymers and plastics; Conception of polymers, formation of polymers, types of polymers reactions such as addition and condensation, Mechanism of polymerization - Thermoplastic and Thermosetting materials methods of polymerization

Unit-6:

Polymeric structure, raw materials and properties; Classification of polymers, raw materials for polymers and their sources. Brief study of structure of polymers and properties. Glass transition temperature and its significance. Crystallinity of polymeric materials, effect of time, temperature, catalysts and solvents on polymer properties, molecular weight of polymers.

Reference Books

1. Principles of Electronic Materials and Devices, S.O. Kasap, 3rd Ed,
2. Semiconductor devices: Physics & Technology, S.M.Sze, 2nd Ed, Wiley, 2008.
3. V.R. Gowariker, N.V. Viswanathan and Jayadev Sreedhar, "Polymer Science" New Age International (p) Ltd., New Delhi , 2010.
4. F.W. Bill Mayer, "Text book of polymer science" 3rd Edition – John Wiley & sons, Inc., New York, 2011.
5. Fundamentals of Ceramcs, - M.W. Barsoum, CRC Press.
6. Modern Ceramic engineering- David W. Richerson
7. Ceramic Materials - Science and Engineering - Barry Carter, M G Norton

Course Code	Course Name	Course Category	L-T-P	Credits
21AM1202	Advanced Engineering Materials	PCC	3-1-0	3

Course Content

Unit-1:

Introduction, Demand of advanced materials, design principles and processing.
Alloy Steels - General Introduction, Maraging Steels (Heat-treatment Cycle, Aging behavior), High-Strength Low-Alloy Steels (Role of Microalloying of Steels), Advanced High Strength Steels (Role of Alloying Elements).

Unit-2:

Dual-Phase Steels, Multi-phase TRIP, Stainless Steels (Fe-Cr-Ni System, Schaeffler Diagram, Precipitation of Carbides/Nitrides, Microstructural Aspects of Various Types of SS, Ni-free Duplex SS, Embrittlement Phenomena), Tool Steels (Secondary Hardening, Types of Carbides), Factors affecting performance, Concept of δ-TRIP Steel), Bearing Steels (Metallurgical & Engineering Requirements of Steel, Microstructural Aspects, Microcracking, Spheroidise Annealing, Inclusions, Aerospace Bearings)

Unit-3:

Nickel-Based Superalloys (Microstructural features, Role of Alloying Elements, Strengthening Mechanisms, HeatTreatments, Dispersion-Hardened Superalloys), Titanium Alloys (Deformation Modes, Effect of Alloy Addition on Phase Diagrams, Alloy Classification, Phase Transformations, Microstructures, Hardening Mechanisms of Alfa- & Beta- Phases, Microstructure in Dependent of Processing, Basic Correlation between Microstructure & Mechanical Properties, Ti-based Intermetallic Compounds),

Unit-4:

Aluminum Alloys (Microstructures of Al-Si Alloys, Modified/Unmodified Al-Si Alloys, Aging Process in Al-4%Cu alloy), Brass, Bronze Physical metallurgy concepts of special alloys.

Unit-5:

Bulk Nanostructured Steels – the Latest Development in Steels, Mechanically Alloyed Metals, Shape Memory Alloys, Metallic-glass Forming Alloys, Nuclear Power Plant Alloys (Irradiation Damages in Microstructure, Irradiation Hardening, Concepts of ODS Steels)

Unit-6:

Shape Memory Alloys: Definition – Two phases – One way and two way memory effect – Pseudo elasticity – Applications of shape memory alloys. Introduction to high entropy alloys.

Reference Books

1. Reza Abbaschian, Robert E. Reed-Hill, "Physical Metallurgy Principles", Cengage, 4th edition, 2013.
2. Sidney H. Avner, "Introduction to Physical Metallurgy", McGraw Hill Education; 2nd edition, 2017
3. Gandhi, M.V., Thompson, B.S., Smart Materials and Structures, Chapman and Hall
4. Ray, A.K. (ed), Advanced Materials, Allied publishers.
5. Rama Rao, P. (ed), Advances in Materials and their applications, Wiley Eastern Ltd.
6. Bhushan, B., Nano Technology (ed), Springer.
7. Roger C. Reed, The Superalloys: Fundamentals and applications, Cambrige university press, 2006
8. B. S. Murthy, J. W. Yeh, S. Ranganathan, P. P. Bhattacharjee, High entropy alloys, 2nd Edition, Elsevier, 2019

Course Code	Course Name	Course Category	L-T-P	Credits
21AM1281	Microstructure and Mechanical Properties Correlation Lab	PLC	0-0-3	1.5

List of Experiments

1. Study of TTT and CCT diagrams
2. Hardening of plain carbon steel under different cooling rate and observation of hardness and microstructure.
3. Tempering of plain carbon steel under different temperature and observation of hardness and microstructure.
4. Age hardening of Al-Cu alloy and observation of hardness and microstructure
5. Determination of hardenability of a steel using Jominy End Quench Test
6. Cold working of copper and observation of hardness and microstructure
7. Re-crystallization studies on cold worked Cu or Cu alloys
8. Verification of hall-Petch relation in mild steel specimens.
9. Cooling curve Analysis of Sn alloys.
10. To perform Tensile test on a given material and to determine its various mechanical properties under tensile loading
11. To perform Impact test on a given material and to determine its resilience.
12. To study and perform Fatigue test on a given material and to determine fatigue strength of the material.

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX11	Solar Photovoltaic: Principles, Technologies and Materials	PEC	3-1-0	3

Course Content

Unit-1:

Solar radiations as a source of energy and mechanism for its entrapment; Measurements and limits of solar energy entrapment; Flat plate collectors and solar concentrators; Introduction of energy conversion devices, State-of-the art status of portable power sources, Solar/photovoltaic (PV) cells as a source of green energy;

Unit-2:

Introduction to solar cells, structure solar cell, Review of Semiconductor Physics, Charge carrier generation and Recombination, p-n junction model and depletion capacitance, Current-voltage characteristics in dark and light, Device physics of solar cells, principles of solar energy conversion, conversion efficiency

Unit-3:

Introduction to tendem multi-junction solar cells, crystalline silicon and III-V solar cells, thin-film solar cells: amorphous Si and quantum dot solar cells.

Unit-4:

Introduction, fabrication and design aspects of dye sensitized solar cells, introduction, fabrication, photo-physics of perovskite solar cells, stability in perovskite solar cells and lead free perovskite solar cells.

Unit-5:

Introduction to organic solar cells, Physics of bulk heterojunction (BHJ) solar cells, morphology and charge separation in BHJ, design of low bandgap polymers, Novel architecture in BHJ

Unit-6:

Efficiency of solar cells and PV array analysis, Photovoltaic system design (stand alone and grid connected) and applications; Balance of system (BOS) with emphasis on role of storage batteries; Cost analysis, Case study for performance evaluation and problem identification in wide-spread commercialization of the technology.

Reference Books

1. Solar Energy: Fundamentals & Applications; H. P. Garg and J. Prakash; Tata McGraw Hill, 1997.
2. Fundamentals of Photovoltaic Modules and their Applications, G. N. Tiwari, S. Dubey & Julian C. R. Hunt, RSC Energy Series, 2009.
3. Solar Photovoltaics: Fundamentals, Technologies and Applications (2nd ed.), C. S. Solanki, Prentice Hall of India, 2011 (ISBN: 978-81-203-4386-6)
4. Solar Cell Device Physics, Stephen Fonash (2nd ed.), Academic Press, 2010 (ISBN: 978-0-12-374774-7).Energy Storage, R. A. Huggins, Springer, 2010.
5. Handbook of Advanced Electronic and Photonic Materials and Devices: Ferroelectrics &

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX12	Energy storage materials	PEC	3-1-0	3

Course Content

Unit-1:

Basics of electrochemistry, Reversible cells and irreversible cell, Thermodynamic parameters like EMF, redox potential, Faraday law and Nernst equation, Gibbs free energy. Kinetics of electrochemical cells, electrical double layer (EDLs), Butler-Volmer equation and Tafel plot, importance of electrochemical energy storage system in electric vehicles (EVs) and portable electronic devices (PED).

Unit-2:

Principle, chemistry and materials used for various components (electrodes, electrolytes, separator and binders) in primary batteries: Leclanche/Dry/Alkaline cell, Silver cell, Mercury cell. Principle, chemistry and materials used for various components (electrodes, electrolytes, separator and binders) Secondary batteries: Lead-acid battery, Edison Cell, Ni-Cd battery, Ni Metal Hydride (Ni-MH) battery, Ni-Hydrogen battery, Sodium-Sulphur battery, Li-S battery, Metal-air batteries and its applications.

Unit-3:

Lithium-ion battery overview, History of battery Lithium-ion battery, Lithium-ion battery operation, Different types of lithium-ion chemistries and its comparison, different materials and its function, Cathode materials for lithium-ion batteries, Intercalation and conversion cathode materials, Anode materials for lithium-ion batteries, intercalation and conversion anode materials, Electrolytes and conducting salts, Liquid and solid electrolytes, separators, Sealing and elastomer components for lithium battery systems.

Unit-4:

Detailed study on high reversible capacity nanostructured anode materials such as nano-carbons, alloys, metal oxides, and metal sulphides/nitrides, detailed study on high reversible capacity nanostructured cathode materials such as lithium cobalt oxide, lithium manganese oxide, alloys, lithium iron phosphates, and other cathode materials, Design and fabrication of lithium-ion batteries: cylindrical configuration, pouch and prismatic.

Unit-5:

Next generation and beyond lithium chemistries, the future and energy storage, Recycling of Li ion battery: Social and environmental impacts of LIBs, Battery assessment and disassembly, Diagnostics of battery pack, modules and cells, Automating battery disassembly, Stabilization and passivation of end-of-life batteries. Recycling methods: Pyrometallurgical, Hydrometallurgical metals reclamation, Physical materials separation recovery, Direct recycling, biological metals reclamation.

Unit-6:

Brief Historic Overview of Supercapacitors, Charge Storage Mechanisms, Operation of Supercapacitors, Background for Supercapacitors and their differences from batteries, Electric Double Layer Capacitors, Pseudocapacitors, Capacitive Asymmetric Supercapacitors Vs Hybrid Capacitors, Electrolytes, Thermodynamic and Kinetic Considerations for Potential Window of Pseudocapacitive Materials, Principles and Methods of Experimental Evaluation, Calculating the Capacitance for a Single Electrode, Evaluation of the Capacitance and Energy Density of Asymmetric Supercapacitors, Charge-

Balancing Principles between Two Electrodes, Power Density and Equivalent Series Resistance (ESR), Aqueous Electrolyte-Based Asymmetric Supercapacitors, Aqueous Capacitive Asymmetric Supercapacitors, Faradaic Materials-Based Aqueous Hybrid Capacitors, Redox-Active Electrode-Based Nonaqueous Asymmetric Supercapacitors, Intercalation Pseudocapacitive Materials Based Electrodes for Nonaqueous Capacitive Asymmetric Supercapacitors, Other Asymmetric Supercapacitors
Reference Books

1. Bard, Allen J., and Larry R. Faulkner. *Electrochemical Methods: Fundamentals and Applications*. 2nd ed. Wiley, 2000. ISBN: 9780471043720.
2. Warner, John T. Lithium-ion Battery Chemistries- A Premer. Elsevier, 2019. ISBN: 9780128147788
3. Huggins, Robert A. *Advanced Batteries: Materials Science Aspects*. Springer, 2008. ISBN: 9780387764238.
4. Conway, Brian E. *Electrochemical Supercapacitors: Scientific Fundamentals and Technological Applications*. Springer, 2019. ISBN: 9780306457364
5. Liwen Ji et al., *Recent developments in nanostructured anode materials for rechargeable lithium-ion batteries*. Energy Environ. Sci., 2011, 4, 2682-2699
6. Gavin Harper et al., *Recycling lithium-ion batteries from electric vehicles*. Nature, 2019, 575, 75-86
7. Yuanlong Shao et al., *Design and Mechanisms of Asymmetric Supercapacitors*. Chem. Rev., 2018, 118, 9233−9280

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX13	**Nanomaterials**	PEC	3-1-0	3

Course Content

Unit-1:

Basic concepts – nanomaterial, nanoparticle, nanoscience, and nanotechnology; History and evolution of nanotechnology; Importance of size reduction of a material, Classification of nanomaterials – 0D, 1D, 2D, and 3D nanostructures.

Unit-2:

Melting point, lattice parameters; Optical properties of nanomaterials – surface plasmon resonance bands; Quantum dots; Magnetic properties of nanomaterials – superparamagnetism; Mechanical properties of nanomaterials; Electrical properties of nanomaterials.

Unit-3:

Energy Characteristics - Fundamentals of environment, Environmental impact assessment, Nanomaterials used in energy and environmental applications and their properties. Nanomaterials in automobiles.

Unit-4:

Better energy-efficient lighting; stronger and lighter materials that will improve energy transportation efficiency; use of low-energy chemical pathways to break down toxic substances for remediation and restoration; and better sensors and controls to increase efficiency in manufacturing and processing.

Unit-5:

Energy – Hydrogen Storage and Production – Fuel Cells – Battery – Carbon Nanotubes for energy storage, Hydrogen Storage in Carbon Nanotubes, Use of nanoscale catalysts to save energy and increase the productivity in industry, Rechargeable batteries based on nanomaterials.

Unit-6:

Waste remediation: Nanoporous polymers and their applications in water purification, Photo-catalytic fluid purification. Energy conversion, Hierarchical self-assembled nano-structures for adsorption of heavy metals.

Reference Books

1. W.F. Kenney: Energy Conservation in the Process Industries, Academic Press, 1984
2. Tetsuo Soga, Nanostructured Materials For Solar Energy Conversion, Elsevier
3. Robert K, Ian H, Mark G, Nanoscale Science and Technology, john Wiley & sons Ltd.,
   2005.

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX14	Carbon Materials and Manufacturing	PEC	3-1-0	3

Course Content

Unit-1:

Introduction to carbon (carbon economy, atomic structure and hybridization, carbon allotropes, nomenclature and terminology), Bulk industrial carbon (graphite: natural and pyrolytic, activated carbon, glass-like carbon, granular amorphous carbon)

Unit-2:

Carbon fibers and composites (activated carbon fiber, carbon fiber reinforced plastics, carbon fiber composite manufacturing techniques), Carbon nanomaterials (graphene, carbon nanotube, fullerene, graphite whiskers, diamondlike carbon)

Unit-3:

Physics of carbon devices (graphene and carbon nanotube based carbon devices), Raw materials (polymer precursors: Polyacrylonitrile, cellulose, resins, PVC etc.; needle coke, coal and its distillation, gaseous hydrocarbons for CVD)

Unit-4:

Manufacturing techniques for carbon materials - I (pyrolysis, electrospinning, chemical vapor deposition), Manufacturing techniques for carbon materials - II (composite preparation, material/ binder interface)

Unit-5:

Testing methods for mechanical, physical and thermal properties (density, hardness, porosity, electrical resistivity, flexural strength, compressive strength, tensile strength, thermal expansion, modulus of elasticity, ash/ moisture content), Applications (graphite electrodes, carbon-based micro and nano devices: sensors, microelectrodes etc., filters and adsorbers)

Unit-6:

Examples from carbon-fiber industry and supply chain of carbon fibers (Sports and apparels, Aeronautics and space, Nuclear industries, Heavy Engineering Industry, High volume applications: wind energy and Automotive, Structural and civil Engineering applications, Environmental/Energy Plants), Special topics (health and environmental safety of carbon nanomaterials, carbon-based flexible electronics, future of carbon technology)

Reference Books

1. Jenkins, G. M. & Kawamura, K. Polymeric carbons--carbon fibre, glass and char. (Cambridge University Press, 1976).
2. Marsh, H. & Rodríguez-Reinoso, F. Activated carbon. (Elsevier, 2006).
3. Kinoshita, K. Carbon: electrochemical and physicochemical properties. (Wiley, 1988)

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX15	Optoelectronic Materials and Devices	PEC	3-1-0	3

Course Content

Unit-1:

Electronic Structure of Materials

Pre-quantum mechanics picture: Drudes Model. Review of quantum mechanics and free electron theory, failures of free electron theory and introduction to the role of lattice. Review of reciprocal lattice, Brillouin zone, free electron band diagram, potential in a crystal electron dynamics and concept of holes, conductivity in relation to band structure.

Unit-2:

Electrical Properties of Materials

Band structure of metals and semiconductors, empirical estimates of conductivity in metals and alloys. Semiconductors-band diagrams, direct and indirect band gap, degenerate and non-degenerate semiconductors, intrinsic and extrinsic semiconductors, determination of dopant levels and mobility measurements.

Unit-3:

Dielectric properties of Materials

Dielectric materials- dielectric constants and polarization, linear dielectric materials capacitors and insulators, C-V characterization, Electronic structure of interfaces: metal-semiconductor, insulator-semiconductor, semiconductor heterostructures

Unit-4:

Opto electronic Device Physics

Optical materials-electron- hole recombination, band gap engineering. Light interaction with materials- transparency, translucency and opacity, refraction and refractive index, reflection, absorption and transmission. Carrier generation processes, recombination processes, R-G statistics, surface R-Gprocesses. Carrier transport, drift, diffusion, equation of state

Unit-5:

P-N junctions and its application in solar cells and light emitting diodes, MOS devices and Transistors Organic electronics- Thin Film Transistors, Light Emitting Diodes, Solar cells.

Unit-6:

Photoelectric effect- introduction and characteristics of photodetectors, Light Emitting Diodes and LASERs

Reference Books

1. Electronic properties of Materials: An introduction of Engineers, Rolf E.Hummel , Springer Verlag,1985
2. Physical Properties of Semiconductors, Charles M Wolfe Nick Holonyak and Gregory E. Stillmann, Prentice Hall, 1989
3. Advanced Semiconductor Fundamentals, Robert F. Pierret as part of Modular Series on Solid State Devices Vol.6, AddisonWesley,1989
4. Solid State Electronic Devices, Steetman, Ben, G, Streetman, Prentice-Hall, inc N.J. USA,1980
5. Advanced Theory of Semiconductor Devices, Karl Hess, Prentice Hall, 1988

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX16	VLSI Fabrication Technology	PEC	3-1-0	3

Course Content

Unit-1:

Introduction on VLSI technology, semiconductor materials basics, Diodes and transistors basics, diode fabrication, Bipolar Junction Transistor Fabrication, MOSFET Fabrication for IC, Silicon for VLSI

Unit-2:

Bulk Crystal Growth and Epitaxy :Crystal Structure of Si, Defects in Semiconductor Crystals, Crystal growth- Czochralski method, Bridgman Technique, Float-zone technique, liquid phase epitaxy, vapours phase epitaxy, molecular beam epitaxy, chemical vapour deposition, PECVD, MOCVD, Doping during Epitaxy

Unit-3:

Oxidation and Doping in semiconductors: Oxidation- Kinetics of Oxidation, Oxidation rate constants, Dopant Redistribution, Oxide Charges, Diffusion, Theory of Diffusion, Infinite Source, Actual Doping Profiles, Diffusion Systems, Ion - Implantation Process, Annealing of Damages, Masking during Implantation

Unit-4:

Lithography and Etching : Lithography, Photoresist, Mask making, Etching-Wet Chemical Etching, Dry Etching, Plasma Etching Systems, Etching of Si,SiO_2,SiN and other materials

Unit-5:

Metallization and BJT technology : Introduction, Plasma Deposition Process, Metallization, Problems in Aluminium Metal contacts, IC BJT - From junction isolation to LOCOS, Problems in LOCOS, Trench isolation More about BJT Fabrication and Realization

Unit-6:

CMOS: Circuits and Transistors in ECL Circuits, MOSFET I - Metal gate vs. Self-aligned Poly-gate, MOSFET II Tailoring of Device Parameters, CMOS Technology, Latch - up in CMOS, BICMOS Technology

Reference Books

1. S.M. Sze, "Semiconductor Devices: Physics & Technology", Wiley
2. S.O. Kasap, "Principles of Electronic Materials and Devices", Tata McGraw Hill.
3. S.M. Sze, “VLSI Technology”, Wiley
4. J. D. Plummer, M. D. Deal and P. B. Griffin, “Silicon VLSI Technology”, Pearson
5. Sorab K Gandhi, “VLSI Fabrication principles: silicon and gallium arsenide”, Wiley

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX17	Advanced Welding Technology	PEC	3-1-0	3

Course Content

Unit-1:

Fundamentals of physical metallurgy: Need, phase diagrams: Fe-C, Al-Cu, Cu-Zn system, phase transformations in Fe-C system, TTT diagram, CCT diagram, carbon equivalent, Schaffer diagram, relevance of above in welding. Solidification of weld metal: Principle of solidification of weld metal, modes of solidification, effect of welding parameters on weld structure, grain refinement principle of weld metal, method of weld metal refinement, inoculation, arc pulsation, external excitation

Unit-2:

Heat affected zone and weld metal: Transformations in HAZ of steel, factors affecting changes in microstructure and mechanical properties of HAZ, reactions in weld pool- gas metal reaction, slag metal reaction. Metallurgical issue in weld joint: Mechanisms, causes and remedy of cold cracking, solidification cracking, nonmetallic inclusions, lamellar tearing, hydrogen damage, banding, segregation.

Unit-3:

Theory of resistance welding: Heating, pressure, current and current control, power supply. Resistance welding processes: Resistance spot welding, resistance seam welding, Projection welding. Advantages and limitations of resistance welding.

Unit-4:

Solid state welding: Forge welding, Forge-seam welding, cold welding, roll welding or roll bonding, Friction welding and Inertia welding, Friction-stir welding, Ultrasonic welding, Diffusion welding, Explosive welding.

Unit-5:

Other welding processes, brazing and soldering: Thermit welding, Electro-slag welding, Electron beam welding, Laser beam welding, Flash welding.

Unit-6:

Inspection of Welds: Destructive techniques like Tensile, Bend, and Nick break, Impact & Hardness. Non-Destructive techniques like 'X' rays, Ultrasonic, Magnetic particle, Dye Penetrate, Gamma ray inspection.

Reference Books

1. Parmer R.S., “Welding Engineering and Technology”, 1stEdition, Khanna Publishers, New Delhi, 2008.
2. Robert and Messler, Principles of Welding (Processes, Physics, Chemistry and Metallurgy), Wiley Interscience Publishers, 2008
3. Lancaster, The Metallurgy of Welding, 6th Edition, William Andrew Publishing, NY, 2007
4. S Kou, Welding Metallurgy, John Wiley, USA, 2003
5. Welding Hand Book Vol. 5; 7th edition, AWS.

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX18	Additive Manufacturing	PEC	3-1-0	3
Course Content				
Unit-1:				
Process Physics for Additive Manufacturing (AM): General Overview - Why Additive Manufacturing? - Direct Digital Manufacturing and AM; parts and their uses - Computer Aided Design (CAD) and Manufacturing (CAM) and AM - Different AM processes and relevant Process Physics				
Unit-2:				
Materials Science for Additive Manufacturing: Polymer and Photopolymerization- Polymer and selective Laser Sintering (SLS) - Ceramics: SLS and Laser Chemical Vapor Deposition (LCVD) - Metals: Direct Metal Deposition (DMD) and SLS - Role of Rapid Solidification - Evolution of Non---Equilibrium Structure - Structure Property relationship - Design of tailored structure for end application - Selection of process for desired application				
Unit-3:				
Mathematical Models for Additive Manufacturing: Transport phenomena models - Temperature History- Fluid Flow History -Composition – Residual stress history				
Unit-4:				
Process monitoring and Control for AM: Defects-Geometry-Temperature-Composition-Phase Transformation				
Unit-5:				
Application of AM for various Industries - Aerospace: Reactive and Lightweight materials -Automobile: Light Weight components, mold Thermal and Wear management -Oil and Gas: Wear and Corrosion management - Agriculture: Wear and Corrosion management				
Unit-6:				
Additive Manufacturing Systems: Stereolithography-3D Printing -Selective Laser Sintering (SLS) - Direct Metal Deposition (DMD) and Light Engineered Net Shaping (LENS)				
Reference Books				

1. Ian Gibson, Davin Rosen, Brent Stucker "Additive Manufacturing Technologies, Springer, 2nd Ed, 2014.
2. Chua C.K., Leong K.F. and LIM C.S Rapid prototyping: Principles an Applications, World Scientific publications, 3rdEd., 2010
3. D.T. Pham and S.S. Dimov, "Rapid Manufacturing", Springer, 2001
4. Terry Wohlers, " Wholers Report 2000", Wohlers Associates, 2000
5. Paul F. Jacobs, " Rapid Prototyping and Manufacturing"–, ASME Press, 1996

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX19	Thermo-mechanical processing	PEC	3-1-0	3
Course Content				
Unit-1:				
Plasticity: Flow Stresses and Strains- Generalized Stresses and Strains- Yield Criteria - Stress–Strain Relations-Plastic Anisotropy. Work Hardening: Low'Temperature - Basic Microscopic Mechanisms - Influence of Alloying Elements- Hardening Laws - Hot Deformation - Hot Deformation Microstructures.				
Unit-2:				
Softening Mechanisms- Recovery- Recrystallization - Grain Coarsening, Alternative Deformation Mechanisms- Creep, Grain Boundary Sliding, Twinning				
Unit-3:				
Textural Developments During Thermo-Mechanical Processing: Graphical Representation of Texture Data - Some Important Cold Deformation Textures - Recrystallization Textures - Textures in Hot Deformed Materials				
Unit-4:				
SPD based thermo-mechanical processes, Friction stir Processing, Equal Channel Angular Processing, High pressure torsion.				
Unit-5:				
Defects in Thermo-Mechanical Processing: Form Defects-Surface Defects-Fracture-Related Defects-Strain Localizations - Structural Defects				
Unit-6:				
Thermomechanical processing of aluminum alloys, steels and other key engineering materials				
Reference Books				
1. Bert Verlinden, Julian Driver, Indradev Samajdar, Roger D. Doherty, "Thermo-Mechanical Processing of Metallic Materials" Pergamon Press, 2007 2. Cemil Hakan Gur, Jiansheng Pan "Handbook of Thermal Process Modelling Steels" CRC Press, 2009 3. Eric J. Mittemeijer, Marcel A. J. Somers "Thermochemical Surface Engineering of Steels" Elsevier Science, 2018				

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX20	Advanced Solidification Process	PCC	3-1-0	3

Course Content

Unit-1:

Phase equilibrium: Introduction, Thermodynamics and stability of phases, Classification of phase transformations, Order of transformation, Gibbs rule and application, Phase diagrams construction and interpretation.

Unit-2:

Liquid-solid transformation: Nucleation, homogeneous and heterogeneous, Growth continuous and lateral; Interface stability; Alloy solidification cellular and dendritic, Eutectic, off-eutectic, peritectic solidification; Welding, casting and rapid solidification.

Unit-3:

Length scale, Thermodynamics of solidification- equilibrium, Undercooling, Hierarchy of equilibrium, Local Interface equilibrium, Interface non-equilibrium, Macro scale Phenomena-formation of macrostructures, relevant transport equations.

Unit-4:

Mathematics of diffusive transport, Macro mass Transport-solute diffusion controlled segregation, analysis of solute redistribution, Fluid flow controlled segregation, macro energy transport, governing equations, boundary conditions, Analytical solutions for steady state and non-steady state casting solidification. Macro modeling of solidification: numerical approximation methods. Multi scale phenomena and interface Dynamics.

Unit-5:

Role of kinetics, heterogeneous and homogeneous kinetics, Role of heat & mass transfer in metallurgical kinetics, rate expression, Effect of Temperature and concentration on reaction kinetics: effect of temperature (Arrhenius Equation), Effect of concentration (order of a reaction), significance and determination of activation energy.

Unit-6:

Kinetics of solid-fluid reaction: kinetic steps, rate controlling step, definition of various resistances in series, shrinking core model, chemical reaction as rate controlling step, Product layer diffusion as rate controlling step, Mass transfer through external fluid film as rate controlling step, heat transfer as the rate controlling step.

Reference Books

1. Doru Michael Stefanescu, Science and Engineering of Casting Solidification, Kluwer Academic/Plenum publishers, 2002.
2. Winegard, W.C. An Introduction to Solidification of Metals. London: The Institute of Metals, 1964.
3. Oystein Grong, Metallurgical modeling of welding, 2nd Edn, Institute of materials, 1997.
4. Koenraad Janssens, Computational materials Engineering –An Introduction to microstructure evolution, Academic Press, 2007,
5. Gaskell David R., Introduction to the Thermodynamics of Materials, 3rd ed., Taylor & Francis Publishers, 1995.

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX21	Facture Mechanics	PEC	3-1-0	3
Course Content				
Unit-1:				
Fracture Mechanics: Introduction and historical review, Sources of micro and macro cracks. Stress concentration due to elliptical hole, Strength ideal materials, Griffith's work, Fracture mechanics, Dilemma of Griffith, Surface energy, Griffith's realization, Griffith's analysis, Mathematical formulation, Thin plate vs thick plate, Critical energy release rate.				
Unit-2:				
Stress intensity factor (SIF): Linear elastic fracture mechanics (LEFM), Stress and displacement fields in isotropic elastic materials, Stress and Displacement field in isotropic elastic materials, Airy stress function, Westergard approach for different modes of fracture, Stress analysis of crack, Stress intensity factor (SIF), relation between K and global behaviour, Effect of finite size.				
Unit-3:				
Elastic-Plastic Fracture Mechanics: Crack tip deformation, approximate shape and size of the plastic zone, plane stress vs plane strain, effective crack length, Irwin plastic zone correction, Dugdale approach, effect of plate thickness.				
Unit-4:				
Elastic plastic analysis through J-Integral: Relevance and scope, Definition of J-Integral, Path independence, Stress-strain relation.				
Unit-5:				
Crack tip opening displacement (CTOD): Relationship between CTOD, K_I and G_I for small scale yielding, Equivalence between CTOD and J. Test methods to determine K_{IC} , J_{IC} , G_{IC} and critical CTOD.				
Unit-6:				
Fatigue Fracture: Introduction to fatigue, factors affecting fatigue performance, fatigue loading, constant and variable amplitude loading, some characteristics of fatigue crack, Paris Law.				
Reference Books				
1. Richard W. Hertzberg, Richard P. Vinci, Jason L. Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials", John Wiley and Sons, 2012. 2. D. Broek, Elementary Engineering Fracture Mechanics, 3rd ed., Sijthoff Noordhoff, 1982. 3. T. L. Anderson: Fracture Mechanics: Fundamentals and Applications, CRC Press, 2005. 4. Preshant Kumar, "Elements of Fracture Mechanics", Wheeler Publishing, 1999.				

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX22	Creep and Fatigue Behavior of Materials	PEC	3-1-0	3

Course Content

Unit-1:

DEFORMATION AND FAILURE MECHANISMS: an overview on creep of solids, Phenomenology of creep-Temperature-stress-strain rate relations, Microstructural considerations in metals, alloys, ceramics and Composites.

Unit-2:

CREEP MECHANISMS: Dislocation (power-law) creep, Diffusion (linear, viscous) creep Deformation mechanism maps, Cavitation failure at elevated temperatures by the nucleation, growth and interlinkage of cavities. CREEP CRACK GROWTH: Crack-tip fields C(t) integral, transition time, steady-state creep parameter C*, v-C (v-K) curves.

Unit-3:

SUPERPLASTICITY: Super plasticity in metallic alloys, ceramics and nano phase materials, Commercial applications and considerations. DESIGNING CREEP-RESISTANT ALLOYS: Use of creep and stress rupture data for life prediction, Designing creep-resistant alloys.

Unit-4:

CYCLIC FATIGUE FAILURE:Cyclic stress and cyclic strain controlled fatigue, Fatigue life estimation of notched components. CRACK INITIATION: Fatigue initiation mechanism, Mechanistic aspects, Crack initiation models, $\Delta K/\sqrt{\rho}$ approach, Effects of different variables on fatigue life.

Unit-5:

CRACK PROPAGATION: Fatigue crack propagation, Crack propagation Paris law (da/dN = CΔKm), cyclic plastic-zone size, load-ratio effects, ΔKTH thresholds, Damage-tolerant design life prediction, Models for crack growth striation growth, Stress-strain/life analysis role of mean stress, notches, etc. Miner's rule, Multiaxial fatigue equivalent stress models, mixed-mode crack growth microscopic fatigue fracture mechanism, crack growth behavior at low, intermediate and high oxidation kinetics.

Unit-6:

CRACK CLOSURE: Crack closure concept, crack closure plasticity-oxide-and roughness-induced, variable-amplitude loading Wheeler, Willenborg, closure models, Small cracks Continuum, LEFM, shielding limitations. FATIGUE IN CERAMICS: Cyclic fatigue of ceramics mechanisms. OTHER FATIGUE MECHANISMS: Corrosion fatigue, thermal fatigue, creep-fatigue interaction.

Reference Books

1. Polreer J P, “Creep of crystals”, Cambridge University Press, 1984.
2. Suresh S, “Fatigue of Materials”, Cambridge university press, 1998.
3. R. W. Evans and B. Whilshire: Introduction to creep, The Institute of Materials, 1993
4. Michael Kassner: Fundamentals of Creep in Metals and Alloys, 2nd Edition, Elsevier Science, 2009.
5. Frost H J and Ashby M F, “Deformation-Mechanism Maps: The Plasticity and Creep of Metals and ceramics”, Pergamon Press, 1982.
6. Ellyin F, “Fatigue Damage, Crack Growth and Life Prediction”,Chapman and Hall, 1997.
7. Riedel H, “Fracture at high temperatures”, Springer, Berlin, 1987.

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX23	Texture in Materials	PEC	3-1-0	3
Course Content				
Unit-1:				
Introduction: Microstructure and Texture - Description of Grain Orientation and Texture-Development of Texture During Processing- Representation of Texture: Pole Figure Method- Orientation Distribution Function (ODF) Method - Representation of Texture in the Orientation Space - Volume Fraction of Texture Components				
Unit-2:				
Experimental Determination of Texture : Macro texture Measurement Techniques (by X-Ray Diffraction, Synchrotron X Rays) - Micro texture Measurement Techniques (by SEM-EBSD, TEM-OIM)				
Unit-3:				
Texture Evolution During Solidification and Solid-State Transformation - Deformation Textures				
Unit-4:				
Texture Evolution During Dynamic Recovery and Recrystallization - Theories of Formation of Recrystallization Textures - The Cube Texture in FCC Metals				
Unit-5:				
Texture and Properties: Texture Dependence of Mechanical Properties - Texture Dependence of Magnetic and Electrical Properties - Texture Dependence of Chemical Properties				
Unit-6:				
Texture Control in Steels, Aluminium Alloys, Nickel Alloys, Titanium Alloys, Ceramics, Polymeric Materials				
Reference Books				
1. Satyam Suwas · Ranjit Kumar Ray, Crystallographic Texture of Materials, Springer, 2014. 2. Bunge, H.-J, Texture Analysis in Materials Science, Butterworth, London, 1983. 3. V. Randle and O. Engler, Introduction to Texture Analysis: Macrotexture, Microtexture and orientation mapping, 2nd edition, CRC Press, 2009. 4. F.J. Humphreys and M. Hatherly, Recrystallisation and Related Phenomenon, Pergamon Press, 2004. 5. U.F. Cocks, C.N. Tome and H.-R. Wenk, Texture and Anisotropy, Cambridge University Press, 2000. 6. Adam J. Schwartz, Mukul Kumar, Brent L. Adams, David P: Electron Backscatter Diffraction in Materials Science, Springer, 2000.				

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX24	Mathematical Modelling in Materials Processing	PEC	3-1-0	3

Course Content

Unit-1:

Basic equations of diffusive, convective heat, mass, momentum transfer, turbulent system and concept of friction factor, heat & mass transfer coefficients and correlations.

Unit-2:

Formulation of mathematical model. Numerical solution of partial differential equations. Case studies.

Unit-3:

Physical Simulation: Experimental design based on dimensional analysis, similarity criteria, case studies.

Unit-4:

Reactor Design: Ideal reactors (PFR, CSTR), real reactors, characterization of these reactors, chemical performance of reactors, Modeling/design of reactors.

Unit-5:

Phase prediction using first principles and CALPHAD approach; Structure-property relationship using molecular dynamic simulation.

Unit-6:

Processing – microstructure correlation using finite element and phase field simulation methods.

Reference Books

1. Jonathan A. Dantzig, Charles L. Tucker "Modeling in Materials Processing", Cambridge University Press, 2001
2. Gregory C. Stangle, Modelling of Materials Processing, Springer, 1998
3. David R. Gaskell, "An Introduction to Transport Phenomena In Materials Engineering", Momentum Press; 2nd edition, 2012

Course Code	Course Name	Course Category	L-T-P	Credits
21AM1171	Research Methodology and IPR	MLC	2-0-0	2
Course Content				
Unit-1:				
Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations				
Unit-2:				
Effective literature studies approaches, analysis Plagiarism, Research ethics,				
Unit-3:				
Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee				
Unit-4:				
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.				
Unit-5:				
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.				
Unit-6:				
New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.				
Reference Books				
1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'" 2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction" 3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners" 4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007. 5. Mayall, "Industrial Design", McGraw Hill, 1992. 6. Niebel, "Product Design", McGraw Hill, 1974. 7. Asimov, "Introduction to Design", Prentice Hall, 1962. 8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016. 9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008				

Course Code	Course Name	Course Category	L-T-P	Credits
21AM1161	Business Analytics	OEC	3-1-0	3

Course Content

Unit-1:

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

Unit-2:

Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

Unit-3:

Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.

Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

Unit-4:

Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.

Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor
Model, Overbooking Model, Cash Budget Model.

Unit-5:

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

Unit-6:

Recent Trends in: Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

Reference Books

1. Marc J. Schniederjans, Dara G, Schniederjans, Christopher M. Starkey, Business analytics Principles, Concepts, and Applications, Pearson FT Press.
2. James Evans, Business Analytics, Persons Education.

Course Code	Course Name	Course Category	L-T-P	Credits
21AM1162	Industrial Safety	OEC	3-1-0	3
Course Content				
Unit-1:				
Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.				
Unit-2:				
Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.				
Unit-3:				
Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.				
Unit-4:				
Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.				
Unit-5:				
Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance.				
Unit-6:				
Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance				
Reference Books				
1. Higgins & Morrow, Maintenance Engineering Handbook, Da Information Services. 2. H. P. Garg, Maintenance Engineering, S. Chand and Company. 3. Audels,Pump-hydraulic Compressors, Mcgrew Hill Publication. 4. Winterkorn, Hans, Foundation Engineering Handbook, Chapman & Hall London.				

Course Code	Course Name	Course Category	L-T-P	Credits
21AM1163	Operations Research	OEC	3-1-0	3
Course Content				
Unit-1:				
Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models				
Unit-2:				
Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming				
Unit-3:				
Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT				
Unit-4:				
Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.				
Unit-5:				
Competitive Models, Single and Multi-channel Problems, Sequencing Models,				
Unit-6:				
Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation				
Reference Books				
1. H.A. Taha, Operations Research, An Introduction, PHI, 2008 2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982. 3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008 4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009 5. Pannerselvam, Operations Research: Prentice Hall of India 2010 6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010.				

Course Code	Course Name	Course Category	L-T-P	Credits
21AM1164	Cost Management of Engineering Projects	OEC	3-1-0	3

Course Content

Unit-1:

Introduction and Overview of the Strategic Cost Management Process, Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Unit-2:

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents

Unit-3:

Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Unit-4:

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis.

Unit-5:

Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Unit-6:

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Reference Books

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

Course Code	Course Name	Course Category	L-T-P	Credits
21AM1165	Composite Materials	OEC	3-1-0	3
Course Content				
Unit-1:				
INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.				
Unit-2:				
REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.				
Unit-3:				
Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.				
Unit-4:				
Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.				
Unit-5:				
Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure.				
Unit-6:				
Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.				
Reference Books				
1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany. 2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007. 3. Hand Book of Composite Materials-ed-Lubin. 4. Composite Materials – K.K.Chawla. 5. Composite Materials Science and Applications – Deborah D.L. Chung. 6. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.				

Course Code	Course Name	Course Category	L-T-P	Credits
21AM1166	Waste to Energy	OEC	3-1-0	3

Course Content

Unit-1:

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

Unit-2:

Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit-3:

Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Unit-4:

Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit-5:

Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion

Unit-6:

Biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion – Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Reference Books

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons,1996.

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX72	English for Research Paper Writing	AC	2-0-0	0
Course Content				
Unit-1:				
Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness				
Unit-2:				
Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction				
Unit-3:				
Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.				
Unit-4:				
Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,				
Unit-5:				
Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions				
Unit-6:				
Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission				
Reference Books				
1. Goldbort R (2006) Writing for Science, Yale University Press 2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press 3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book . 4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011				

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX73	Disaster Management	AC	2-0-0	0
Course Content				
Unit-1:				
Introduction: Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.				
Unit-2:				
Repercussions Of Disasters And Hazards: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods,Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.				
Unit-3:				
Disaster Prone Areas In India: Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics				
Unit-4:				
Disaster Preparedness And Management Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.				
Unit-5:				
Risk Assessment Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co- Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.				
Unit-6:				
Disaster Mitigation Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.				
Reference Books				
1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies, New Royal book Company. 2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi. 3. Goel S. L. , Disaster Administration And Management Text And Case Studies", Deep &Deep Publication Pvt. Ltd., New Delhi.				

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX74	Sanskrit for Technical Knowledge	AC	2-0-0	0
Course Content				
Unit-1:				
Alphabets in Sanskrit				
Unit-2:				
Past/Present/Future Tense, Simple Sentences				
Unit-3:				
Order, Introduction of roots				
Unit-4:				
Technical information about Sanskrit Literature				
Unit-5:				
Technical concepts of Engineering-Electrical, Mechanical				
Unit-6:				
Technical concepts of Engineering- Architecture, Mathematics				
Reference Books				
1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi 2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication 3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.				

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX75	Value Education	AC	2-0-0	0
Course Content				
Unit-1:				
Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non- moral valuation. Standards and principles. Value judgements				
Unit-2:				
Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness.				
Unit-3:				
Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature ,Discipline				
Unit-4:				
Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking.				
Unit-5:				
Free from anger, Dignity of labour. Universal brotherhood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature				
Unit-6:				
Character and Competence –Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence , Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively				
Reference Books				
1. Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi				

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX76	Constitution of India	AC	2-0-0	0

Course Content

Unit-1:

History of Making of the Indian Constitution: History Drafting Committee, (Composition & Working)

Unit-2:

Philosophy of the Indian Constitution: Preamble Salient Features

Unit-3:

Contours of Constitutional Rights & Duties: Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

Unit-4:

Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions

Unit-5:

Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy

Unit-6:

Election Commission:Election Commission: Role and Functioning.Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

Reference Books

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX77	Pedagogy Studies	AC	2-0-0	0

Course Content

Unit-1:

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions. Overview of methodology and Searching.

Unit-2:

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education.

Unit-3:

Evidence on the effectiveness of pedagogical practices, Methodology for the in depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

Unit-4:

Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies.

Unit-5:

Professional development: alignment with classroom practices and follow- up support Peer support Support from the head teacher and the community. Curriculum and assessment, Barriers to learning: limited resources and large class sizes

Unit-6:

Research gaps and future directions, Research design, Contexts, Pedagogy, Teacher education, Curriculum and assessment, Dissemination and research impact.

Reference Books

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX78	Stress Management by Yoga	AC	2-0-0	0
Course Content				
Unit-1				
Definitions of Eight parts of yoga. (Ashtanga)				
Unit-2:				
Definitions of Eight parts of yoga. (Ashtanga) (cont.)				
Unit-3:				
Yam and Niyam.				
Unit-4:				
Do`s and Don't's in life. i) Ahinsa, satya, astheya, bramhacharya and aparigraha ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan				
Unit-5:				
Asan and Pranayam				
Unit-6:				
i) Various yog poses and their benefits for mind & body ii)Regularization of breathing techniques and its effects-Types of pranayam				
Reference Books				
1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur 2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata				

Course Code	Course Name	Course Category	L-T-P	Credits
21AMXX79	Personality Development Through Life Enlightenment Skills	AC	2-0-0	0

Course Content

Unit-1

Neetisatakam-Holistic development of personality
Verses- 19,20,21,22 (wisdom)
Verses- 29,31,32 (pride & heroism)
Verses- 26,28,63,65 (virtue)

Unit-2:

Neetisatakam-Holistic development of personality
Verses- 52,53,59 (dont's)
Verses- 71,73,75,78 (do's)

Unit-3:

Approach to day to day work and duties.

Unit-4:

Shrimad Bhagwad Geeta :
Chapter 2-Verses 41, 47,48;
Chapter 3-Verses 13, 21, 27, 35,
Chapter 6-Verses 5,13,17, 23, 35;
Chapter 18-Verses 45, 46, 48.

Unit-5:

Statements of basic knowledge.
Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68
Chapter 12 -Verses 13, 14, 15, 16,17, 18

Unit-6:

Personality of Role model.
Shrimad Bhagwad Geeta:
Chapter2-Verses 17,
Chapter 3-Verses 36,37,42,
Chapter 4-Verses 18, 38,39
Chapter18 – Verses 37,38,63

Reference Books

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath,
3. Rashtriya Sanskrit Sansthanam, New Delhi.

Course Name: Advanced Data Structures and Algorithms

Course Code: 21AI1101 **Course Type:** PCC

(4Hrs and 3 Credit)

Unit-I:

Data structures – Introduction to elementary data structures. Linear and non-linear data structures. **Trees:** Representation Binary trees using arrays and linked lists and Binary tree traversals: Inorder, Preorder, Postorder. Types of binary tree. Binary Search Trees and operations. **Heaps:** Min heap, Max heap, insertion and deletion, search operations.

Unit-II:

Balanced BST: AVL trees, Operations: Rotation, Insertion, deletion. Red-Black trees representation, properties, operations. B-Trees- 2-3 trees: Insertion and deletion. Splay Trees. **Dictionaries:** Definition, ADT and implementation of Dictionaries.

Unit-III:

Skip-lists: Definition, ADT and implementation, Search and update operations. Deterministic skip lists. **Hashing:** Hashing, Hash functions, Hash Table, analysis of collision resolution techniques: Closed hashing and open hashing: Linear probing, Quadratic probing and rehashing. Extendable hashing.

Unit-IV:

Graphs: Graphs Representation, Graph traversal: Breadth First Search, Depth First Search, Spanning Trees. Union-find.

Applications of Graphs: Topological Sorting, Shortest-Path Algorithms – Weighted Shortest Paths – Dijkstra's Algorithm, Minimum spanning tree- Prim's Algorithm,

Unit-V:

Tries: Standard tries, Compressed tries, Suffix trees, matching.

Pattern matching: Boyer-Moore algorithm. The naive string-matching algorithm, The Rabin-Karp algorithm, String matching with finite automata, The Knuth-Morris-Pratt algorithm.

Unit-VI:

Introduction to NP-Completeness. Polynomial time, Polynomial-time verification, NP-completeness and reducibility, NP-completeness proofs, NP-complete problems

Computational Geometry: Line-segment properties, Determining whether any pair of segments intersects, Finding the convex hull, Finding the closest pair of points

Text books:

1. Richard F.Gilberg, Behrouz A. Forouzon, Data Structures: A PseudoCode Approach, 2/e, Cengage, 2004.

2. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, Introduction to Algorithms, 3/e, The MIT Press, 2009.

References:

1. Mark Allen Weiss, Data Structures And Algorithm Analysis, 2/e, ,Pearson,2012.

2. SartajSahni, Data Structures, Algorithms and Applications in java, 2/e, University Press, 2005.

3. Adam Drozdek, Data Structures And Algorithms, 3/e, Cenage. 2008.

Course Name: Mathematical Foundation for Machine Learning

Course Code: 21AI1102 **Course Type:** PCC

(4Hrs and 3 Credit)

Unit-1

Linear Algebra Basics: Vector spaces and subspaces, basis and dimensions, linear transformation, four fundamental subspaces MATRIX THEORY- Norms and spaces, eigen values and eigenvectors, Special Matrices and their properties, least squared and minimum normed solutions.

Unit-2

Matrix Decomposition Algorithms - SVD: Properties and applications, low rank approximations, Gram Schmidt process, polar decomposition.

Dimensionality Reduction Algorithms and JCF: Principal component analysis, linear discriminant analysis, and minimal polynomial and Jordan canonical form.

Unit-3

Calculus: Basic concepts of calculus: partial derivatives, gradient, directional derivatives, Jacobian, hessian, convex sets, convex functions and its properties

Unit-4

Optimization: Unconstrained and Constrained optimization, Numerical optimization techniques for constrained and unconstrained optimization: Newton's method, Steepest descent method, Penalty function method.

Unit-5

Probability – Basic concepts of probability: conditional probability, Bayes' theorem, independence, theorem of total probability, few discrete and continuous distributions, joint distributions and covariance.

Unit - 6:

Statistics: Simple Random Sampling, Measures of central tendency: mean, median, mode. Dispersion, mathematical expectations: mean variance, skewness and kurtosis of Random variable, Moment Generating functions.

Text books:

1. W. Cheney, Analysis for Applied Mathematics. New York: Springer Science+Business Medias, 2001.
2. S. Axler, Linear Algebra Done Right, 3/e. Springer International Publishing, 2015.
3. Fundamentals of statistics, Goon.A M, Gupta.M.K.

References:

1. J. Nocedal and S. J. Wright, Numerical Optimization. New York: Springer Science+Business Media, 2006.

2. J. S. Rosenthal, A First Look at Rigorous Probability Theory 2/e. Singapore: World Scientific Publishing, 2006.

3. Fundamentals of statistics, Goon.A M, Gupta.M.K.

Online Resources:

Online course: Essential Mathematics for Machine Learning:
https://nptel.ac.in/courses/111/107/111107137/

Course Name: Artificial Intelligence and Neural Networks

Course Code: 21AI1103 **Course Type:** PCC

(4Hrs and 3 Credit)

Unit - I

Introduction to AI Problems: AI technique, Criteria for success. Problems; Problem Space and Search: Defining the problem as a state space search, Problem characteristics.

Search Algorithms Heuristic search, Best first search, A* algorithm, AO* algorithm,

Unit-II

Knowledge representation: Representations and mappings, Approaches to knowledge representation. Issues in knowledge representation.

Different Knowledge Representation Schemes: Semantic nets, Frames, Scripts.

Expert systems: Characteristic features, rule-based system architecture.

Unit-III

Introduction to ANN, McCulloch Pitts Neuron, Single layer neural networks, problem of linear seperability, Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent. Supervised and Unsupervised learning, Learning Laws: Hebbian, Perceptron, Delta, Correlation, Out Star learning rules .

Unit-IV

Associative Memory Stochastic learning algorithm, Characteristics of associative memory, Associative memory model, Matrix Memory, Condition for Perfect recall. Auto associative memory networks - Hopfield networks.

Unit-V

Feed Forward Network: Back propagation algorithm, practical consideration in back propagation algorithm, Modes of training, Solution of Non-Linearity separable problems using MLP, Heuristics for Back Propagation, Multi-Class classification using Multilayered perceptrons.

Unit-VI

Self-Organizing Networks: Hamming Net and MAXNET, Unsupervised learning of clusters, Counterpropagation Network, Feature Mapping, Self-Organizing Maps, Cluster Discovery Network(ART1)

Text Books:

1. Stuart Russell and Peter Norvig, ―Artificial Intelligence: A Modern Approach‖ , 3rd Edition, Prentice Hall
2. Jacek M. Zurada, Introduction to Artificial Neural Systems, West publication Company.

Reference:

1. Laurene V. Fausett , 'Fundamentals of Neural Networks: Architectures, Algorithms and Applications', Pearson publications.
2. Simon Haykin, Neural Networks and Learning Machines, 3rd Edition, Pearson Prentice Hall.

Program Elective-1:-Machine Learning Techniques / Data mining and data warehousing / Image Processing

(Program Elective-1)

Course Name: Machine Learning Techniques

Course Code: 21AI1111 **Course Type:** PEC

(3Hrs and 3 Credit)

Unit-I: Introduction:

Learning Problems – Perspectives and Issues - A brief introduction to Machine Learning, Supervised Learning, Unsupervised Learning, Reinforcement Learning – Concept Learning – Version Spaces and Candidate Eliminations – Inductive bias – Decision Tree learning

Unit-II: Genetic Algorithms:

Introduction to Genetic Algorithms – Hypothesis Space Search – Genetic Programming – Models of Evolution and Learning.

Unit-III: Bayesian Learning:

Bayes Theorem – Concept Learning – Maximum Likelihood – Minimum Description Length Principle – Bayes Optimal Classifier – Gibbs Algorithm – Naïve Bayes Classifier – Bayesian Belief Network – EM Algorithm – Probability Learning – Sample Complexity – Finite and Infinite Hypothesis Spaces – Mistake Bound Model.

Unit-IV: Computational Learning

Probability Learning – Sample Complexity – Finite and Infinite Hypothesis Spaces – Mistake Bound Model. Learning Sets of Rules – Sequential Covering Algorithm – Learning Rule Set – First Order Rules – Sets of First Order Rules.

Unit-V: Instance Based Learning

K- Nearest Neighbor Learning – Locally weighted Regression – Radial Bases Functions – Case Based Learning.

Unit-VI: Advanced Learning

SVM – Formulation, SVM – Interpretation & Analysis, SVMs for Linearly Non-Separable Data, SVM Kernels. Reinforcement Learning – Task – Q-Learning – Temporal Difference Learning

Text Books:

1. Tom M. Mitchell, Machine Learning, McGraw-Hill, 2013.
2. Stephen Marsland, Machine Learning: An Algorithmic Perspective, 2/e, Taylor & Francis, 2015.

Reference Books:

1. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, Trevor Hastie," An Introduction to Statistical Learning: with Applications in R", Springer, 1/e, 2009.
2. Kevin Murphy, "Machine learning: a probabilistic perspective", MIT Press, 1/e,2012.
3. Christopher Bishop, "pattern recognition and machine learning",Springer, 1/e, 2007.

(Program Elective-1)

Course Name: Data Mining and Data Warehousing

Course Code: 21AI1112 **Course Type:** PEC

(3Hrs and 3 Credit)

UNIT-1

Data Mining: Data mining functionalities, Integration of a data mining system with a database or data warehouse systems, Classification of data mining systems, Data mining task primitives, Major issues in data mining. Data Processing: Data cleaning, Data integration and transformation, Data reduction, Discretization and concept hierarchy generation.

UNIT-2

Data Warehouse and OLAP Technology: Differences between operational database system and data warehouses, A Multidimensional data model, Data warehouse architecture, Data warehouse implementation - Efficient computation of data cubes, From Data warehousing to data mining.

UNIT-3

Association Rules in Large Databases: Basic concepts of association rule mining, Efficient and scalable frequent item set mining methods.

Mining Multilevel Association Rules: Mining multidimensional association rules from relational databases and data warehouses, From Association mining to correlation analysis, Constraint based association mining.

UNIT-4

Classification: Issues regarding classification and prediction, Classification by decision tree induction, Bayesian classification, Rule-Based classification. Prediction: Linear regression, Nonlinear regression, Other regression based methods.

UNIT-5

Cluster Analysis: Basic of cluster analysis, Types of data in cluster analysis, A categorization of major clustering methods, Partitioning methods – k-Means and k-Medoids.

UNIT- 6

Hierarchical method - Agglomerative vs. divisive hierarchical clustering, Distance measures in algorithmic methods, BIRCH, Chameleon, Density based clustering:

DBSCAN. Outlier analysis - Statistical distribution based outlier detection, Distance based outlier detection.

Text Book:

1. Jiawei Han, Micheline Kamber, “Data Mining: Concepts & Techniques”, 3 rd Edition, Morgan Kaufmann Publishers, 2012.

Reference Books:

1. Sam Anahory, Denni’s Murray, “Data Warehousing in the real world”, Pearson Education, 2000.
2. Arun K. Pujari, “Data Mining Techniques”, Universities Press, 2001.

(Program Elective-1)

Course Name: Image Processing

Course Code: 21AI1113 **Course Type:** PEC

(3Hrs and 3 Credit)

UNIT-1

Introduction: Digital Image Processing, Example of Fields that Use Digital Image Processing, Fundamental Steps in Digital Image Processing, Components of an Image Processing System; Digital Image Fundamentals: Image Sensing and Acquisition, Image Sampling and Quantization, Some basic relationships between pixels;

UNIT-2

Filtering in the Frequency Domain: A brief History of the Fourier series and Transform, Fourier Transform of Functions of one Continuous Variable, Discrete Fourier Transform of one Variable, Extension to Functions of Two Variables, Some Properties of the 2D Discrete Fourier Transform.

UNIT-3

Image Restoration and Reconstruction: A Model of the Image Degradation/Reconstruction Process, Noise Models; Restoration in the Presence of Noise Only-Spatial Filtering: Mean Filters; Image Compression: Fundamentals; Some Basic Compression Methods: Huffman coding, LZW Coding;

UNIT-4

Image Segmentation: Fundamentals, Point, Line and Edge Detection; Thresholding: Foundation, Basic Global Thresholding, using Image Smoothing to Improve Global Thresholding, Using Edges to Improve Global thresholding, Variable Thresholding, Region-Based Segmentation.

UNIT-5

Morphological Image Processing: Preliminaries, Erosion and Dilation, Opening and Closing, The Hit or Miss Transformation. Representation and Description: representation, Boundary Descriptors.

UNIT-6

Image compression: Lossy and lossless compression schemes, prediction based compression schemes, vector quantization, sub-band encoding schemes, JPEG compression standard, Fractal compression scheme, Wavelet compression scheme.

Color Image Processing: Color Representation, Laws of color matching, chromaticity diagram, color enhancement, color image segmentation, color edge detection, color demosaicing.

Text Book:

1. Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", 4 th Edition, Pearson Education, 2014.

Reference Books:

1. Anil K. Jain, "Fundamentals of Digital Image Processing", First Edition, PHI,2004.
2. Chanda Bhabatosh, Majunmder Dwijesh Dutta, "Digital Image Processing and Analysis", Prentice Hall Of India, 2011.
3. Chris Solomon,Toby Breckon,, "Fundamentals of Digital Image Processing: A Practical Approach with Examples in Matlab", 1st Edition, Wilkey Black Well Publication, 2011.

Open Electives:-Business Analytics/Industrial Safety/Operations Research/Cost Management of Engineering Projects/Composite Materials/Waste to Energy

Course Name: Business Analytics (Open Elective)

Course Code: 21AI1161 **Course Type:** OEC

(3Hrs and 3 Credit)

Unit-I:

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organization, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modeling, sampling and estimation methods overview.

Unit-II:

Trendiness and Regression Analysis: Modeling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

Unit-III:

Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modeling, Predictive analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modeling, nonlinear Optimization.

Unit-IV:

Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

Unit-V:

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, the Value of Information, Utility and Decision Making.

Unit-VI:

Recent Trends: Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

Text Book:

1. Christopher M. Starkey, Marc J. Schniederjans, Dara G.Schniederjans, Business analytics Principles, Concepts, and Applications by Pearson FT Press.

Reference:

1. James Evans, Business Analytics, Pearsons Education.

Course Name: Industrial Safety (Open Elective)

Course Code: 21AI1162 **Course Type:** OEC

(3Hrs and 3 Credit)

Unit-I:

Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Unit-II:

Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Unit-III:

Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Unit-IV:

Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

Unit-V:

Periodic and preventive maintenance- I: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance.

Unit-VI:

Periodic and preventive maintenance-II: Steps/procedure for periodic and preventive maintenance of: i. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Text Books:

1. Higgins & Morrow, Maintenance Engineering Handbook, Da Information Services.
2. Audels, Pump-hydraulic Compressors, McGraw Hill Publication.

Reference:

1. H. P. Garg, Maintenance Engineering, S. Chand and Company.
2. Winterkorn, Foundation Engineering Handbook, Hans, Chapman & Hall London

Course Name:Operations Research (Open Elective)

Course Code: 21AI1163 **Course Type:** OEC

(3Hrs and 3 Credit)

Unit-I:

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models.

Unit-II:

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming.

Unit-III:

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT.

Unit-IV:

Formulation of transportation problems, sensitivity analysis in transportation problems, assignment problems.

Unit-V:

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Unit-VI:

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation.

Text Books:

1. Kanthi Swarup, P.K. Gupta and Man Mohan, Operations Research, 14th Edition, Sultan chand and sons, New Delhi, 2008.
2. S. D. Sharma, Operations Research, Kedar Nath and Ram Nath, Meerut,2008.

References:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brother
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010

Course Name:Cost Management of Engineering Projects (Open Elective)

Course Code: 21AI1164 **Course Type:** OEC

(3Hrs and 3 Credit)

Unit-I:

Introduction and Overview of the Strategic Cost Management Process.

Unit-II:

Cost concepts in decision-making; relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Unit-III:

Project: meaning, Different types, why to manage, cost overruns centers, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.

Unit-IV:

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning,

Unit - V

Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Unit-VI:

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Text books:

1. Charles T. Horngren, George Foster, Srikant M. Datar, Madhav V. Rajan, Chris M. Ittner, Cost Accounting: A Managerial Emphasis, Pearson, Prentice Hall of India, New Delhi, 1996.

References:

1. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
2. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
3. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

Course Name:Composite Materials (Open Elective)

Course Code: 21AI1165 **Course Type:** OEC

(3Hrs and 3 Credit)

Unit–I:

INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

Unit – II:

REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures, Isostrain and Isostress conditions.

Unit – III:

Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing, Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering.

Unit–IV:

Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications. Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method

Unit–V:

Autoclave method – Filament winding method – Compressionmoulding – Reaction injection moulding. Properties and applications. Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria.

Unit–VI:

Interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

Text books:

1. R.W.Cahn , Material Science and Technology – Vol 13 — VCH, West Germany.
2. WD Callister,R. Balasubramaniam, Jr., Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian edition, 2007.

References:

1. Lubin, Hand Book of Composite Materials- 1/e -.Van Nostrand Reinhold, New York, 1982

2. K.K.Chawla, Composite Materials –3/e Springer, New York, NY

3. Composite Materials Science and Applications – Deborah D.L. Chung.

Course Name:Waste to Energy (Open Elective)

Course Code: 21AI1166 **Course Type:** OEC

(3Hrs and 3 Credit)

Unit-I:

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors.

Unit-II:

Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods – Yieldsand application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit-III:

Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration ingasifier operation.

Unit-IV:

Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixedbed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit-V:

Biogas-I: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes –

Unit-VI:

Biogas-II: Thermo chemical conversion - Direct combustion -biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion –Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Text Books:

1. Desai, Ashok V, "Non Conventional Energy", Wiley Eastern Ltd., 1990
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley &Sons, 1996.

References:

1. Khandelwal, K. C. and Mahdi, S. S, "Biogas Technology - A Practical Hand Book", Vol. I & II Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Challal, D. S, "Food, Feed and Fuel from Biomass", IBH Publishing Co. Pvt. Ltd., 1991.KL Shah, "Basics of Solid and Hazardous Waste Management Technology", Prentice Hall, Reprint Edition, 2000.

Web References:

1. http://nptel.ac.in/courses/103107125/

Course Name: Advanced Neural Networks

Course Code: 21AI1201 **Course Type:** PCC

(4Hrs and 3 Credit)

Unit-I:

Review of Neural Networks: Neural networks as universal function approximators, Training feed-forward neural network: The pros and cons of using Gradient Descent. Mini-Batch Gradient Descent.

Unit-II:

Problem of over fitting and Regularization to prevent over fitting. Data augmentation, Penalized cost function, dropout, early stopping.

Optimizing the deep neural network: momentum, AdaGrad, adam and RMSProp.

Unit-III:

Introduction to Convolution Neural Networks. Kernel responses, max and average pooling in CNNs. Building a CNN by choosing the grid size, padding, stride, depth and pooling. Application of the CNN: The handwritten digits recognition using MNIST dataset.

Unit IV:

Popular CNN architectures: Lenet, Alexnet, ZFnet, VGG net, Google Net, Resnet and their Applications.

Unit V:

Recurrent Neural Networks(RNN) and Back propagation through time. Problem of vanishing and exploding gradients. Long Short Term Memory (LSTM).

Unit-VI:

Generative models of deep neural networks, Autoencoders, Variational Autoencoders and the Generative Adversarial Neural networks.

Textbooks:

1. Ian Goodfellow and Yoshua Bengio and Aaron Courville, “Deep Learning”, An MIT Press book.
2. Charu C Agarwal, “Neural Networks and Deep Learning”, Springer 2007.

Reference:

1. Christopher Bishop, “Pattern Recognition and Machine Learning”,Springer, 1/e, 2007.

Course Name: Natural Language Processing

Course Code: 21AI1202 **Course Type:** PCC

(4Hrs and 3 Credit)

Unit 1:

Language Processing and Python: Computing with Language: Texts and Words, A Closer Look at Python: Texts as Lists of Words, Computing with Language: Simple Statistics, back to Python: Making Decisions and Taking Control, Automatic Natural Language Understanding

Accessing Text Corpora and Lexical Resources: Accessing Text Corpora, Conditional Frequency Distributions, More Python: Reusing Code, Lexical Resources, WordNet

Unit 2:

Processing Raw Text: Accessing Text from the Web and from Disk, Strings: Text Processing at the Lowest Level, Text Processing with Unicode, Regular Expressions for Detecting Word Patterns, Useful Applications of Regular Expressions, Normalizing Text, Regular Expressions for Tokenizing Text, Segmentation, Formatting: From Lists to Strings.

Writing Structured Programs: Back to the Basics, Sequences, Questions of Style, Functions: The Foundation of Structured Programming, Doing More with Functions, Program Development, Algorithm Design, A Sample of Python Libraries

Unit 3:

Categorizing and Tagging Words: Using a Tagger, Tagged Corpora, Mapping Words to Properties Using Python Dictionaries. Automatic Tagging, N-Gram Tagging, Transformation-Based Tagging, How to Determine the Category of a Word.

Learning to Classify Text: Supervised Classification, Further Examples of Supervised Classification, Evaluation, Decision Trees, Naive Bayes Classifiers, Maximum Entropy Classifiers, Modeling Linguistic Patterns.

Unit 4:

Extracting Information from Text: Information Extraction, Chunking, Developing and Evaluating Chunkers, Recursion in Linguistic Structure, Named Entity Recognition, Relation Extraction

Unit 5:

Analyzing Sentence Structure: Some Grammatical Dilemmas, What's the Use of Syntax? Context-Free Grammar. Parsing with Context-Free Grammar, Dependencies and Dependency Grammar, Grammar Development

Unit 6:

Building Feature-Based Grammars: Grammatical Features, Processing Feature Structures, Extending a Feature-Based Grammar.

Analysing the Meaning of Sentences: Natural Language Understanding, Propositional Logic, First-Order Logic, The Semantics of English Sentences, Discourse Semantics.

Textbook:

1. Christopher D. Manning and Hinrich Schütze, Foundations of Statistical Natural Language Processing, Published May 1999 by The MIT Press Cambridge, Massachusetts

References:

2. Natural Language Processing with Python, Steven Bird, Ewan Klein, and Edward Loper, Published by O'Reilly.

Program Electives 2:

(Program Elective-2)

Course Name: Computer Vision

Course Code: 21AI1211 **Course Type:** PEC

(3 Hrs and 3 Credit)

Unit 1:

Introduction: What is computer vision? A brief history, Geometric primitives and transformations, Photometric image formation, The digital camera, Feature detection and matching Points and patches, Edges, Lines.

Unit 2:

Feature-based alignment: 2D and 3D feature-based alignment, Pose estimation, Geometric intrinsic calibration.

Unit 3:

Structure from motion: Triangulation, Two-frame structure from motion, Factorization, Bundle adjustment, Constrained structure and motion.

Dense motion estimation: Translational alignment, Parametric motion, Spline-based motion, Optical flow, Layered motion

Unit 4:

Image stitching: Motion models, Global alignment, Compositing.

Computational photography: Photometric calibration, High dynamic range imaging, Super-resolution and blur removal, Image matting and compositing, Texture analysis and synthesis

Unit 5:

Stereo correspondence: Epipolar geometry, Sparse correspondence, Dense correspondence, Local methods, Global optimization, Multi-view stereo.

3D reconstruction: Shape from X, Active range finding, Surface representations, Point-based representations, Volumetric representations, Model-based reconstruction, Recovering texture maps and albedos.

Unit 6:

Image-based rendering: View interpolation, Layered depth images, Light fields and Lumigraphs, Environment mattes, Video-based rendering.

Recognition: Object detection, Face recognition, Instance recognition, Category recognition, Context and scene understanding, Recognition databases and test sets.

Text Books:

1. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer Publications.

References:

1. Mubarak Shah, Fundamentals of Computer Vision, 1997.
2. Simon J.D. Prince, Computer Vision: Models, Learning, and Inference, Cambridge University Press

(Program Elective-2)

Course Name: Speech Technology

Course Code: 21AI1212 **Course Type:** PEC

(3Hrs and 3 Credit)

Unit-I:

Fundamentals of Digital Speech processing: Anatomy and physiology of speech organs, the process of speech production, the acoustic theory of speech production, Digital models for speech signals.

Unit-II:

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 average energy and zero crossing, Pitch period estimation using parallel processing approach. The short time autocorrelation function, The short time average magnitude difference function, Pitch period estimation using the autocorrelation function.

Unit-III:

Linear Predictive Coding(LPC) Analysis: Basic principles of linear predictive analysis: The autocorrelation methods, the Covariance method, Solution of LPC equations, cholesky decomposition, solution for covariance method, Durbin's recursive solution for the Autocorrelation equations, Comparison between the methods of solution of the LPC analysis equations, Applications of LPC parameters: Pitch Detection using LPC parameters, Format analysis using LPC Parameters.

Unit-IV:

Homomorphic speech processing: Introduction, Homomorphic systems for convolution, properties of the complex cepstrum, computational considerations, the complex cepstrum of speech, Pitch detection, Formant estimation, The Homomorphic vocoder.

Speech enhancement: Nature of interfering sounds, speech enhancement techniques, spectral subtraction, and enhancement by re-synthesis.

Unit-V:

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.

Speaker recognition: Recognition techniques, features that distinguish speakers, Speaker recognition systems, Speaker verification system, speaker identification system.

Unit-VI:

Hidden Markov model (HMM) for speech: Hidden Markov model (HMM) for speech recognition, Viterbi algorithm, Training and testing using HMMS, Adapting to variability in speech, Language models.

Text Books:

1. L.R Rabiner and S.W.Schafer ,“ Digital processing of speech signals”, 1/e Pearson, 2003

References

1. Douglas O. Shaughnessy, “Speech Communication”, Second edition, Oxford university press,2000.

(Program Elective-2)

Course Name: Text Mining

Course Code: 21AI1213 **Course Type:** PEC

(3Hrs and 3 Credit)

Unit-I:

An Introduction to Text Mining: Introduction, Algorithms for Text Mining.

Information Extraction from Text: Named Entity Recognition, Relation Extraction, Unsupervised Information Extraction

Unit-II:

Text Clustering Algorithms: Introduction, Feature Selection and Transformation Methods for Text Clustering, Distance-based Clustering Algorithms, Word and Phrase-based Clustering, Probabilistic Document Clustering and Topic Models, Online Clustering with Text Streams, Clustering Text in Networks.

Unit-III:

Dimensionality Reduction and Topic Modeling: Introduction, Latent Semantic Indexing, Topic Models and Dimension Reduction, Interpretation and Evaluation.

Unit-IV:

Text Analytics in Social Media: Introduction, Distinct Aspects of Text in Social Media, Applying Text Analytics to Social Media, An Illustrative Example, Seed Phrase Extraction, Semantic Feature Generation, Feature Space Construction

Unit-V:

Sentiment analysis: The Problem of Opinion Mining, Document Sentiment Classification, Sentence Subjectivity and Sentiment Classification, Opinion Lexicon Expansion, Aspect-Based Sentiment Analysis, Mining Comparative Opinions.

Unit-VI:

Biomedical Text Mining: Introduction, Resources for Biomedical Text Mining, Corpora, Annotation, Knowledge Sources, Supporting Tools, Information Extraction, Named Entity Recognition, Relation Extraction, Event Extraction.

Text Book

1. Charu C. Aggarwal and ChengXiangZhai, Mining Text Data. 1/e, Springer, 2012.
2. Ashok N. Srivastava, Mehran Sahami, Text Mining: Classification, Clustering, and Applications,
3. Soumen Charabarti, Mining the Web: Discovering Knowledge from Hypertext Data, 1/e, Morgan-Kaufmann, 2002.

References:

1. Julia Silge and David Robinson, O'Reilly , Text Mining with R: A Tidy approach, 2017

(Program Elective-2)

Course Name: Reinforcement Learning

Course Code: 21AI1214 **Course Type:** PEC

(3Hrs and 3 Credit)

Unit-I: Introduction:

Course logistics and overview. Origin and history of Reinforcement Learning research. Its connections with other related fields and with different branches of machine learning. **Probability Primer:** Brush up of Probability concepts - Axioms of probability, concepts of random variables, PMF, PDFs, CDFs, Expectation. Concepts of joint and multiple random variables, joint, conditional and marginal distributions. Correlation and independence.

Unit-II: Markov Decision Process:

Introduction to RL terminology, Markov property, Markov chains, Markov reward process (MRP). Introduction to and proof of Bellman equations for MRPs along with proof of existence of solution to Bellman equations in MRP. Introduction to Markov decision process (MDP), state and action value functions, Bellman expectation equations, optimality of value functions and policies, Bellman optimality equations.

Unit-III: Prediction and Control by Dynamic Programming:

Overview of dynamic programming for MDP, definition and formulation of planning in MDPs, principle of optimality, iterative policy evaluation, policy iteration, value iteration, Banach fixed point theorem, proof of contraction mapping property of Bellman expectation and optimality operators, proof of convergence of policy evaluation and value iteration algorithms, DP extensions.

Unit-IV: Monte Carlo Methods for Model Free Prediction and Control:

Overview of Monte Carlo methods for model free RL, First visit and every visit Monte Carlo, Monte Carlo control, On policy and off policy learning, Importance sampling.**TD Methods** Incremental Monte Carlo Methods for Model Free Prediction, Overview TD(0), TD(1) and TD(λ), k-step estimators, unified view of DP, MC and TD evaluation methods, TD Control methods - SARSA, Q-Learning and their variants.

Unit-V: Function Approximation Methods:

Getting started with the function approximation methods, Revisiting risk minimization, gradient descent from Machine Learning, Gradient MC and Semi-gradient TD(0) algorithms, Eligibility trace for function approximation, After states, Control with function approximation, Least squares, Experience replay in deep Q-Networks.

Unit-VI: Policy Gradients:

Getting started with policy gradient methods, Log-derivative trick, Naive REINFORCE algorithm, bias and variance in Reinforcement Learning, Reducing variance in policy gradient estimates, baselines, advantage function, actor-critic methods.

Text Books:

1. Richard S. Sutton, Andrew G. Barto, Francis Bach, Reinforcement Learning – An Introduction, 1/e, MIT Press, Cambridge, MA, 2018.

Reference:

1. Phil Winder, Reinforcement Learning: Industrial Applications Of Intelligent Agents, O’Reilly.

Program Electives 3:

(Program Elective-3)

Course Name: Probabilistic Graphical Models

Course Code: 21AI1215 **Course Type:** PEC

(3Hrs and 3 Credit)

Unit-I:

Fundamentals: Fundamentals of Probability Theory - Views of Probability, Random Variables and Joint Distributions, Conditional Probability, Conditional Independence, Expectation and Variance, Probability Distributions - Conjugate Priors, Introduction to Exponential Family; Fundamentals of Graph Theory - Paths, Cliques, Subgraphs, Cycles and Loops.

Unit-II:

Graphical Models: Introduction - Directed Models (Bayesian Network), Undirected Models (Markov Random Fields), Dynamic Models (Hidden Markov Model &Kalman Filters) and Factor Graph

Unit-III:

Conditional Independence (Bayes Ball Theorem and D-separation), Markov Blanket, Factorization (Hammersley-Clifford Theorem), Equivalence (I-Maps & Perfect Maps); Factor Graphs - Representation, Relation to Bayesian Network and Markov Random Field

Unit-IV:

Inference in graphical models: Exact Inference - Variable Elimination, Elimination Orderings, Relation to Dynamic Programming, Dealing with Evidence, Forward-Backward Algorithm, Viterbi Algorithm; Junction Tree Algorithm; Belief Propagation (Sum Product); Approximate Inference - Variational Methods (Mean Field, Kikuchi & Bethe Approximation), Expectation Propagation, Gaussian Belief Propagation

Unit-V:

MAP Inference - Max-Product, Graph Cuts, Linear Programming Relaxations to MAP (Tree-Reweighted Belief Propagation, MPLP); Sampling - Markov Chain Monte Carlo, Metropolis Hastings, Gibbs (Collapsing & Blocking), Particle filtering.

Unit-VI:

Learning in Graphical Models: Parameter Estimation - Expectation Maximization, Maximum Likelihood Estimation, Maximum Entropy, Pseudo likelihood, Bayesian Estimation, Conditional Likelihood, Structured Prediction; Learning with Approximate Inference; Learning with Latent Variables; Structure Learning, Structure Search, L1 priors.

Text Books:

1. Koller, D. and Friedman, N., Probabilistic Graphical Models: Principles and Techniques. 1/e, MIT Press, 2009.
2. Kevin P. Murph, Machine Learning: A Probabilistic Perspective. 4th Printing. MIT Press, 2013.

Reference Books:

1. Jensen, F. V. and Nielsen, T. D. (2002). Bayesian Networks and Decision Graphs. Information Science and Statistics. Springer, 2nd edition.

2. Barber, D., Bayesian Reasoning and Machine Learning. 1/e, Cambridge University Press, 2011.

(Program Elective-3)

Course Name: Big Data Frameworks

Course Code: 21AI1216 **Course Type:** PEC

(3Hrs and 3 Credit)

Unit-I:

Introduction To Big Data: Big Data Storage and Analysis - Characteristics of Big Data – Big Data Analytics - Typical Analytical Architecture – Requirement for new analytical architecture – Challenges in Big Data Analytics – Need of big data frameworks.

Unit-II:

Hadoop Framework: Hadoop – Requirement of Hadoop Framework - Design principle of Hadoop –Comparison with other system - Hadoop Components – Hadoop 1 vs Hadoop 2 – Hadoop Daemon's – HDFS Commands – Map Reduce Programming: I/O formats, Map side join, Reduce Side Join, Secondary sorting, Pipelining Map Reduce jobs.

Unit-III:

Hadoop Ecosystem: Hadoop ecosystem technologies: Serialization: AVRO, Co-ordination: Zookeeper, Databases: HBase, Hive, Scripting language: Pig, Streaming: Flink, Storm.

Unit-IV:

Spark Framework: Introduction to GPU Computing, CUDA Programming Model, CUDA API, Simple Matrix, Multiplication in CUDA, CUDA Memory Model, Shared Memory Matrix Multiplication, Additional CUDA API Features.

Unit-V:

Data Analysis with Spark Shell: Writing Spark Application - Spark Programming in Scala, Python, R, Java - Application Execution.

Unit-VI:

Spark SQL and GraphX: SQL Context – Importing and Saving data – Data frames – using SQL – GraphX overview – Creating Graph – Graph Algorithms. Errors and Recovery – Streaming Source – Streaming live data with spark

Text Book:

1. Raj Kamal, PreetiSaxena, Big data analytics, 1/e, Mc Graw Hill, 2019.
2. V.K. Jain, Big Data and Hadoop, 1/e, Khanna Publishing, 2019.

Reference Books

1. Mike Frampton, "Mastering Apache Spark", Packt Publishing, 2015.
2. TomWhite,"Hadoop:TheDefinitiveGuide",O'Reilly,4thEdition,2015.
3. NickPentreath, MachineLearningwithSpark,PacktPublishing,2015.

(Program Elective-3)

Course Name: Advanced Optimization Methods for Machine Learning

Course Code: 21AI1217 **Course Type:** PEC

(4Hrs and 3 Credit)

Unit-I:

The Statistical Theory of Machine Learning: Classification, Regression, Aggregation, Empirical Risk Minimization, Regularization and Suprema of Empirical Processes

Unit-II:

Basics of convex optimization: convex sets, convexity-preserving operations, examples of convex programs (linear programming (LP), second-order cone programming (SOCP), semi definite programming (SDP)), convex relaxation, KKT conditions, duality.

Unit-III:

Gradient based methods: gradient descent, subgradient, mirror descent, Frank–Wolfe method, Nesterov's accelerated gradient method, ODE interpretations, dual methods, Nesterov's smoothing, proximal gradient methods, Moreau–Yosida regularization.

Unit-IV:

Support vector machines: functional and geometric margins, optimum margin classifier, constrained optimization, Lagrange multipliers, primal/dual problems, KKT conditions, dual of the optimum margin classifier, soft margins, kernels, quadratic programming, SMO algorithm.

Unit-V:

Operator splitting methods: Augmented Lagrangian methods, alternating direction method of multipliers (ADMM), monotone operators, Douglas–Richford splitting, primal and dual decomposition.

Unit-VI:

Stochastic and non-convex optimization: Dual averaging, Polyak–Juditsky averaging, stochastic variance reduced gradient (SVRG), Langevin dynamics, escaping saddle points, landscape of nonconvex problems, deep learning.

Text Book:

1. SuvritSra, Sebastian Nowozin and Stephen J. Wright Optimization for Machine Learning, 1/e, Neural Information Processing series, 2012

Reference:

1. Anand J. Kulkarni, Suresh Chandra Satapathy, Optimization in Machine Learning and Applications, 1/e, Springer, 2020

(Program Elective-3)

Course Name: Game Theory

Course Code: 21AI1218 **Course Type:** PEC

(4Hrs and 3 Credit)

Unit 1:

Introduction to Game theory, Human–Environment–Social System and Evolutionary Game Theory, Modelling a Real Complex World, Evolutionary Game Theory.

Unit 2:

Fundamental Theory for Evolutionary Games: Linear Dynamical Systems, Non-linear Dynamical Systems, 2-Player & 2-Stratey (2 X 2) Games, Dynamics Analysis of the 2 X 2 Game, Multi-player Games, Social Viscosity; Reciprocity Mechanism, Universal Scaling for Dilemma Strength in 2 X 2 Games, R-Reciprocity and ST-Reciprocity.

Unit 3:

Network Reciprocity: What Is Most Influential to Enhance Network Reciprocity? Is Topology So Critically Influential on Network Reciprocity?, Effect of the Initial Fraction of Cooperators on Cooperative Behavior in the Evolutionary Prisoner's Dilemma Game, Several Applications of Stronger Network Reciprocity, Discrete, Mixed and Continuous Strategies Bring Different Pictures of Network Reciprocity, A Substantial Mechanism of Network Reciprocity.

Unit 4:

Evolution of Communication: Communication; as an Authentication Mechanism, An Evolutionary Hypothesis Suggested by Constructivism Approach, Model Setup, Results and Discussion.

Unit 5:

Traffic Flow Analysis Dovetailed with Evolutionary Game Theory: Modeling and Analysis of the Fundamental Theory of Traffic Flow, A Cellular Automaton (CA) Model to Reproduce Realistic Traffic Flow, Social Dilemma Structure Hidden Behind Various Traffic Contexts

Unit 6:

Pandemic Analysis and Evolutionary Games: Modeling the Spread of Infectious Diseases and Vaccination Behavior, Infinite & Well-Mixed Population, Topological Influence, Vaccination Games in Complex Social Networks

Textbook:

1. Jun Tanimoto, Fundamentals of Evolutionary Game Theory and its Applications, , Springer, 2015

Reference:

1. Michael Maschler, Eilon Solan, Shmuel Zamir, Game Theory, Cambridge University Press, 2013.

First Semester	Geometric Design of Transportation Facilities	L	T	P	Credits
		3	0	0	3

UNIT – I

Highway System and alignment: Introduction, Functional Classification of Highway System, factors controlling alignment, Obligatory points, Engineering surveys for Highway alignment. Highway Design Controls: Design Speed, Topography, Traffic, Capacity and LOS. Cross Section Elements: Typical Cross Sections of Roads, Pavement Surface Characteristics, Factors affecting skid resistance, Pavement Unevenness, IRI, Camber, Providing camber in the field, Width of carriageway, Design Vehicle, Medians, Kerbs, Road Margins, Right of Way.

UNIT – II

Sight Distances: Sight Distances, Stopping Sight Distance, Overtaking Sight distance, Analysis of Overtaking Sight distance, Effect of grade on sight distances, Overtaking zone, Intermediate sight distance, Sight distance at intersections.

UNIT – III

Horizontal Alignment: Design speed, Horizontal curves, Super elevation, widening of pavement on horizontal curves, Different types of Transition curves, Methods of introducing extra widening , length of transition curve, setting out of transition curve, Set-back distance on horizontal curves, Geometric specifications of 2-lane, 4-lane, 6-lane and Expressways.

UNIT - IV

Vertical Alignment: Introduction, Gradients, Compensation in gradient on horizontal curves, Vertical curves, Summit curve, Length of summit curve, Valley Curve, Length of valley curve, Combination of Vertical and Horizontal Curves. Relevant IRC standards for Urban and Rural roads.

UNIT - V

Geometric Design of Intersections: Types of Intersections; Design Principles for Intersections; Design of At-grade Intersections – Channelization, Objectives; Traffic Islands and Design standards; Rotary Intersection – Concept, Advantages and Disadvantages; Grade separated Interchanges – Types, warrants and Design standards.

UNIT – VI

Other Facilities on Highway: Requirements of Pedestrians; Pedestrian facilities on Urban Roads; Cycle Tracks – Guidelines and Design standards; Bus bays – Types and Guide lines; Design of On-street and Off-street Parking facilities – Guidelines for lay out Design.

Recommended Books

1) AASHO, "A Policy on Geometric Design of Highways and Streets', American Association of State Highway and Transportation Officials, Washington D.C.
2) Principles of Transportation Engineering by Chakraborty & Das, Prentice Hall, India.
3) Principles and Practice of Highway Engineering, L.R.Kadiyali and N.B.Lal, Khanna, 2007.
4) Jack E Leish and Associates, `Planning and Design Guide: At-Grade Intersections', Illinios.
5) O'Flaherty, A. Coleman, "Highways: The Location, Design, Construction and Maintenance of Road Pavements", 4th Edition, Elsevier, 2006.
6) Design codes IRC 38 – 1988, IRC 52 – 2019, IRC 73-1990, IRC 86-2018, IRC: SP: 41-1994, IRC SP: 31-1992,
7) *Indian Highway Capacity Manual* (Indo-*HCM*), 2017

First Semester	Pavement Materials	L	T	P	Credits
		3	0	0	3

UNIT I

Sub- grade Soil Characterization: Embankment and Subgrade, Properties of sub-grade layer, Soil Classification: Index and other basic properties of soil, different laboratory, and in-situ procedures for evaluating the mechanical properties of soils viz. SPT, DCPT, CPT, CBR, Plate Load test & resilient modulus; Suitability of different type of soil for the construction of highway subgrade; Field compaction and quality control.

UNIT II

Introduction to Soil Stabilization: Mechanical Stabilization, Chemical modification: Stabilization with admixtures like cement, lime, and fly ash. Stabilization with non-conventional stabilizers (liquid and powder-based), strength and durability tests on stabilized materials, stabilized materials for base layers, Geo textiles and geo grids.

UNIT III

Aggregate Characterization: Origin, Classification, Types of aggregates; Sampling of aggregates; Mechanical and shape properties of aggregates, Aggregate texture, and skid resistance, polishing of aggregates; Proportioning and Blending of aggregates: Super pave gradation, Fuller and Thompson's Equation, 0.45 power maximum density graph; Use of locally available materials in lieu of aggregates. Design of WMM and GSB mixes.

UNIT IV

Bituminous Materials: Bitumen sources and manufacturing, Chemistry of bitumen, Rheology of bitumen, grading of bitumen: Penetration, Viscosity and Performance Granding, Creep test, stiffness modulus of bitumen mixes using shell nomographs. Modified bitumen: Crumb Rubber Modified bitumen, Natural rubber modified bitumen, polymer modified bitumen; Introduction to emulsified bitumen and its characterization; Long-term and short-term ageing and its effect on bitumen performance, Tests to simulate ageing of bitumen viz. RTFOT and PAV.

UNIT V

Design of bituminous mixes: Desirable properties of bituminous mixes, Marshall's Mix design, importance of volumetric properties, super pave mix design procedure, testing of bituminous mixes; fatigue, resilient modulus, rutting.

UNIT VI

Cement and Cement Concrete Mixes: Types of cements and basic cement properties, Tests on cement concrete including compressive strength, flexural strength, modulus of elasticity and fatigue properties; Introduction to advanced concretes like self-compacted concrete, Light weight concrete, Roller Compacted Concrete for pavement application; IS method of cement concrete mix design;

Role of different admixtures in cement concrete performance; Joint filers for Jointed Plain Cement Concrete Pavements and their characterization.

Recommended Books

1. Highway Materials by Kerbs Robert D. and Richard D. Walker, McGraw-Hill.
2. Highway Materials, Soils and Concretes by Atkins, N. Harold, Fourth Edition, 1980, Prentice-Hall.
3. Asphalt Institute. Mix Design Methods – For Asphalt Concrete and Other Hot-Mix Types Manual Series No. 2 (MS-2), Asphalt Institute, Kentucky, USA, 1997. 2.
4. Ministry of Road Transport and Highways (MoRTH), Specifications for Road and Bridge Works, Fifth Revision, Indian Roads Congress, New Delhi, India
5. "The Shell Bitumen Handbook", by Read, J. And Whiteoak, D., Fifth edition, Shell Bitumen, Thomas, Telford Publishing, London 2003 4
6. Mallick, R.B. and T. El-Korchi Pavement Engineering – Principles and Practice, CRC Press, Taylor and Francis Group, Florida, USA, 2009
7. Asphalt Institute. Mix Design Methods – For Asphalt Concrete and Other Hot-Mix Types Manual Series No. 2 (MS-2), 7th Edition, Asphalt Institute, Kentucky, USA, 1997.
8. Design Codes IRC 15 – 2017, IRC 44-2017, IRC SP89-1-2010, IRC SP89-2-2018, IRC 88-1988, IRC 113-2013, IRC 49 -1973, IRC 50 -1973 and IRC 51 -1992.

First Semester	Urban Transportation Planning	L	T	P	Credits
		3	0	0	3

UNIT I

Urban Transportation Planning: Goals and objectives - Hierarchical levels of Transportation planning - Forecast - Implementation - Constraints. UTP survey – Inventory of land use, Introduction of classical four stage modeling. Zonal Classifications.

UNIT II

Data Collection and Inventories: Collection of data – Organization of surveys and Analysis, Study Area, Zoning, Types and Sources of Data, Road Side Interviews, Home Interview Surveys, Commercial Vehicle Surveys, Sampling Techniques, Expansion Factors, Accuracy Checks, Use of Secondary Sources, Economic data – Income – Population – Employment – Vehicle Owner Ship.

UNIT III

Trip Generation and Trip Distribution: Trip classification - productions and attractions - Multiple regression models - Category analysis - Trip production models - Trip distribution models – Linear programming approach.

UNIT IV

Mode Split and Traffic Assignments: Behavioral models - Probabilistic models - Utility functions – logit models - Two stage model. Traffic assignment - Assignment methods - Route choice behavior - Network analysis.

UNIT V

Land-Use and its Interaction: Lowry derivative models - Quick response techniques – non-transport solutions for transport problems, Characteristics of urban structure, Town planning concepts.

UNIT VI

Applications of UTP: Preparation of alternative plans - Evaluation techniques - Plan implementation – Monitoring - Case studies.

Recommended Books:

1. Principles of Urban Transportation System Planning by Hutchinson, B.G., McGraw Hill, 1974.
2. An Introduction to Transportation Planning (The Living Environment) by Bruton, M. J., UCL Press, London, UK, 2000

3. Transportation Engineering by C.J. Khisty and B. Kent Lall, Prentice Hall of India Pvt. Ltd., 2002.
4. Transportation Engineering and Planning by C.S. Papacostas and P.D. Prevedouros, Prentice Hall of India Pvt. Ltd., 2001.
5. Metropolitan Transportation Planning by Dicky J.W.,Script Book Co., Washington, D.C., 1975

ELECTIVE-1	Geotechnical Investigations and Ground Improvement Techniques	L	T	P	Credits
		3	0	0	3

UNIT I

Soil investigation and Methods: Soil investigation Programme for different Civil Engineering Projects, investigation Methods: Methods of Boring, Auguring and Drilling. Machinery used for drilling, types of augers and their usage for various projects.

UNIT II

Soil Sampling and Bore Logging: Sampling methods, types of samples, storage of samples and their transport, sample preparation and sample sizes, various tests on soil samples specifications for testing. Borehole Logging: Logging of Boreholes-logging methods- Ground water observations – water table fluctuations and effects - Preparation of soil profiles – calculations.

UNIT III

Field testing of soils and Reports: Methods and specifications – visual identification tests, vane shear test, penetration tests, analysis of test results, soil testing reports: analysis, identification, and preparation.

UNIT IV

Introduction to ground improvement techniques: Engineering properties of soft – weak and compressible deposits – problems associated with weak deposit – Requirements of ground improvements – introduction to engineering ground modification, need and objectives.

UNIT V

Recent Ground improvement techniques: stabilization using industrial waste – modification by inclusion and confinement – soil nailing – stone column – compaction piles – dynamic compaction – prefabricated vertical drains – preloading – electro – osmosis – soil freezing vacuum consolidation – deep explosion – dry powdered polymers - enzymes

UNIT VI

Soil reinforcement: Historical background, Concept of reinforced earth – Mechanisms – Types of reinforcements – Soil – Reinforcement – Interaction studies – Internal & External stability criteria – Design Principles of steep reinforced soil slops – pavements – Embankments on soft soils.

Recommended Books

1. Hausmann, M.R., Engineering Principles of Ground Modification, McGraw – Hill International Editions, 1990.
2. Purushotham Raj, Ground Improvement Techniques, Laxmi Publications, New Delhi
3. Sharma.S.K., Priniciples, Practice and Design of Highway Engineering, S.Chand & Co. New Delhi,1985.
4. Jones C. J. F. P, Earth Reinforcement and Soil Structures, Butterworths, London.
5. Basic and Applied Soil Mechanics- A.S. Rao and Gopal Ranjan, New Age International.
6. Construction and Geotechnical Methods in Foundation Engineering By R.M. Koerner, McGraw – Hill Book Co.
7. Current Practices in Geotechnical Engineering Vol.1, Alam Singh and Joshi, International Book Traders, Delhi, & Geo- Environ Academia

ELECTIVE-1	Road Safety	L	T	P	Credits
		3	0	0	3

UNIT I:

Safety in Road Design: Operating the road network for safety, highway operation and counter measures, road safety audit, principles – procedures and practice, code of good practice and checklist, vehicle design factors, driver and Friction characteristics influencing road safety.

UNIT II

Road Accidents: Causes, Scientific investigations and data collection, Analysis of individual accidents to arrive at real causes, Basic concepts of Road accident statistics, safety performance function: the empirical Bayes method Identification of Hazards Road location. Application of computer analysis of accident.

UNIT III

Statistical Interpretation and Analysis of Crash Data: Before-after methods in crash analysis, Recording of crash data; Accident Investigation and Analysis; Statistical testing and the role of chance; Black Spot Identification and Investigations, Case Studies

UNIT IV

Road Safety Audits: Key elements of a road safety audit, Road Safety Audits & Investigations, Work zone safety audit; Crash investigation and analysis, Methods for identifying hazardous road locations, Case Studies.

UNIT V

Mitigation Measures: Accident prevention by better planning, Accident prevention by better design of roads, Crash Countermeasures, Highway operation and accident control measures, Highway Safety Measures during construction, Highway geometry and safety; Safety in urban areas; Public transport and safety; Road safety policy making, Stakeholder's involvement; Road safety law.

UNIT VI

Road Signs and Traffic Signals: Classifications, location of signs, measures of sign effectiveness, Types of visual perception, sign regulations, sign visibility sign variables, text versus symbols. Road Markings: Role of Road marking, classification, visibility. Traffic Signals need, signal face, Illumination and location of signals, factors affecting signal design, pedestrian safety, fixed and vehicle actuated signals, Design of signals, Area Traffic control. Delineators, Traffic Impact Attenuators, Road Side rest areas, safety Barriers, Traffic Aid Posts.

Recommended Books

1. AthelstanPopkess, Traffic Control and Road Accident Prevention, Chapman and Hall, 1997 (Digitized 2008)
2. Ezra Hauer, Observational Before-After Studies in Road Safety, Pergamon Press, 1997 (reprinted 2002).
3. Geetam Tiwari and Dinesh Mohan, Transport Planning and Traffic Safety: Making Cities, Roads, and Vehicles Safer, CRC Press, 2016.
4. Institute of Transportation Engineers (ITE), The Traffic Safety Toolbox: A Primer on Traffic Safety, ITE, 1999.
5. J. Stannard Baker, Traffic Collision Investigation, Northwestern University Center for Public Safety, 2002.
6. Traffic Control and Road Accident Prevention by Popkess C.A.Chapman and Hall, 1997

ELECTIVE-1	Transit Planning and Operations	L	T	P	Credits
		3	0	0	3

UNIT-I

Transit System and Issues: Introduction to Mass Transport – Role of various modes of Mass Transport – Problems and their Impact – System Characteristics: Technological Characteristics – Resistances, acceleration & velocity Profiles – Operational characteristics speed, capacity & payloads – Route capacity – Comfort conditions - Performance relationships - Public and Private Operations - Modes for Intercity Transport System Performance at National, State, Local and International levels

UNIT-II

Public Transit System: Urban Transport System – Public Transport System Re-genesis and Technology – Physical performance of Public Transport System – Public Transport and Urban Development Strategies - Characteristics of Rail Transit – Vehicle Characteristics, ITS, Para transit systems – Intermediate Public Transport.

UNIT-III

Mass Transit Corridor Identification & Planning: Corridor identification – Network Compression Method - Planning of Rapid Transit System - System Selection - Supporting and Enclosing Structures - System Evaluation - Track Structures - Power Supply and Distribution - Signal System – Aesthetics and Noise Consideration - Cost of Construction - Station Arrangements - Platform Capacity - Fare Collection, Transit Marketing.

UNIT-IV

Bus Transit Planning and Scheduling: Route Location, Route Structure, Route Coding Techniques, Route Capacity - Planning of Transit Network - Different Types - Service Area Coverage - Evaluation - Selection of Optimal Network - Path Building Criteria - Route Planning and Scheduling – Bus Transport System – Performance and Evaluation – Scheduling – Conceptual patterns of bus service – Network Planning and Analysis – Bus Transport System Pricing – Bus Transit System Integration – Analytical Tools and Techniques for Operation and Management – Bus Rapid Transit Systems.

UNIT-V

Rail Transit Terminals and Performance Evaluation: Performance Evaluation – Efficiency, Capacity, Productivity and Utilization – Performance Evaluation Techniques and Application – System Network Performance – Transit Terminal Planning and Design Urban Rail Transit Planning – MRTS – LRTS, Metro Rail – Monorail – Network Design, Capacity and Traffic Fore casting

UNIT-VI

Impact of Transit: Policies and Strategies for Mass Transport – Need for Integrated Approach – Unified Transport Authorities – Institutional arrangement – Urban Transport Fund – Parking Policies - Private Sector in Mass Transport – Bus and Rail Integration – Co-ordination of Feeder Services – Transit Oriented Land Use Development – Case Studies - Urban Transportation and Land use – Impact of Transport Development on Environment – Remedial measures – Policy Decisions – Recent Trends in Mass Transportation Planning and Management.

Recommended Books

1) Black, Urban Mass Transport Planning, McGraw Hill
2) V. R. Vuchic, Urban Public Transport System and Technology, Prentice Hall Inc.
3) Fundamentals of Transportation Engineering – C. S. Papacostas, Prentice-Hall India Publication
4) G. E. Gray and C. A. Hoel: Public Transport Planning Operation and Management, Prentice Hall
5) White P. R., Planning for Public Transport, UCL Press Ltd.

ELECTIVE-2	Probability and Statistics	L	T	P	Credits
		3	0	0	3

Unit - I

Permutations and Combinations, Probability introduction through Sets and Relative Frequency, Experiments and Sample Spaces, Discrete and Continuous Sample Spaces, Events, Probability Definitions and Axioms, Mathematical Model of Experiments, Probability as a Relative Frequency, Joint Probability, Conditional Probability, Total Probability, Bayes' Theorem, and Independent Events.

Unit - II

Random Variable, Bivariate random variable, Mathematical Expectation, Discrete Probability Distributions, Continuous Probability Distributions, Functions of Random Variables, Correlation coefficient and Bivariate Normal Distribution.

Unit - III

Definition of population, sampling, statistics, and parameters. Types of sampling, expected values of sample mean and variance, sampling distribution, standard error, sampling distribution of mean and sampling distribution of variance.

Unit- IV

Sampling -Distributions (t, F and Chi-square), confidence interval and interval estimation.

Unit – V

Definition of Null and alternative hypothesis, critical region. Type I and II errors, power of the test, one tail, two tail tests, Tests for the single mean, two means, single proportion and two proportions using Z-test and t-test, tests significance of difference in variances.

Unit -VI

Chi-square test for goodness of fit, ANOVA for one-way and two-way classified data.

Recommended Books

1. William W. Hines and Douglas C. Montgomery, 'Probability and Statistics in Engineering', Willy Publications, 4th Edition.
2. Sheldon Ross, 'A First Course in Probability', Pearson Publications, 9th Edition.
3. Athanasios Papoulis and S. Unnikrishna Pillai, 'Probability, Random Variables and Stochastic Processes', TMH, 4th Edition.

ELECTIVE-2	Research Methodology & IPR	L	T	P	Credits
		3	0	0	3

Unit I

Introduction: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit II

Literature studies and Analysis: Effective literature studies approaches, analysis Plagiarism, Research ethics

Unit III

Writing research proposal: Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit IV

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit V

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit VI

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

References:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"

2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall, "Industrial Design", McGraw Hill, 1992.
6. Niebel, "Product Design", McGraw Hill, 1974.
7. Asimov, "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

ELECTIVE-2	Project Planning and Management	L	T	P	Credits
		3	0	0	3

UNIT I

Introduction: Project Planning, Need of Project Planning, Objectives and functions, stages in construction, Process of development of plans and schedules, work break-down structure, activity lists, assessment of work content, estimating durations, sequence of activities, activity utility data.

UNIT II

Stages of project planning: Pre-tender planning, pre-construction planning, detailed construction planning, role of client and contractor, level of detail, application of MS-Project and PrimaVera for project planning.

UNIT III

Project Costing and Budgeting: Classification of costs, time cost trade-off in construction projects, Compression and decompression. Preparing budgets, master networks.

UNIT- IV

Introduction to Project Management: A systems Approach, Systems Theory and Concepts, Organisation, Management Fuctions, Overview of Management Objectives, Tools and Techniques, Project Management, Processes and Organizational Structures, Team Management, Project Manager as a Team Leader, Leadership qualities, PMIS.

UNIT-V

Construction Cost and Value Engineering: Types of Estimates, Implementation of Cost Controls, Project Cost Forecasting, Cost optimization and Resources Planning – Value Engineering, Techniques for Project Selection, Break-Even Analysis, Cost Modelling, Energy Modelling, Life Cycle Cost Approach.

UNIT-VI

Project Scheduling and Analysis Methods: Methods of scheduling, CPM, PERT, bar charts, limitations of bar charts, milestone charts, preparation of material, equipment, labour and finance schedule, linear programming, queuing concept, simulation, bidding models, game theory.

References:

1. Herold Kerzer- Project Management – Asystems approach to Planing, Scheduling and Controlling. CBS Publishers and Distributors.

2. L.Waker A Teraih and Jose M.Grevarn; Fundamentals of Construction Management and Organisations.

3. Anghel petterson – Construction Cost Engineering Handbook- Marcel Dekken Inc.

4. Dell Isola- Value Engineering in Construction Industry, Van Nostrand Reinhold Co.,

5. Choudhary, S. Project Management, Tata McGraw Hill Publishing Co., Ltd

6. Raina UK, Construction management Practices, Tata McGraw Hill Publishing Co., Ltd

7. Sengupta B and Guha H, Construction Management and Planning, Tata McGraw Hill Publishing Company Limited, New Delhi.

8. Prasanna Chandra (1986); "Project preparation, appraisal, budgeting and implementation", Tata McGraw Hill. ISBN13: 978-0074516287.543p.

9. Gregory T. Haugan (2002); "Construction Project Management", Tata McGraw Hill, ISBN 13:9781567261363.102p.

10. Chitkara K K (1998); " Construction Project Management", Tata McGraw Hill, ISBN 13:9780074620625, 558P.

11. Barrie D.S & Paulson B C (1992); "Professional Construction Management", McGraw Hill, ISBN: 13 9780070038899.577p.

12. Harold R. Kerzner (2013); " Project management: A System approach to planning, scheduling and controlling" John Wiley & Sons.

First Semester	Pavement Engineering Laboratory -1	L	T	P	Credits
		0	0	3	1.5

1. Tests on Aggregates - Aggregate Impact Test and Los Angeles Abrasion Test
2. Tests on Aggregates - Crushing strength of Aggregates and Specific Gravity & Water Absorption
3. Tests on Aggregates - Soundness and stripping value
4. Tests on Bitumen – Penetration and softening point
5. Tests on Bitumen – Viscosity Grading of bitumen
6. Mix design for granular sub base layers and determining OMC & CBR
7. Permeability test on granular subbase material
8. Mix design for granular base layer and determining OMC & CBR
9. Cement treated sub base mixes and testing
10. Cement treated base mixes and testing

Recommended Text Books

1. Highway materials and pavement testing by Khanna, S.K., Justo, C.E.G., and A. Veeraragavan, 5th edition, Nem chand and brothers, Roorkee, India, 2009.
2. Huang, Y.H. Pavement Analysis and Design, Pearson Prentice Hall, New Jersey, USA, 2004.
3. Relevant IS, IRC, ASTM Codes.

First Semester	Geometric Design of Transportation Facilities Laboratory	L	T	P	Credits
		0	0	3	1.5

1. Topographic survey of an existing alignment
2. Importing topographic data in any geometric design software
3. Design of Horizontal alignment as per IRC specification
4. Design of Vertical alignment as per IRC specifications
5. Estimation of earth work quantities
6. Development of cross section at different intervals
7. Creating a drive through 3D animation

Recommended Books

1. Bentley MX Road Tutorials
2. Autodesk – Civil 3d Tutorials
3. IRC 38 -1988 – Guidelines for Design of Horizontal Curves for Highways and Design Tables (First Revision)
4. IRC SP 23 – 1993 - Vertical Curves for Highways

Second Semester	Pavement Analysis and Design	L	T	P	Credits
		3	0	0	3

UNIT – I

Factors Affecting Pavement Design: Types of Pavements, Functions of Individual Layers, Variables Considered in Pavement Design, Classification of Axle Types of Rigid Chassis and Articulated Commercial Vehicles, Legal Axle, Tire Pressure, Contact Pressure, EAL and ESWL Concepts, Traffic Analysis: ADT, AADT, Lane Distributions & Vehicle Damage Factors and plate bearing tests, Resilient Modulus, fatigue tests on bitumen mixes.

UNIT - II

Stresses In flexible Pavements: Stress Inducing Factors in Flexible pavements; Stress In Flexible Pavements, Layered Systems Concepts, Stress Solutions for One, Two and Three Layered Systems, Fundamental Design Concepts.

UNIT - III

Stresses in Rigid Pavements: Westergaard's Theory and Assumptions, Stresses due to Curling, Stresses and Deflections due to Loading, Frictional Stresses, calculation of stresses using Picket and Ray charts.

UNIT – IV

Design of Flexible and Rigid Pavements: Design Concepts, Design subgrade CBR, concept of rich DBM layer, Importance of voids in the Mixes, Stepwise procedure for design of Flexible Pavements as per IRC 37:2012.

UNIT – V

Design of Rigid Pavements: Step wise design procedure of Rigid pavement as per IRC 58:2015 guidelines, Design of Dowel Bars & Tie Bars.

UNIT – VI: Design of Bitumen and Concrete Overlays

Design of bitumen pavement Overlays as per IRC 81 procedure, FWD approach for design of bitumen overlays, Design of rigid overlays as per IRC SP76-2008 guidelines.

Recommended Books:

1. Pavement Analysis & Design, Yang H. Huang, Prentice Hall Inc.
2. Principles of Pavement Design, Yoder.J. & Witzac Mathew, W. John Wiley & Sons Inc
3. IRC: 37-2018 Tentative Guidelines for the Design of Flexible Pavements.

4. IRC: 58-2015 Guidelines for Design of Plain Jointed Rigid Pavements for Highways.
5. Concrete Pavements, AF Stock, Elsevier, Applied Science Publishers
6. Design of Functional Pavements, Nai C. Yang, McGraw Hill Publications
7. Design codes IRC 81-1997, IRC 1

Second Semester	Traffic Engineering and Management	L	T	P	Credits
		3	0	0	3

UNIT-I

Basic traffic stream characteristics: Speed, flow and density, Relationship between Speed, Flow and density; Volume Studies - Objectives, Methods; Speed studies - Objectives: Definition of Spot Speed, time mean speed and space mean speed.

UNIT-II

Traffic measurement procedures: Measurement at a Point (Volume data collection and analysis, PCU, PHF etc), Measurement over a Short Section (Speed data collection and analysis), Measurement along a Length of Road (Density and travel time measurement and analysis), Moving Observer Method, Traffic forecasting and growth studies. Microscopic traffic flow modeling: Car Following Models: Linear models, Car Following Models: Non-linear models, Lane Changing Models, Microscopic Traffic Simulation.

UNIT-III

Parking Studies and Analysis: Types of parking facilities - on street parking and off-street Parking facilities; Parking studies and analysis. Traffic Safety: Accident studies and analysis; Causes of accidents; Engineering, Enforcement and Education measures for the prevention of accidents, Road safety audit.

UNIT-IV

Traffic intersection control: Principles of Traffic Control and Traffic Signs, Road Markings and Channelization, Uncontrolled Intersection: Gap acceptance and capacity concepts, Uncontrolled Intersection: Capacity and LOS analysis, Traffic Rotaries and Grade Separated
Intersection, Basic definitions related to capacity; Factors affecting capacity and level of service; Computation of capacity and level of service for two lane highways Multilane highways and freeways.

UNIT-V

Traffic Control and Regulation: Design Principles of Traffic Signal, Evaluation of a Traffic Signal: Delay Models, Capacity and LOS Analysis of a Signalized I/S, Coordinated Traffic Signal, Vehicle Actuated Signals and Area Traffic Control.

UNIT-VI:

Traffic Management: Area Traffic Management System – Traffic System Management (TSM) with IRC standards -Traffic Regulatory Measures-Travel Demand Management (TDM) – Direct and indirect methods -Congestion and parking pricing – All segregation methods- Coordination among different agencies – Intelligent Transport System for traffic management, enforcement and education.

Recommended Books

1. Traffic Engineering and Transportation Planning by L.R. Kadiyali, Khanna Publishers, 2011.
2. Traffic Engineering by Roger P. Roess, Elena S. Prassas and William R. McShane, Prentice Hall, 4th edition, 2010.
3. Traffic & Highway Engineering by Nicholas J Garber, Lester A Hoel, Third edition, Bill, 2011
4. Fundamentals of Transportation Engineering C. S. Papa Costas and P. D Prevedouros, Prentice-Hall, New Delhi, 2009.
5. Introductions to Traffic Engineering: A Manual for Data Collection and Analysis, Thomas R.Currin, Brooks/Cole Thomason Learning, Canada, 2001. Design codes: IRC: SP: 41-1994, IRC SP: 31-1992, IRC 43-1994, Indian Roads Congress, New Delhi., Highway Capacity Manual 2010, Transportation Research Board, Indo-HCM, CSIR- CRRI, 2017, New Delhi. 15 -2014 and IRC SP 76-2008.

Second Semester	Traffic Flow Analysis	L	T	P	Credits
		3	0	0	3

UNIT - I

Traffic Flow Description: Traffic Stream Characteristics and Description Using Distributions; Measurement, Microscopic and Macroscopic Study of Traffic Stream Characteristics - Flow, Speed and Concentration; Use of Counting, Interval and Translated Distributions for Describing Vehicle Arrivals, Headways, Speeds, Gaps and Lags; Fitting of Distributions, Goodness of Fit Tests.

UNIT – II

Traffic Stream Models: Fundamental Equation of Traffic Flow; Speed-Flow-Concentration Relationships, Normalized Relationship, Fluid Flow Analogy Approach; Shock Wave Theory – Flow-Density diagram use in Shockwave analysis; Use of Time-space diagram for shockwave description; Bottleneck situations and shockwaves; Traffic signal and shockwave theory; Numerical examples for application of shockwave theory; Car-Following Theory.

UNIT – III

Queuing Theory: Fundamentals of Queuing Theory - Demand Service Characteristics- Deterministic Queuing Models - Stochastic Queuing Models - Multiple Service Channels,

UNIT – IV

Queuing Analysis: Analysis of M/M/1 system; Assumptions and Derivation of System State Equations; Application of M/M/1 analysis for parking and Toll Plazas- Numerical Examples; Analysis of D/D/1 system for delay characteristics; Traffic Signal analysis as D/D/1 system; Computation of delays and queue dissipation Time – Numerical Examples.

UNIT – V

Pedestrian Delays and Gaps: Pedestrian Gap acceptance and delays; Concept of Blocks, Anti-blocks, Gaps and Non-Gaps; Underwood's analysis for Pedestrian Delays; Warrants for Pedestrian Crossing Facilities – Minimum Vehicular Volume Warrant, Minimum Pedestrian Volume Warrant, Maximum Pedestrian Volume Warrant.

UNIT – VI

Simulation of Traffic: Introduction - Advantages of Simulation techniques; Steps in Simulation - Scanning techniques - Example of Simulation.

Recommended Books

1. Traffic Engineering and Transportation Planning by L.R. Kadiyali, Khanna Publishers, 2011.
2. Fundamentals of Transportation Engineering – C. S. Papacostas, Prentice Hall India Publication
3. Traffic Flow Theory: A Monograph, TRB Special Report
4. Principles of Highway Engineering and Traffic Analysis – F. L. Mannering & W. P. Kilareski, John Wiley Publishers.
5. Traffic Flow Fundamentals – A. D. May, Prentice Hall India Publication
6. Coleman A. O 'Flaherty, Transport Planning and Traffic Engineering, Butterworth Heinemann, 2009.

ELECTIVE-3	Planning and Design of Airports	L	T	P	Credits
		3	0	0	3

UNIT I

General: History, development, policy of air transport, aircrafts, aerodromes, air transport authorities, air transport activities, air crafts and its characteristics, airport classifications as per ICAO.

UNIT II

Airport Planning: General- Regional Planning- Development of New Airport- Data Required before Site Selection- Airport Site Selection- Surveys for Site Selection- Drawings to be prepared- Estimation of Future Air Traffic Needs.

UNIT - III

Runway Design: Runway Orientation- Basic Runway Length- Corrections for Elevation, Temperature and Gradient- Airport Classification- Runway Geometric Design- Airport Capacity- Runway Configurations- Runway Intersection Design.

UNIT - IV

Structural Design of Airport Pavements: Introduction- Various Design Factors- Design Methods for Flexible Pavement- Design Methods for Rigid Pavement- LCN System of Pavement Design- Joints in Cement Concrete Pavement- Airport Pavement Overlays- Design of an Overlay.

UNIT - V

Air Traffic Control and Visual Aids: Air traffic control objectives, control system, control network-visual aids-landing information system, airport markings and lighting.

UNIT - VI

Airport Grading and Drainage: General- Computation of Earthwork- Airport Drainage- Special Characteristics and Requirements of Airport Drainage- Design Data- Surface Drainage Design, Subsurface Drainage Design.

Recommended Books

1. Planning and Design of Airports By Robert M. Horonjeff, Francis X. McKelvey, William J Sproule, Seth B Young, 5 th edition, Mc-Graw Hill, 20010
2. Airport Engineering: Planning, Design, and Development of 21st Century Airports, 4th Edition by Norman J. Ashford, Saleh Mumayiz, Paul H. Wright
3. Airport Planning and Designing by S.K. Khanna, M.G. Arora.

4. Highway Engineering including Expressways and Airport Engineering by Dr. L. R. Kadayali, Dr. N. B. Lal.
5. Highway Engineering including Airport Pavements by Dr. S. K. Sharma.

ELECTIVE-3	Pavement Construction, Maintenance and Management	L	T	P	Credits
		3	0	0	3

UNIT I:

Construction of Embankment, Subgrade, Subbase and Base Layers: Construction of embankment and subgrade, Importance of compaction, gradation for Granular Subbase and Granular Base, mix design and construction of granular subbase and base, construction of Shoulders and drains. Construction cement treated subbases and bases, use of Geosynthetic materials in pavement construction.

UNIT II:

Construction of Bituminous layers: Different types of bituminous concretes - Bituminous Macadam, Penetration Macadam, Built- up Spray Grout, Open Graded Premix, Mix Seal Surface, Semi-Dense Bituminous Macadam (DBM) and Bituminous Concrete (BC). Construction of DBM and BC layers, quality control.

UNIT III:

Construction of Cement Concrete layers: Construction of Dry Lean Concrete (DLC) and Pavement Quality Concrete (PQC) Layers, Manual and Mechanical Methods, Different types of Joints in Cement Concrete pavement and their construction, Joint compounds.

UNIT IV:

Introduction to Pavement Maintenance: Importance of pavement Maintenance, collection of pavement condition data – manual and using NSV vehicle, Serviceability Concepts; Visual Rating; Pavement Serviceability Index; Roughness Measurements, functional and structural evaluation of pavements, Skid Resistance, Roughness, Safety – Aspects.

UNIT V:

Maintenance of Bituminous Concrete and Cement Concrete Pavements:

Causes of bituminous and concrete pavement Deterioration, Traffic and Environmental Factors, different types of distresses on pavements, treatments to the distresses, recycling and different methods of recycling, Profile Correction Course.

UNIT- VI

Pavement management system: Components of PMS and their activities; Major steps in implementing PMS; HDM packages; Pavement Maintenance Management Components of

Maintenance Management and Related Activities – Network and Project Level Analysis; Prioritization Techniques and Formulation of Maintenance Strategies.

Recommended Books

1. Construction Planning Equipment and Method, Peurifoy R. L., and Clifford J. S., McGrawHill Book Co.
2. Hot Mix Asphalt Materials, Mixture Design and Construction, Freddy L. Roberts, Prithvi S. Kandhal et al, (2nd Edition), National Asphalt Pavement Association Research and Education Foundation, Maryland, USA.
3. Construction Equipment and its Management, Sharma S. C. Khanna Publishers.
4. Hot Mix Asphalt Paving Handbook, National Asphalt Pavement Association, 5100 Forbes Boulevard, Lanhm, Mary Land, USA
5. MoRTH – V Edition, Manual for Construction and Supervision of Bituminous Works, 2013, Indian Roads Congress

   Various IRC Codes: IRC:15-2017, IRC SP :11-1984, IRC 57-2018, IRC 58-2015, IRC 19-2005, IRC 27-2009, IRC 29-1988, IRC 34-2011, IRC 36-2010, IRC 48-1972, IRC 63-1976, IRC 68-1976, IRC 81-1997, IRC 82-2015, IRC 93- 1985, IRC 94-1986, IRC 95-1987, IRC 98-2011, IRC 105-2019.

Elective 3	Intelligent Transportation Systems	L	T	P	Credits
		3	0	0	3

UNIT-I

Introduction To ITS: System Architecture, Standards, Database – Tracking Database – Commercial Vehicle Operations – Intelligent Vehicle Initiative - Metropolitan ITS – Rural ITS – ITS for Rail network.

UNIT-II

ITS Travel Management: Autonomous Route Guidance System – Infrastructure based systems – Telecommunications – Vehicle – Road side communication – Vehicle Positioning System – RFID System, Electronic Toll Collection – Electronic Car Parking

UNIT-III

ITS Designs: Modeling and Simulation Techniques - Peer – to – Peer Program – ITS for Road Network – System Design – Mobile Navigation Assistant – Traffic Information Center – Public Safety Program.

UNIT-IV

Automated Highway Systems: Evolution of AHS and Current Vehicle Trends - Vehicles in Platoons,Automatic Vehicle Classification System(AVCS)
– Aerodynamic Benefits - Integration of Automated Highway Systems – System Configurations - Step by Step to an Automated Highway System.

UNIT-V

Spacing and Capacity for Different AHS Concepts – Communication Technologies for AHS – The Effects of AHS on the Environment – Regional Mobility - Impact Assessment of Highway Automation.

UNIT-VI

Implementation of ITS: ITS programs globally- overview of ITS in developed countries and developing countries

Recommended Books

1. ITS Hand Book 2000: Recommendations for World Road Association (PIARC) by Kan Paul Chen, John Miles.
2. Intelligent Transport Systems – Cases and Policies by Roger R. Stough, Publisher: Edward Elgar, 2001.

3. Intermodal Freight Transport by David Lowe, Elsevier Butterworth-Heinemann Publishers, 2005
4. Positioning Systems in Intelligent Transportation Systems by Chris Drane and Chris Rizos, Artech House Publishers, London, 2000
5. Perspectives on Intelligent Transport Systems by Joseph M. Sussman, Springer Publishers, 2000
6. Intelligent transport System, Intelligent Transportation primer, Washington, US, 2001.

ELECTIVE-4	Environmental Impacts of Transportation Projects	L	T	P	Credits
		3	0	0	3

UNIT-I

Introduction: Concepts, Objectives, Advantages and Limitations of EIA approach for environmental impact studies economic survey, mitigation measures, clearances required for road projects, Flow chart for obtaining environmental clearance, standards – liquid effluents air quality, noise.

UNIT-II

Environmental and Social Legal Framework: Enforcement agencies-MOEF, CPCB, state pollution control boards, Coastal Management regulatory authority, Central ground water board, key environmental legislations – Environmental act, air acts, forest act, wild life protection act, water acts, coastal zone act, key legislations to road projects-national highways acts, NHAI act, land acquisition act, rehabilitation and resettlement policy, building and construction workers welfare act.

UNIT-III

Environmental clearances: General conditions, procedure for obtaining environmental clearances screening, scoping, public consultation, appraisal, grant or rejection, post environmental clearance monitoring.

Forest and CRZ clearance: Procedure for obtaining clearance forest, CRZ, wild life clearance, other clearance from – state /central water authority, irrigation/water resources dept, archeological dept, permission for quarrying and borrowing operations.

UNIT-IV

Procedure for assessing environmental Impact of Highway projects: Collect information on Exisiting features: Road factors, Terrain, Traffic factors, Land use, Environmental factors; Need for the proposed project: Transportation demand, access, capacity; discuss adverse effects on traffic factors, traffic convenience, environmental and economic; Physical and environmental features of proposed project; length, terrain, land width category of land, displacement of households, cut and fill sections, vegetation, erosion potential, landslide potential, number of major river crossings, utilities to be relocated, air quality and estimated cost.

UNIT-IV

Impact of the selected alternative on environment and proposed mitigation measures: Land acquisition, highway location, highway alignment, highway cross section, erosion control, drainage, vegetation, traffic movement, construction, traffic noise and vibration, air and water quality; overall assessment of selective alternative: positive and negative impacts.

SEMESTER WISE COURSE STRUCTURE

First Semester

Subject Code	Subject Name	L-T-P	Credits	Marks Weightage		Course Type
				Internal	External	
21TE1101	Geometric Design of Transportation Facilities	3-0-0	3	40	60	Core-1
21TE1102	Pavement Materials	3-0-0	3	40	60	Core-2
21TE11XX	Urban Transportation Planning	3-0-0	3	40	60	Core-3
21TE11XX	Discipline Specific Elective - 1	3-0-0	3	40	60	Programme Elective - 1
21TE11XX	Discipline Specific Elective - 2	3-0-0	3	40	60	Programme Elective - 2
21TE1181	Pavement Engineering Laboratory - 1	0-0-3	1	50	50	Core
21TE1182	Geometric Design of Transportation Facilities Laboratory	0-0-3	1	50	50	Core
21TE1172	Seminar-I	0-0-3	1	50	50	Core
	Total	**16-0-9**	**18**			

List of Discipline Specific Elective -1

1) Geo-technical Investigations and Ground Improvement Techniques
2) Road Safety
3) Transit Planning and Operations

List of Discipline Specific Elective -2

1) Probability and Statistics
2) Research Methodology and IPR
3) Project Planning and Management

Second Semester

Subject Code	Subject Name	L-T-P	Credits	Marks Weightage		Course Type
				Internal	External	
21TE1203	Pavement Analysis and Design	3-0-0	3	40	60	Core-4
21TE1203	Traffic Engineering and Management	3-0-0	3	40	60	Core-5
21TE12XX	Intelligent Transportation Systems	3-0-0	3	40	60	Core-6
21TE12XX	Discipline Specific Elective - 3	3-0-0	3	40	60	Programme Elective - 3
21TE12XX	Discipline Specific Elective - 4	3-0-0	3	40	60	Programme Elective - 4
21TE1283	Pavement Engineering Laboratory -2	0-0-3	1	50	50	Core
21TE1284	Traffic Engineering Laboratory	0-0-3	1	50	50	Core
21TE12XX	Seminar-II	0-0-3	1	50	50	Core
	Total	**17-0-6**	**18**			

List of Discipline Specific Elective -3

1) Planning and Design of Airports
2) Pavement Construction, Maintenance and Management
3) Traffic Flow Analysis

List of Discipline Specific Elective -4

1) Environmental Impacts of Transportation Projects
2) GIS and Remote Sensing
3) Highway bridges and flyovers

Third Semester

Subject Code	Subject Name	L-T-P	Credits	Marks Weightage		Course Type
				Internal	External	
21TE2191	Dissertation – part 1	0-0-32	8	180	420	Dissertation
21TE21XX	MOOC-I		3			
21TE21XX	MOOC-II		3			

21TE21XX	Comprehensive viva		2			
	Total	**4-0-32**	**16**			

Fourth Semester

Subject Code	Subject Name	L-T-P	Credits	Marks Weightage		Course Type
				Internal	External	
21TE2292	Dissertation – part 2	0-0-32	16	180	420	Dissertation
	Total	**0-0-32**	**16**			

<u>Total Credits for the programme = 18 + 18 +16 +16 = **68**</u>

First Semester	Geometric Design of Transportation Facilities	L	T	P	Credits
		3	0	0	3

UNIT – I

Highway System and alignment: Introduction, Functional Classification of Highway System, factors controlling alignment, Obligatory points, Engineering surveys for Highway alignment. Highway Design Controls: Design Speed, Topography, Traffic, Capacity and LOS. Cross Section Elements: Typical Cross Sections of Roads, Pavement Surface Characteristics, Factors affecting skid resistance, Pavement Unevenness, IRI, Camber, Providing camber in the field, Width of carriageway, Design Vehicle, Medians, Kerbs, Road Margins, Right of Way.

UNIT – II

Sight Distances: Sight Distances, Stopping Sight Distance, Overtaking Sight distance, Analysis of Overtaking Sight distance, Effect of grade on sight distances, Overtaking zone, Intermediate sight distance, Sight distance at intersections.

UNIT – III

Horizontal Alignment: Design speed, Horizontal curves, Super elevation, widening of pavement on horizontal curves, Different types of Transition curves, Methods of introducing extra widening , length of transition curve, setting out of transition curve, Set-back distance on horizontal curves, Geometric specifications of 2-lane, 4-lane, 6-lane and Expressways.

UNIT - IV

Vertical Alignment: Introduction, Gradients, Compensation in gradient on horizontal curves, Vertical curves, Summit curve, Length of summit curve, Valley Curve, Length of valley curve, Combination of Vertical and Horizontal Curves. Relevant IRC standards for Urban and Rural roads.

UNIT - V

Geometric Design of Intersections: Types of Intersections; Design Principles for Intersections; Design of At-grade Intersections – Channelization, Objectives; Traffic Islands and Design standards; Rotary Intersection – Concept, Advantages and Disadvantages; Grade separated Interchanges – Types, warrants and Design standards.

UNIT – VI

Other Facilities on Highway: Requirements of Pedestrians; Pedestrian facilities on Urban Roads; Cycle Tracks – Guidelines and Design standards; Bus bays – Types and Guide lines; Design of On-street and Off-street Parking facilities – Guidelines for lay out Design.

Recommended Books

1) AASHO, "A Policy on Geometric Design of Highways and Streets', American Association of State Highway and Transportation Officials, Washington D.C.
2) Principles of Transportation Engineering by Chakraborty & Das, Prentice Hall, India.
3) Principles and Practice of Highway Engineering, L.R.Kadiyali and N.B.Lal, Khanna, 2007.
4) Jack E Leish and Associates, `Planning and Design Guide: At-Grade Intersections', Illinios.
5) O'Flaherty, A. Coleman, "Highways: The Location, Design, Construction and Maintenance of Road Pavements", 4th Edition, Elsevier, 2006.
6) Design codes IRC 38 – 1988, IRC 52 – 2019, IRC 73-1990, IRC 86-2018, IRC: SP: 41-1994, IRC SP: 31-1992,
7) *Indian Highway Capacity Manual* (Indo-*HCM*), 2017

RAJIV GANDHI UNIVERSITY OF KNOWLEDGE TECHNOLOGIES, ANDHRA PRADESH, INDIA
CIVIL ENGINEERING DEPARTMENT
Course Structure and Syllabus for M. Tech in Transportation Engineering

First Semester	Pavement Materials	L	T	P	Credits
		3	0	0	3

UNIT I

Sub- grade Soil Characterization: Embankment and Subgrade, Properties of sub-grade layer, Soil Classification: Index and other basic properties of soil, different laboratory, and in-situ procedures for evaluating the mechanical properties of soils viz. SPT, DCPT, CPT, CBR, Plate Load test & resilient modulus; Suitability of different type of soil for the construction of highway subgrade; Field compaction and quality control.

UNIT II

Introduction to Soil Stabilization: Mechanical Stabilization, Chemical modification: Stabilization with admixtures like cement, lime, and fly ash. Stabilization with non-conventional stabilizers (liquid and powder-based), strength and durability tests on stabilized materials, stabilized materials for base layers, Geo textiles and geo grids.

UNIT III

Aggregate Characterization: Origin, Classification, Types of aggregates; Sampling of aggregates; Mechanical and shape properties of aggregates, Aggregate texture, and skid resistance, polishing of aggregates; Proportioning and Blending of aggregates: Super pave gradation, Fuller and Thompson's Equation, 0.45 power maximum density graph; Use of locally available materials in lieu of aggregates. Design of WMM and GSB mixes.

UNIT IV

Bituminous Materials: Bitumen sources and manufacturing, Chemistry of bitumen, Rheology of bitumen, grading of bitumen: Penetration, Viscosity and Performance Granding, Creep test, stiffness modulus of bitumen mixes using shell nomographs. Modified bitumen: Crumb Rubber Modified bitumen, Natural rubber modified bitumen, polymer modified bitumen; Introduction to emulsified bitumen and its characterization; Long-term and short-term ageing and its effect on bitumen performance, Tests to simulate ageing of bitumen viz. RTFOT and PAV.

UNIT V

Design of bituminous mixes: Desirable properties of bituminous mixes, Marshall's Mix design, importance of volumetric properties, super pave mix design procedure, testing of bituminous mixes; fatigue, resilient modulus, rutting.

UNIT VI

Cement and Cement Concrete Mixes: Types of cements and basic cement properties, Tests on cement concrete including compressive strength, flexural strength, modulus of elasticity and fatigue properties; Introduction to advanced concretes like self-compacted concrete, Light weight concrete, Roller Compacted Concrete for pavement application; IS method of cement concrete mix design;

Role of different admixtures in cement concrete performance; Joint filers for Jointed Plain Cement Concrete Pavements and their characterization.

Recommended Books

1. Highway Materials by Kerbs Robert D. and Richard D. Walker, McGraw-Hill.
2. Highway Materials, Soils and Concretes by Atkins, N. Harold, Fourth Edition, 1980, Prentice-Hall.
3. Asphalt Institute. Mix Design Methods – For Asphalt Concrete and Other Hot-Mix Types Manual Series No. 2 (MS-2), Asphalt Institute, Kentucky, USA, 1997. 2.
4. Ministry of Road Transport and Highways (MoRTH), Specifications for Road and Bridge Works, Fifth Revision, Indian Roads Congress, New Delhi, India
5. "The Shell Bitumen Handbook", by Read, J. And Whiteoak, D., Fifth edition, Shell Bitumen, Thomas, Telford Publishing, London 2003 4
6. Mallick, R.B. and T. El-Korchi Pavement Engineering – Principles and Practice, CRC Press, Taylor and Francis Group, Florida, USA, 2009
7. Asphalt Institute. Mix Design Methods – For Asphalt Concrete and Other Hot-Mix Types Manual Series No. 2 (MS-2), 7th Edition, Asphalt Institute, Kentucky, USA, 1997.
8. Design Codes IRC 15 – 2017, IRC 44-2017, IRC SP89-1-2010, IRC SP89-2-2018, IRC 88-1988, IRC 113-2013, IRC 49 -1973, IRC 50 -1973 and IRC 51 -1992.

First Semester	Urban Transportation Planning	L	T	P	Credits
		3	0	0	3

UNIT I

Urban Transportation Planning: Goals and objectives - Hierarchical levels of Transportation planning - Forecast - Implementation - Constraints. UTP survey – Inventory of land use, Introduction of classical four stage modeling. Zonal Classifications.

UNIT II

Data Collection and Inventories: Collection of data – Organization of surveys and Analysis, Study Area, Zoning, Types and Sources of Data, Road Side Interviews, Home Interview Surveys, Commercial Vehicle Surveys, Sampling Techniques, Expansion Factors, Accuracy Checks, Use of Secondary Sources, Economic data – Income – Population – Employment – Vehicle Owner Ship.

UNIT III

Trip Generation and Trip Distribution: Trip classification - productions and attractions - Multiple regression models - Category analysis - Trip production models - Trip distribution models – Linear programming approach.

UNIT IV

Mode Split and Traffic Assignments: Behavioral models - Probabilistic models - Utility functions – logit models - Two stage model. Traffic assignment - Assignment methods - Route choice behavior - Network analysis.

UNIT V

Land-Use and its Interaction: Lowry derivative models - Quick response techniques – non-transport solutions for transport problems, Characteristics of urban structure, Town planning concepts.

UNIT VI

Applications of UTP: Preparation of alternative plans - Evaluation techniques - Plan implementation – Monitoring - Case studies.

Recommended Books:

1. Principles of Urban Transportation System Planning by Hutchinson, B.G., McGraw Hill, 1974.
2. An Introduction to Transportation Planning (The Living Environment) by Bruton, M. J., UCL Press, London, UK, 2000

3. Transportation Engineering by C.J. Khisty and B. Kent Lall, Prentice Hall of India Pvt. Ltd., 2002.
4. Transportation Engineering and Planning by C.S. Papacostas and P.D. Prevedouros, Prentice Hall of India Pvt. Ltd., 2001.
5. Metropolitan Transportation Planning by Dicky J.W.,Script Book Co., Washington, D.C., 1975

ELECTIVE-1	Geotechnical Investigations and Ground Improvement Techniques	L	T	P	Credits
		3	0	0	3

UNIT I

Soil investigation and Methods: Soil investigation Programme for different Civil Engineering Projects, investigation Methods: Methods of Boring, Auguring and Drilling. Machinery used for drilling, types of augers and their usage for various projects.

UNIT II

Soil Sampling and Bore Logging: Sampling methods, types of samples, storage of samples and their transport, sample preparation and sample sizes, various tests on soil samples specifications for testing. Borehole Logging: Logging of Boreholes-logging methods- Ground water observations – water table fluctuations and effects - Preparation of soil profiles – calculations.

UNIT III

Field testing of soils and Reports: Methods and specifications – visual identification tests, vane shear test, penetration tests, analysis of test results, soil testing reports: analysis, identification, and preparation.

UNIT IV

Introduction to ground improvement techniques: Engineering properties of soft – weak and compressible deposits – problems associated with weak deposit – Requirements of ground improvements – introduction to engineering ground modification, need and objectives.

UNIT V

Recent Ground improvement techniques: stabilization using industrial waste – modification by inclusion and confinement – soil nailing – stone column – compaction piles – dynamic compaction – prefabricated vertical drains – preloading – electro – osmosis – soil freezing vacuum consolidation – deep explosion – dry powdered polymers - enzymes

UNIT VI

Soil reinforcement: Historical background, Concept of reinforced earth – Mechanisms – Types of reinforcements – Soil – Reinforcement – Interaction studies – Internal & External stability criteria – Design Principles of steep reinforced soil slops – pavements – Embankments on soft soils.

Recommended Books

1. Hausmann, M.R., Engineering Principles of Ground Modification, McGraw – Hill International Editions, 1990.
2. Purushotham Raj, Ground Improvement Techniques, Laxmi Publications, New Delhi
3. Sharma.S.K., Priniciples, Practice and Design of Highway Engineering, S.Chand & Co. New Delhi,1985.
4. Jones C. J. F. P, Earth Reinforcement and Soil Structures, Butterworths, London.
5. Basic and Applied Soil Mechanics- A.S. Rao and Gopal Ranjan, New Age International.
6. Construction and Geotechnical Methods in Foundation Engineering By R.M. Koerner, McGraw – Hill Book Co.
7. Current Practices in Geotechnical Engineering Vol.1, Alam Singh and Joshi, International Book Traders, Delhi, & Geo- Environ Academia

ELECTIVE-1	Road Safety	L	T	P	Credits
		3	0	0	3

UNIT I:

Safety in Road Design: Operating the road network for safety, highway operation and counter measures, road safety audit, principles – procedures and practice, code of good practice and checklist, vehicle design factors, driver and Friction characteristics influencing road safety.

UNIT II

Road Accidents: Causes, Scientific investigations and data collection, Analysis of individual accidents to arrive at real causes, Basic concepts of Road accident statistics, safety performance function: the empirical Bayes method Identification of Hazards Road location. Application of computer analysis of accident.

UNIT III

Statistical Interpretation and Analysis of Crash Data: Before-after methods in crash analysis, Recording of crash data; Accident Investigation and Analysis; Statistical testing and the role of chance; Black Spot Identification and Investigations, Case Studies

UNIT IV

Road Safety Audits: Key elements of a road safety audit, Road Safety Audits & Investigations, Work zone safety audit; Crash investigation and analysis, Methods for identifying hazardous road locations, Case Studies.

UNIT V

Mitigation Measures: Accident prevention by better planning, Accident prevention by better design of roads, Crash Countermeasures, Highway operation and accident control measures, Highway Safety Measures during construction, Highway geometry and safety; Safety in urban areas; Public transport and safety; Road safety policy making, Stakeholder's involvement; Road safety law.

UNIT VI

Road Signs and Traffic Signals: Classifications, location of signs, measures of sign effectiveness, Types of visual perception, sign regulations, sign visibility sign variables, text versus symbols. Road Markings: Role of Road marking, classification, visibility. Traffic Signals need, signal face, Illumination and location of signals, factors affecting signal design, pedestrian safety, fixed and vehicle actuated signals, Design of signals, Area Traffic control. Delineators, Traffic Impact Attenuators, Road Side rest areas, safety Barriers, Traffic Aid Posts.

Recommended Books

1. AthelstanPopkess, Traffic Control and Road Accident Prevention, Chapman and Hall, 1997 (Digitized 2008)
2. Ezra Hauer, Observational Before-After Studies in Road Safety, Pergamon Press, 1997 (reprinted 2002).
3. Geetam Tiwari and Dinesh Mohan, Transport Planning and Traffic Safety: Making Cities, Roads, and Vehicles Safer, CRC Press, 2016.
4. Institute of Transportation Engineers (ITE), The Traffic Safety Toolbox: A Primer on Traffic Safety, ITE, 1999.
5. J. Stannard Baker, Traffic Collision Investigation, Northwestern University Center for Public Safety, 2002.
6. Traffic Control and Road Accident Prevention by Popkess C.A.Chapman and Hall, 1997

ELECTIVE-1	Transit Planning and Operations	L	T	P	Credits
		3	0	0	3

UNIT-I

Transit System and Issues: Introduction to Mass Transport – Role of various modes of Mass Transport – Problems and their Impact – System Characteristics: Technological Characteristics – Resistances, acceleration & velocity Profiles – Operational characteristics speed, capacity & payloads – Route capacity – Comfort conditions - Performance relationships - Public and Private Operations - Modes for Intercity Transport System Performance at National, State, Local and International levels

UNIT-II

Public Transit System: Urban Transport System – Public Transport System Re-genesis and Technology – Physical performance of Public Transport System – Public Transport and Urban Development Strategies - Characteristics of Rail Transit – Vehicle Characteristics, ITS, Para transit systems – Intermediate Public Transport.

UNIT-III

Mass Transit Corridor Identification & Planning: Corridor identification – Network Compression Method - Planning of Rapid Transit System - System Selection - Supporting and Enclosing Structures - System Evaluation - Track Structures - Power Supply and Distribution - Signal System – Aesthetics and Noise Consideration - Cost of Construction - Station Arrangements - Platform Capacity - Fare Collection, Transit Marketing.

UNIT-IV

Bus Transit Planning and Scheduling: Route Location, Route Structure, Route Coding Techniques, Route Capacity - Planning of Transit Network - Different Types - Service Area Coverage - Evaluation - Selection of Optimal Network - Path Building Criteria - Route Planning and Scheduling – Bus Transport System – Performance and Evaluation – Scheduling – Conceptual patterns of bus service – Network Planning and Analysis – Bus Transport System Pricing – Bus Transit System Integration – Analytical Tools and Techniques for Operation and Management – Bus Rapid Transit Systems.

UNIT-V

Rail Transit Terminals and Performance Evaluation: Performance Evaluation – Efficiency, Capacity, Productivity and Utilization – Performance Evaluation Techniques and Application – System Network Performance – Transit Terminal Planning and Design Urban Rail Transit Planning – MRTS – LRTS, Metro Rail – Monorail – Network Design, Capacity and Traffic Fore casting

UNIT-VI

Impact of Transit: Policies and Strategies for Mass Transport – Need for Integrated Approach – Unified Transport Authorities – Institutional arrangement – Urban Transport Fund – Parking Policies - Private Sector in Mass Transport – Bus and Rail Integration – Co-ordination of Feeder Services – Transit Oriented Land Use Development – Case Studies - Urban Transportation and Land use – Impact of Transport Development on Environment – Remedial measures – Policy Decisions – Recent Trends in Mass Transportation Planning and Management.

Recommended Books

1) Black, Urban Mass Transport Planning, McGraw Hill
2) V. R. Vuchic, Urban Public Transport System and Technology, Prentice Hall Inc.
3) Fundamentals of Transportation Engineering – C. S. Papacostas, Prentice-Hall India Publication
4) G. E. Gray and C. A. Hoel: Public Transport Planning Operation and Management, Prentice Hall
5) White P. R., Planning for Public Transport, UCL Press Ltd.

ELECTIVE-2	Probability and Statistics	L	T	P	Credits
		3	0	0	3

Unit - I

Permutations and Combinations, Probability introduction through Sets and Relative Frequency, Experiments and Sample Spaces, Discrete and Continuous Sample Spaces, Events, Probability Definitions and Axioms, Mathematical Model of Experiments, Probability as a Relative Frequency, Joint Probability, Conditional Probability, Total Probability, Bayes' Theorem, and Independent Events.

Unit - II

Random Variable, Bivariate random variable, Mathematical Expectation, Discrete Probability Distributions, Continuous Probability Distributions, Functions of Random Variables, Correlation coefficient and Bivariate Normal Distribution.

Unit - III

Definition of population, sampling, statistics, and parameters. Types of sampling, expected values of sample mean and variance, sampling distribution, standard error, sampling distribution of mean and sampling distribution of variance.

Unit- IV

Sampling -Distributions (t, F and Chi-square), confidence interval and interval estimation.

Unit – V

Definition of Null and alternative hypothesis, critical region. Type I and II errors, power of the test, one tail, two tail tests, Tests for the single mean, two means, single proportion and two proportions using Z-test and t-test, tests significance of difference in variances.

Unit -VI

Chi-square test for goodness of fit, ANOVA for one-way and two-way classified data.

Recommended Books

1. William W. Hines and Douglas C. Montgomery, 'Probability and Statistics in Engineering', Willy Publications, 4th Edition.
2. Sheldon Ross, 'A First Course in Probability', Pearson Publications, 9th Edition.
3. Athanasios Papoulis and S. Unnikrishna Pillai, 'Probability, Random Variables and Stochastic Processes', TMH, 4th Edition.

ELECTIVE-2	Research Methodology & IPR	L	T	P	Credits
		3	0	0	3

Unit I

Introduction: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit II

Literature studies and Analysis: Effective literature studies approaches, analysis Plagiarism, Research ethics

Unit III

Writing research proposal: Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit IV

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit V

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit VI

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

References:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"

2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall, "Industrial Design", McGraw Hill, 1992.
6. Niebel, "Product Design", McGraw Hill, 1974.
7. Asimov, "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

ELECTIVE-2	Project Planning and Management	L	T	P	Credits
		3	0	0	3

UNIT I

Introduction: Project Planning, Need of Project Planning, Objectives and functions, stages in construction, Process of development of plans and schedules, work break-down structure, activity lists, assessment of work content, estimating durations, sequence of activities, activity utility data.

UNIT II

Stages of project planning: Pre-tender planning, pre-construction planning, detailed construction planning, role of client and contractor, level of detail, application of MS-Project and PrimaVera for project planning.

UNIT III

Project Costing and Budgeting: Classification of costs, time cost trade-off in construction projects, Compression and decompression. Preparing budgets, master networks.

UNIT- IV

Introduction to Project Management: A systems Approach, Systems Theory and Concepts, Organisation, Management Fuctions, Overview of Management Objectives, Tools and Techniques, Project Management, Processes and Organizational Structures, Team Management, Project Manager as a Team Leader, Leadership qualities, PMIS.

UNIT-V

Construction Cost and Value Engineering: Types of Estimates, Implementation of Cost Controls, Project Cost Forecasting, Cost optimization and Resources Planning – Value Engineering, Techniques for Project Selection, Break-Even Analysis, Cost Modelling, Energy Modelling, Life Cycle Cost Approach.

UNIT-VI

Project Scheduling and Analysis Methods: Methods of scheduling, CPM, PERT, bar charts, limitations of bar charts, milestone charts, preparation of material, equipment, labour and finance schedule, linear programming, queuing concept, simulation, bidding models, game theory.

References:

1. Herold Kerzer- Project Management – Asystems approach to Planing, Scheduling and Controlling. CBS Publishers and Distributors.

2. L.Waker A Teraih and Jose M.Grevarn; Fundamentals of Construction Management and Organisations.

3. Anghel petterson – Construction Cost Engineering Handbook- Marcel Dekken Inc.

4. Dell Isola- Value Engineering in Construction Industry, Van Nostrand Reinhold Co.,

5. Choudhary, S. Project Management, Tata McGraw Hill Publishing Co., Ltd

6. Raina UK, Construction management Practices, Tata McGraw Hill Publishing Co., Ltd

7. Sengupta B and Guha H, Construction Management and Planning, Tata McGraw Hill Publishing Company Limited, New Delhi.

8. Prasanna Chandra (1986); "Project preparation, appraisal, budgeting and implementation", Tata McGraw Hill. ISBN13: 978-0074516287.543p.

9. Gregory T. Haugan (2002); "Construction Project Management", Tata McGraw Hill, ISBN 13:9781567261363.102p.

10. Chitkara K K (1998); " Construction Project Management", Tata McGraw Hill, ISBN 13:9780074620625, 558P.

11. Barrie D.S & Paulson B C (1992); "Professional Construction Management", McGraw Hill, ISBN: 13 9780070038899.577p.

12. Harold R. Kerzner (2013); " Project management: A System approach to planning, scheduling and controlling" John Wiley & Sons.

First Semester	Pavement Engineering Laboratory -1	L	T	P	Credits
		0	0	3	1.5

1. Tests on Aggregates - Aggregate Impact Test and Los Angeles Abrasion Test
2. Tests on Aggregates - Crushing strength of Aggregates and Specific Gravity & Water Absorption
3. Tests on Aggregates - Soundness and stripping value
4. Tests on Bitumen – Penetration and softening point
5. Tests on Bitumen – Viscosity Grading of bitumen
6. Mix design for granular sub base layers and determining OMC & CBR
7. Permeability test on granular subbase material
8. Mix design for granular base layer and determining OMC & CBR
9. Cement treated sub base mixes and testing
10. Cement treated base mixes and testing

Recommended Text Books

1. Highway materials and pavement testing by Khanna, S.K., Justo, C.E.G., and A. Veeraragavan, 5th edition, Nem chand and brothers, Roorkee, India, 2009.
2. Huang, Y.H. Pavement Analysis and Design, Pearson Prentice Hall, New Jersey, USA, 2004.
3. Relevant IS, IRC, ASTM Codes.

First Semester	Geometric Design of Transportation Facilities Laboratory	L	T	P	Credits
		0	0	3	1.5

1. Topographic survey of an existing alignment
2. Importing topographic data in any geometric design software
3. Design of Horizontal alignment as per IRC specification
4. Design of Vertical alignment as per IRC specifications
5. Estimation of earth work quantities
6. Development of cross section at different intervals
7. Creating a drive through 3D animation

Recommended Books

1. Bentley MX Road Tutorials
2. Autodesk – Civil 3d Tutorials
3. IRC 38 -1988 – Guidelines for Design of Horizontal Curves for Highways and Design Tables (First Revision)
4. IRC SP 23 – 1993 - Vertical Curves for Highways

Second Semester	Pavement Analysis and Design	L	T	P	Credits
		3	0	0	3

UNIT – I

Factors Affecting Pavement Design: Types of Pavements, Functions of Individual Layers, Variables Considered in Pavement Design, Classification of Axle Types of Rigid Chassis and Articulated Commercial Vehicles, Legal Axle, Tire Pressure, Contact Pressure, EAL and ESWL Concepts, Traffic Analysis: ADT, AADT, Lane Distributions & Vehicle Damage Factors and plate bearing tests, Resilient Modulus, fatigue tests on bitumen mixes.

UNIT - II

Stresses In flexible Pavements: Stress Inducing Factors in Flexible pavements; Stress In Flexible Pavements, Layered Systems Concepts, Stress Solutions for One, Two and Three Layered Systems, Fundamental Design Concepts.

UNIT - III

Stresses in Rigid Pavements: Westergaard's Theory and Assumptions, Stresses due to Curling, Stresses and Deflections due to Loading, Frictional Stresses, calculation of stresses using Picket and Ray charts.

UNIT – IV

Design of Flexible and Rigid Pavements: Design Concepts, Design subgrade CBR, concept of rich DBM layer, Importance of voids in the Mixes, Stepwise procedure for design of Flexible Pavements as per IRC 37:2012.

UNIT – V

Design of Rigid Pavements: Step wise design procedure of Rigid pavement as per IRC 58:2015 guidelines, Design of Dowel Bars & Tie Bars.

UNIT – VI: Design of Bitumen and Concrete Overlays

Design of bitumen pavement Overlays as per IRC 81 procedure, FWD approach for design of bitumen overlays, Design of rigid overlays as per IRC SP76-2008 guidelines.

Recommended Books:

1. Pavement Analysis & Design, Yang H. Huang, Prentice Hall Inc.
2. Principles of Pavement Design, Yoder.J. & Witzac Mathew, W. John Wiley & Sons Inc
3. IRC: 37-2018 Tentative Guidelines for the Design of Flexible Pavements.

4. IRC: 58-2015 Guidelines for Design of Plain Jointed Rigid Pavements for Highways.
5. Concrete Pavements, AF Stock, Elsevier, Applied Science Publishers
6. Design of Functional Pavements, Nai C. Yang, McGraw Hill Publications
7. Design codes IRC 81-1997, IRC 1

Second Semester	Traffic Engineering and Management	L	T	P	Credits
		3	0	0	3

UNIT-I

Basic traffic stream characteristics: Speed, flow and density, Relationship between Speed, Flow and density; Volume Studies - Objectives, Methods; Speed studies - Objectives: Definition of Spot Speed, time mean speed and space mean speed.

UNIT-II

Traffic measurement procedures: Measurement at a Point (Volume data collection and analysis, PCU, PHF etc), Measurement over a Short Section (Speed data collection and analysis), Measurement along a Length of Road (Density and travel time measurement and analysis), Moving Observer Method, Traffic forecasting and growth studies. Microscopic traffic flow modeling: Car Following Models: Linear models, Car Following Models: Non-linear models, Lane Changing Models, Microscopic Traffic Simulation.

UNIT-III

Parking Studies and Analysis: Types of parking facilities - on street parking and off-street Parking facilities; Parking studies and analysis. Traffic Safety: Accident studies and analysis; Causes of accidents; Engineering, Enforcement and Education measures for the prevention of accidents, Road safety audit.

UNIT-IV

Traffic intersection control: Principles of Traffic Control and Traffic Signs, Road Markings and Channelization, Uncontrolled Intersection: Gap acceptance and capacity concepts, Uncontrolled Intersection: Capacity and LOS analysis, Traffic Rotaries and Grade Separated
Intersection, Basic definitions related to capacity; Factors affecting capacity and level of service; Computation of capacity and level of service for two lane highways Multilane highways and freeways.

UNIT-V

Traffic Control and Regulation: Design Principles of Traffic Signal, Evaluation of a Traffic Signal: Delay Models, Capacity and LOS Analysis of a Signalized I/S, Coordinated Traffic Signal, Vehicle Actuated Signals and Area Traffic Control.

UNIT-VI:

Traffic Management: Area Traffic Management System – Traffic System Management (TSM) with IRC standards -Traffic Regulatory Measures-Travel Demand Management (TDM) – Direct and indirect methods -Congestion and parking pricing – All segregation methods- Coordination among different agencies – Intelligent Transport System for traffic management, enforcement and education.

Recommended Books

1. Traffic Engineering and Transportation Planning by L.R. Kadiyali, Khanna Publishers, 2011.
2. Traffic Engineering by Roger P. Roess, Elena S. Prassas and William R. McShane, Prentice Hall, 4th edition, 2010.
3. Traffic & Highway Engineering by Nicholas J Garber, Lester A Hoel, Third edition, Bill, 2011
4. Fundamentals of Transportation Engineering C. S. Papa Costas and P. D Prevedouros, Prentice-Hall, New Delhi, 2009.
5. Introductions to Traffic Engineering: A Manual for Data Collection and Analysis, Thomas R.Currin, Brooks/Cole Thomason Learning, Canada, 2001. Design codes: IRC: SP: 41-1994, IRC SP: 31-1992, IRC 43-1994, Indian Roads Congress, New Delhi., Highway Capacity Manual 2010, Transportation Research Board, Indo-HCM, CSIR- CRRI, 2017, New Delhi. 15 -2014 and IRC SP 76-2008.

Second Semester	Traffic Flow Analysis	L	T	P	Credits
		3	0	0	3

UNIT - I

Traffic Flow Description: Traffic Stream Characteristics and Description Using Distributions; Measurement, Microscopic and Macroscopic Study of Traffic Stream Characteristics - Flow, Speed and Concentration; Use of Counting, Interval and Translated Distributions for Describing Vehicle Arrivals, Headways, Speeds, Gaps and Lags; Fitting of Distributions, Goodness of Fit Tests.

UNIT – II

Traffic Stream Models: Fundamental Equation of Traffic Flow; Speed-Flow-Concentration Relationships, Normalized Relationship, Fluid Flow Analogy Approach; Shock Wave Theory – Flow-Density diagram use in Shockwave analysis; Use of Time-space diagram for shockwave description; Bottleneck situations and shockwaves; Traffic signal and shockwave theory; Numerical examples for application of shockwave theory; Car-Following Theory.

UNIT – III

Queuing Theory: Fundamentals of Queuing Theory - Demand Service Characteristics- Deterministic Queuing Models - Stochastic Queuing Models - Multiple Service Channels,

UNIT – IV

Queuing Analysis: Analysis of M/M/1 system; Assumptions and Derivation of System State Equations; Application of M/M/1 analysis for parking and Toll Plazas- Numerical Examples; Analysis of D/D/1 system for delay characteristics; Traffic Signal analysis as D/D/1 system; Computation of delays and queue dissipation Time – Numerical Examples.

UNIT – V

Pedestrian Delays and Gaps: Pedestrian Gap acceptance and delays; Concept of Blocks, Anti-blocks, Gaps and Non-Gaps; Underwood's analysis for Pedestrian Delays; Warrants for Pedestrian Crossing Facilities – Minimum Vehicular Volume Warrant, Minimum Pedestrian Volume Warrant, Maximum Pedestrian Volume Warrant.

UNIT – VI

Simulation of Traffic: Introduction - Advantages of Simulation techniques; Steps in Simulation - Scanning techniques - Example of Simulation.

Recommended Books

1. Traffic Engineering and Transportation Planning by L.R. Kadiyali, Khanna Publishers, 2011.
2. Fundamentals of Transportation Engineering – C. S. Papacostas, Prentice Hall India Publication
3. Traffic Flow Theory: A Monograph, TRB Special Report
4. Principles of Highway Engineering and Traffic Analysis – F. L. Mannering & W. P. Kilareski, John Wiley Publishers.
5. Traffic Flow Fundamentals – A. D. May, Prentice Hall India Publication
6. Coleman A. O 'Flaherty, Transport Planning and Traffic Engineering, Butterworth Heinemann, 2009.

ELECTIVE-3	Planning and Design of Airports	L	T	P	Credits
		3	0	0	3

UNIT I

General: History, development, policy of air transport, aircrafts, aerodromes, air transport authorities, air transport activities, air crafts and its characteristics, airport classifications as per ICAO.

UNIT II

Airport Planning: General- Regional Planning- Development of New Airport- Data Required before Site Selection- Airport Site Selection- Surveys for Site Selection- Drawings to be prepared- Estimation of Future Air Traffic Needs.

UNIT - III

Runway Design: Runway Orientation- Basic Runway Length- Corrections for Elevation, Temperature and Gradient- Airport Classification- Runway Geometric Design- Airport Capacity- Runway Configurations- Runway Intersection Design.

UNIT - IV

Structural Design of Airport Pavements: Introduction- Various Design Factors- Design Methods for Flexible Pavement- Design Methods for Rigid Pavement- LCN System of Pavement Design- Joints in Cement Concrete Pavement- Airport Pavement Overlays- Design of an Overlay.

UNIT - V

Air Traffic Control and Visual Aids: Air traffic control objectives, control system, control network-visual aids-landing information system, airport markings and lighting.

UNIT - VI

Airport Grading and Drainage: General- Computation of Earthwork- Airport Drainage- Special Characteristics and Requirements of Airport Drainage- Design Data- Surface Drainage Design, Subsurface Drainage Design.

Recommended Books

1. Planning and Design of Airports By Robert M. Horonjeff, Francis X. McKelvey, William J Sproule, Seth B Young, 5 th edition, Mc-Graw Hill, 20010
2. Airport Engineering: Planning, Design, and Development of 21st Century Airports, 4th Edition by Norman J. Ashford, Saleh Mumayiz, Paul H. Wright
3. Airport Planning and Designing by S.K. Khanna, M.G. Arora.

4. Highway Engineering including Expressways and Airport Engineering by Dr. L. R. Kadayali, Dr. N. B. Lal.
5. Highway Engineering including Airport Pavements by Dr. S. K. Sharma.

ELECTIVE-3	Pavement Construction, Maintenance and Management	L	T	P	Credits
		3	0	0	3

UNIT I:

Construction of Embankment, Subgrade, Subbase and Base Layers: Construction of embankment and subgrade, Importance of compaction, gradation for Granular Subbase and Granular Base, mix design and construction of granular subbase and base, construction of Shoulders and drains. Construction cement treated subbases and bases, use of Geosynthetic materials in pavement construction.

UNIT II:

Construction of Bituminous layers: Different types of bituminous concretes - Bituminous Macadam, Penetration Macadam, Built- up Spray Grout, Open Graded Premix, Mix Seal Surface, Semi-Dense Bituminous Macadam (DBM) and Bituminous Concrete (BC). Construction of DBM and BC layers, quality control.

UNIT III:

Construction of Cement Concrete layers: Construction of Dry Lean Concrete (DLC) and Pavement Quality Concrete (PQC) Layers, Manual and Mechanical Methods, Different types of Joints in Cement Concrete pavement and their construction, Joint compounds.

UNIT IV:

Introduction to Pavement Maintenance: Importance of pavement Maintenance, collection of pavement condition data – manual and using NSV vehicle, Serviceability Concepts; Visual Rating; Pavement Serviceability Index; Roughness Measurements, functional and structural evaluation of pavements, Skid Resistance, Roughness, Safety – Aspects.

UNIT V:

Maintenance of Bituminous Concrete and Cement Concrete Pavements:

Causes of bituminous and concrete pavement Deterioration, Traffic and Environmental Factors, different types of distresses on pavements, treatments to the distresses, recycling and different methods of recycling, Profile Correction Course.

UNIT- VI

Pavement management system: Components of PMS and their activities; Major steps in implementing PMS; HDM packages; Pavement Maintenance Management Components of

Maintenance Management and Related Activities – Network and Project Level Analysis; Prioritization Techniques and Formulation of Maintenance Strategies.

Recommended Books

1. Construction Planning Equipment and Method, Peurifoy R. L., and Clifford J. S., McGrawHill Book Co.
2. Hot Mix Asphalt Materials, Mixture Design and Construction, Freddy L. Roberts, Prithvi S. Kandhal et al, (2nd Edition), National Asphalt Pavement Association Research and Education Foundation, Maryland, USA.
3. Construction Equipment and its Management, Sharma S. C. Khanna Publishers.
4. Hot Mix Asphalt Paving Handbook, National Asphalt Pavement Association, 5100 Forbes Boulevard, Lanhm, Mary Land, USA
5. MoRTH – V Edition, Manual for Construction and Supervision of Bituminous Works, 2013, Indian Roads Congress

   Various IRC Codes: IRC:15-2017, IRC SP :11-1984, IRC 57-2018, IRC 58-2015, IRC 19-2005, IRC 27-2009, IRC 29-1988, IRC 34-2011, IRC 36-2010, IRC 48-1972, IRC 63-1976, IRC 68-1976, IRC 81-1997, IRC 82-2015, IRC 93- 1985, IRC 94-1986, IRC 95-1987, IRC 98-2011, IRC 105-2019.

Elective 3	Intelligent Transportation Systems	L	T	P	Credits
		3	0	0	3

UNIT-I

Introduction To ITS: System Architecture, Standards, Database – Tracking Database – Commercial Vehicle Operations – Intelligent Vehicle Initiative - Metropolitan ITS – Rural ITS – ITS for Rail network.

UNIT-II

ITS Travel Management: Autonomous Route Guidance System – Infrastructure based systems – Telecommunications – Vehicle – Road side communication – Vehicle Positioning System – RFID System, Electronic Toll Collection – Electronic Car Parking

UNIT-III

ITS Designs: Modeling and Simulation Techniques - Peer – to – Peer Program – ITS for Road Network – System Design – Mobile Navigation Assistant – Traffic Information Center – Public Safety Program.

UNIT-IV

Automated Highway Systems: Evolution of AHS and Current Vehicle Trends - Vehicles in Platoons,Automatic Vehicle Classification System(AVCS)
– Aerodynamic Benefits - Integration of Automated Highway Systems – System Configurations - Step by Step to an Automated Highway System.

UNIT-V

Spacing and Capacity for Different AHS Concepts – Communication Technologies for AHS – The Effects of AHS on the Environment – Regional Mobility - Impact Assessment of Highway Automation.

UNIT-VI

Implementation of ITS: ITS programs globally- overview of ITS in developed countries and developing countries

Recommended Books

1. ITS Hand Book 2000: Recommendations for World Road Association (PIARC) by Kan Paul Chen, John Miles.
2. Intelligent Transport Systems – Cases and Policies by Roger R. Stough, Publisher: Edward Elgar, 2001.

3. Intermodal Freight Transport by David Lowe, Elsevier Butterworth-Heinemann Publishers, 2005
4. Positioning Systems in Intelligent Transportation Systems by Chris Drane and Chris Rizos, Artech House Publishers, London, 2000
5. Perspectives on Intelligent Transport Systems by Joseph M. Sussman, Springer Publishers, 2000
6. Intelligent transport System, Intelligent Transportation primer, Washington, US, 2001.

ELECTIVE-4	Environmental Impacts of Transportation Projects	L	T	P	Credits
		3	0	0	3

UNIT-I

Introduction: Concepts, Objectives, Advantages and Limitations of EIA approach for environmental impact studies economic survey, mitigation measures, clearances required for road projects, Flow chart for obtaining environmental clearance, standards – liquid effluents air quality, noise.

UNIT-II

Environmental and Social Legal Framework: Enforcement agencies-MOEF, CPCB, state pollution control boards, Coastal Management regulatory authority, Central ground water board, key environmental legislations – Environmental act, air acts, forest act, wild life protection act, water acts, coastal zone act, key legislations to road projects-national highways acts, NHAI act, land acquisition act, rehabilitation and resettlement policy, building and construction workers welfare act.

UNIT-III

Environmental clearances: General conditions, procedure for obtaining environmental clearances screening, scoping, public consultation, appraisal, grant or rejection, post environmental clearance monitoring.

Forest and CRZ clearance: Procedure for obtaining clearance forest, CRZ, wild life clearance, other clearance from – state /central water authority, irrigation/water resources dept, archeological dept, permission for quarrying and borrowing operations.

UNIT-IV

Procedure for assessing environmental Impact of Highway projects: Collect information on Exisiting features: Road factors, Terrain, Traffic factors, Land use, Environmental factors; Need for the proposed project: Transportation demand, access, capacity; discuss adverse effects on traffic factors, traffic convenience, environmental and economic; Physical and environmental features of proposed project; length, terrain, land width category of land, displacement of households, cut and fill sections, vegetation, erosion potential, landslide potential, number of major river crossings, utilities to be relocated, air quality and estimated cost.

UNIT-IV

Impact of the selected alternative on environment and proposed mitigation measures: Land acquisition, highway location, highway alignment, highway cross section, erosion control, drainage, vegetation, traffic movement, construction, traffic noise and vibration, air and water quality; overall assessment of selective alternative: positive and negative impacts.

UNIT-VI

Evaluation of Alternatives: Weighing of decision factors, rating / ranking of alternatives, public participation in decision making, techniques for conflict management

Recommended books

1. Environmental Impact Assessment by Canter, L.W., McGraw Hill Pub. Co., New York, 1997
2. Environmental Analysis of Transportation Systems by Louis Franklin Cohen and Gary Richard Mc Voy, John Wiley & Sons, 1982
3. Environmental Impact Analysis by Jain, R.K., Urban, L.V., Stracy, G.S., an Nostrand Reinhold Co., New York, 1991
4. Environmental Fate and Transport Analysis with Compartment Modeling by Keith W. Little, CRC Press, Taylor & Francis Group, 2012.
5. NCHRP Report 541. Consideration of Environmental Factors in Transportation Systems Planning, TRB, 2005.
6. NCHRP Synthesis 272, Best Management Practices for Environmental Issues Related to Highway and Street Maintenance: A Synthesis of Highway Practice, National Research Council, TRB, 1999

ELECTIVE-4	Remote Sensing and GIS	L	T	P	Credits
		3	0	0	3

UNIT - I

Introduction to GIS: Definitions of GIS – Components of GIS – Geographic data presentation: Maps – Mapping process – Coordinate systems – Transformations – Map projections – Geo referencing – Data acquisition.

UNIT - II

Introduction to remote sensing: Definition – Components of Remote Sensing – Energy, Sensor, Interacting Body – Active and Passive Remote Sensing – Platforms – Aerial and Space Platforms – Balloons, Helicopters, Aircrafts and Satellites – Electromagnetic Radiation- EMR Spectrum.

UNIT - III

GIS Data Processing, Analysis and Modelling: Raster based GIS data processing – Vector based GIS data processing – Queries – Spatial analysis – Descriptive statistics – Spatial autocorrelation – Quadrant counts and nearest neighbour analysis – Network analysis – Surface modelling – DTM.

Data Management: The data base designs and approaches, 3 classic data models, Nature of geographic data, Spatial data models, Databases for GIS; Implementation and Maintenance of GIS, Evaluation of alternative systems, system justification and Development of an implementation plan.

UNIT - IV

Remote Sensing Data Interpretation, Processing and Enhancement: Elements of visual interpretation, Image enhancement techniques – necessity and importance, contrast enhancement techniques, low pass (smoothing) filters and high pass (sharpening) filters, linear and non-linear filtering techniques, edge detection, supervied classification, unsupervised classification and Classification accuracy. Introduction to GPS and DGPS.

UNIT - V

Basic applications in Transportation: Highway and Railway Alignment, location of transport terminals and roadside facilities, bus stops – Route optimization – Bus route rationalization – Accident analysis – Applications of Aerial Photography and Satellite Imageries.

UNIT - VI

Advanced applications in Transportation: GIS as an integration technology – Integration of GIS, GPS and Remote Sensing Techniques – Advanced Traveler Information System (ATIS) – Automatic Vehicle Location System (AVLS).

Recommended Books:

1. Remote Sensing and Image Interpretation by Thomas M. Lillesand and Ralph W.Kiefer, Wiley Publishers, 2006.
2. Introduction to Geographic Information systems by Kang-tsung Chang, McGraw-Hill Education (Indian Edition), 2008.
3. Remote Sensing and GIS by Basudeb Bhatta, Oxford University Press, 2003.
4. Basics of Remote sensing and GIS by Dr. S. Kumar, Laxmi Publications, 2002
5. Remote Sensing and Geographical Information systems by M.Anji Reddy, B.S.Publications, 2004.
6. Remote Sensing and Geographical Information systems by Kali Charan Sahu, Atlantic Publishers and Distributors, 2009.

Second Semester	Highway bridges and flyovers	L	T	P	Credits
		3	0	0	3

UNIT-I

Introduction: Components of a bridge, Classification of bridges, Requirements of an ideal bridge, Selection of bridge site, Choice of bridge type, Investigation for bridges Bridge Hydrology: Determination of flood discharge, Waterway, Economic span, Scour depth, Depth of foundation, Afflux, Clearance, Freeboard

UNIT-II

Bridge substructure and Super Structure: Bridge Piers, Abutments, Wing walls, Approaches, Types of bridge superstructures, Bridge flooring, Choice of superstructure type

UNIT-III

Standards of Loadings for Bridge Design: Types of loading for Road bridges – Dead load, Live load, Impact load, Wind loads, Lateral loads, Longitudinal forces, Centrifugal forces, Seismic loads, Forces due to water currents, Earth pressure, Buoyancy, Temperature stresses, Deformation stresses, Erection stresses, Requirements of traffic in the design of highway bridges
UNIT-IV: Reinforced Concrete Bridges: Design of Slab bridge, Design of Girder bridge, Courbon's theory.

UNIT-IV

Reinforced Concrete Bridges: Design of Slab bridge, Design of Girder bridge, Courbon's theory.

UNIT-V

Prestressed Concrete Bridges: Types of prestressing – Pre tensioning, Post tensioning, Pretensioned PSC bridges, Post tensioned PSC bridges

UNIT – VI

Bridge Bearings and Expansion joints: Functions, types and selection of bearings - Bearing materials - Design of elastomeric bearings for different conditions - Expansion joints – types of expansion joints.

Recommended Books:

1. Principles and Practice of Bridge Engineering, S. P. Bindra, Dhanpat Rai Publications
2. Design of Concrete Bridges, M. G. Aswani, V. N. Vazirani, M. M. Ratwani, Khanna Publishers
3. Essentials of Bridge Engineering, D. J. Victor, Oxford & IBH Publishing Co.
4. Design of Bridge Structures, T. R. Jagdeesh and M. A. Jayaram, PHI.
5. Bridge Engineering, S. Ponnuswamy, TMH.
6. Analysis and Design of Substructures, Swami Saran, Oxford & IBH Publishing Co.

Second Semester	Pavement Engineering Laboratory -2	L	T	P	Credits
		0	0	3	1.5

1. Determination of Performance Grading of Bitumen using DSR
2. Studying creep characteristics of bitumen
3. Design of bituminous Concrete Mixes – specific gravities and Aggregates gradation
4. Design of bituminous Concrete Mixes – Marshall sample preparation, volumetric properties, and testing
5. Tensile strength Ratio (TSR) test on bituminous mixes
6. Conduction of axle load studies in the field
7. Road roughness survey using MERLIN and Bump Integrator
8. Test pit investigations and DCP test to evaluate the subgrade strength
9. Structural evaluation by using BBD
10. Structural evaluation by using FWD

Recommended Books

1. Highway materials and pavement testing by Khanna, S.K., Justo, C.E.G., and A. Veeraragavan, 5th edition, Nem chand and brothers, Roorkee, India, 2009.
2. Huang, Y.H. Pavement Analysis and Design, Pearson Prentice Hall, New Jersey, USA, 2004.
3. Relevant IS, IRC, ASTM Codes.

Second Semester	Traffic Engineering Laboratory	L	T	P	Credits
		0	0	3	1.5

1. Traffic volume and turning movement studies and analysis
2. Origin – Destination studies and analysis
3. Speed Studies and analysis.
4. Gap acceptance studies.
5. Travel Time and Delay Studies by Floating Car Method at Mid-Block.
6. Intersection delay studies at Uncontrolled and Signalized Intersection.
7. Parking surveys: Parking Inventory and Turnover Studies.
8. Measurement of driver characteristics: Reaction Testing, Action Judgment Testing.
9. Evaluation of driver Knowledge for Traffic Rules, Traffic Signs & Road Markings.
10. Studies on Highway Capacity Estimation.

Recommended Books

1. Jotin and, B. Kent Lall, Transportation Engineering: An Introduction, Prentice Hall; 3 rd Edition, 2002.
2. Currin, Introduction to Traffic Engineering: Manual F/data Collect & Analysis, CL Engineering, 2 nd Edition, 2012.
3. L.R. Kadiyali, Traffic Engineering and Transportation Planning, Khanna Publishers, 2011.
4. Pignataro LJ. Traffic Engineering: Theory and Practice; Prentice hall, Inc, 1973
5. Roger P. Roess Elena S. Prassas and William R. McShane, Traffic Engineering, Prentice Hall, 4 th Edition, 2010.
   Indo – HCM, CSIR-CRRI, 2017 New Delhi.

Course Code	Course Name	Course Category	L-T-P	Credits
21EAD1101	Advanced Stress Analysis	PCC	3-0-0	3

Unit I

Analysis of Stress: Analysis of stress, analysis of stain, elasticity problems in two dimension and three dimensions, Mohr's circle for three dimensional stresses. Stress tensor, Air's stress function in rectangular and polar coordinates.

Unit II

Deformation and Strain: Deformation, strain displacement relations, strain components, the state of strain at a point, principal strain, strain invariants, strain transformation, compatibility equations.

Unit III

Energy Methods: Energy method for analysis of stress, strain and deflection. The three theorem's - theorem of virtual work, theorem of least work, Castiglioni's theorem, Rayleigh Ritz method, Galekin's method, elastic behavior of anisotropic materials like fiber reinforced composites.

Unit IV

Theory of Torsion: Torsion of prismatic bars of solid section and thin walled section. Analogies for torsion, membrane analogy, fluid flow analogy and electrical analogy. Torsion of conical shaft, bar of variable diameter, thin walled members of open cross section in which some sections are prevented from warping, torsion of noncircular shaft.

Unit V

Unsymmetrical Bending and Shear Centre: Concept of shear center in symmetrical and unsymmetrical bending, stress and deflections in beams subjected to unsymmetrical bending, shear center for thin wall beam cross section, open section with one axis of symmetry, general open section, and closed section.

Unit VI

Pressurized Cylinders and Rotating Disks: Governing equations, stress in thick walled cylinder under internal and external pressure, shrink fit compound cylinders, stresses in rotating flat solid disk, flat disk with central hole, disk with variable thickness, disk of uniform strength, plastic action in thick walled cylinders and rotating disc.

Course outcomes:

At the end of the course the student will be able to:

CO1: Treat general stresses and deformations in continuous materials

CO2: Formulate and solve specific technical problems of displacement, strain and stress.

CO3: Apply energy methods to solve basic two dimensional elasticity problems.

CO4: Model and analyze the stresses and deformations of simple geometries under an arbitrary load in solids.

Reference books:

1. Timoshenko and Goodier, "Theory of Elasticity"-'Tata McGraw Hill, New Delhi,3rd edition ,

1970
2. L S Srinath "Advanced Mechanics of Solids"- Tata McGraw Hill, New Delhi, 3rd edition, 2010
3. G. Thomas Mase, Ronald E. Smelser, George. E. Mase, Continuum Mechanics for Engineers, 3rd Edition, CRC Press, Boca Raton, 2010
4. Batra, R. C., Elements of Continuum Mechanics, Reston, 2006
5. George E. Mase, Schaum's Outline of Continuum Mechanics, McGraw-Hill, 1970
6. Dill, Ellis Harold, Continuum Mechanics: Elasticity, Plasticity, Viscoelasticity, CRC Press , 2006.Sadhu Singh," Theory of Elasticity"- Khanna publisher, 4th edition, 2013
7. Dally, J. W. and W.F. Riley, Experimental Stress Analysis, McGraw Hill International, Third Edition, 1991

Course Code	Course Name	Course Category	L-T-P	Credits
21EAD1102	Finite Element Analysis	PCC	3-0-0	3

Unit I

Introduction: Historical Perspective of FEM and applicability to mechanical engineering design problems.

Mathematical Models and Approximations: Review of elasticity. Mathematical models for structural problems: Equilibrium of continuum-Differential formulation, Energy Approach-Integral formulation: Principle of Virtual work - Variational formulation. Overview of approximate methods for the solution of the mathematical models, Residual methods and weighted residual methods, Ritz, Rayleigh-Ritz and Gelarkin methods. Philosophy of solving continuum problems using Finite Element Method.

Unit II

Finite Element Formulation: Generalized FE formulation based on weighted residual method and through minimization of potential, displacement based formulation, Concept of discretization, Interpolation, Formulation of Finite element characteristic matrices and vectors, Compatibility conditions, Assembly and boundary considerations.

Finite Element Analysis for One Dimensional Structural problems: Structural problems with one dimensional geometry. Bar element: formulation of stiffness matrix, consistent and lumped load vectors. Boundary conditions and their incorporation: Elimination method, Penalty Method, Introduction to higher order elements and their advantages and disadvantages. Formulation for Truss elements, Case studies involving hand calculations with an emphasis on assembly, boundary conditions, contact conditions and multipoint constraints.

Unit III

Beams and Frames: Review of bending of beams, higher order continuity (C^0 and C^1 Continuity), interpolation for beam elements and formulation of FE characteristics, Plane and space frames and examples problems involving hand calculations. Algorithmic approach for developing computer codes involving 1-D elements.

Unit IV

Two dimensional Problems: Interpolation in two dimensions, natural coordinates, Isoparametric representation, Concept of Jacobian. Finite element formulation for plane stress plane strain and axi-symmetric problems; Triangular and Quadrilateral elements, higher order elements, sub-parametric, Isoparametric and superparametric elements. Formulation of plate bending elements using linear and higher order bending theories, Shell elements, General considerations in finite element analysis of design problems, Choosing an appropriate element and the solution strategies. Introduction to pre and post processing of the results and analysis.

Unit V

Three Dimensional Problems: Finite element formulation for 3-D problems, mesh preparation, tetrahedral and hexahedral elements, case studies.

Dynamic Analysis: FE formulation in dynamic problems in structures using Lagrangian Method, Consistent and lumped mass models, Formulation of dynamic equations of motion,

Modelling of structural damping and formulation of damping matrices, Model analysis, Mode superposition methods and reduction techniques.
Unit VI
FEM in Heat Transfer and Fluid Mechanics problems: Finite element solution for one dimensional heat conduction with convective boundaries. Formulation of element characteristics and simple numerical problems. Formulation for 2-D and 3-D heat conduction problems with convective boundaries. Introduction to thermo-elastic contact problems. Finite element applications in potential flows; Formulation based on Potential function and stream function. Case studies. **Algorithmic Approach for problem solving:** Algorithmic approach for Finite element formulation of element characteristics, Assembly and incorporation of boundary conditions. Guidelines for code development. Introduction to commercial Finite Element software packages like ANSYS.
Course outcomes: Students will be able to CO1: make use of the concept of finite element method for solving machinedesign problems. CO2: solve problems in 1-D structural systems involving bars, trusses, beams andframes. CO3: develop 2-D and 3-D FE formulations involving triangular, quadrilateral elements and higher order elements. CO4: apply the knowledge of FEM for stress analysis, model analysis, heat transfer analysis and flow analysis. CO5: develop algorithms and FE code for solving design problems and adapt commercial packages for complex problems.
Reference books:
1. Singiresu S.Rao, Finite element Method in Engineering, 5ed, Elsevier, 2012. 2. Seshu P, Textbook of Finite Element Analysis, PHI. 2004. 3. Reddy, J.N., Finite Element Method in Engineering, Tata McGraw Hill, 2017. 4. Zeincowicz, The Finite Element Method 4 Vol set, 4th Edition, Elsevier 2007.

Course Code	Course Name	Course Category	L-T-P	Credits
21EAD1103	Mechanical Behavior of Materials	PCC	2-1-0	3

Unit I

Introduction to Materials: Constitution of alloys: necessity of alloying, classification of alloys, solid solutions - interstitial solid solutions and substitution solid solutions, Hume-Rothery principles for developing solid solutions, compounds- interstitial, intermetallics and electron compounds.

Unit II

Strengthening Mechanisms

Cold working, grain size strengthening, solid solution strengthening, martensitic strengthening, precipitation strengthening, dispersion strengthening, fiber strengthening, examples of above strengthening mechanisms from ferrous and non-ferrous systems, simple problems, yield point phenomenon, strain aging and dynamic strain aging.

Unit III

Theory of Plasticity: Dislocation theory, properties of dislocations, stress fields around dislocations, application of dislocation theory to work hardening, solid solution strengthening, grain boundary strengthening, and dispersion hardening.

Unit IV

Ductile and Brittle Fracture: Charpy and Izod testing, significance of DBTT, ECT, NDT, and FATT, elements of fractography, Griffith theory, LEFM-COD and J integral, determination of KIC, COD, and J integral.

Unit V

Fatigue Failure: Initiation and propagation of fatigue cracks, factor affecting fatigue strength and methods of improving fatigue behavior, low-cycle fatigue, high-cycle fatigue, testing analysis of fatigue data, mechanism of fatigue crack propagation, corrosion fatigue.

Unit VI

Creep Failure: Creep mechanism, creep curve, variables affecting creep, accelerated creep testing, development of creep resisting alloys, Larsen-Miller parameter, and Manson Hafred parameter.

Polymers: Introduction, structure, elastic response, Hookean elasticity, rubber elasticity, introduction to linear viscoelasticity, creep and stress relaxation, dynamic response.

Course outcomes

Students will be able to

CO1: Describe and predict elastic deformation in isotropic and anisotropic engineering materials;

CO2: Describe and predict yielding of engineering materials under uniaxial and multiaxial states of stress

CO3: Describe the major microstructural-based mechanisms of strengthening in (crystalline) materials, and apply these principles to alloy and process design;

CO4: Identify the microstructural based dependencies of mechanical failure in engineering materials, including yielding, fracture, fatigue, and creep; and apply these principles to design and process failure-resistant materials.

Reference books:

1. Dieter, G. E., Mechanical metallurgy, McGraw Hill.
2. Hertzberg, R.W., Deformation and fracture mechanics of engineering materials, John Wiley
3. Hull, D., Introductions to dislocations, Pergamon.
4. Garofalo, F., Fundamentals of creep and creep rupture in metals, McMillan.
5. Meyers, M. A., and Chawla, K.K., Mechanical behavior of materials, Prentice Hall.

Course Code	Course Name	Course Category	L-T-P	Credits
21EAD1104	Mechanical Vibrations	PCC	3-0-0	3

Unit I
Introduction: Causes and effects of vibration, Classification of vibrating system, Discrete and continuous systems, degrees of freedom, Identification of variables and Parameters, Linear and nonlinear systems, linearization of nonlinear systems, Physical models, Schematic models and Mathematical models. **Single Degree of Freedom (SDF) systems:** Formulation of equation of motion: Newton Euler method, De Alembert's method, Energy method, Free Vibration: Undamped Free vibration response, Damped Free vibration response, Case studies on formulation and response calculation. Forced vibration response of SDF systems: Response to harmonic excitations, solution of differential equation of motion, Vector approach, Complex frequency response, Magnification factor Resonance, Rotating/reciprocating unbalances.
Unit II
Dynamics of Rotors: Whirling of rotors, Computation of critical speeds, influence of bearings, Critical speeds of Multi rotor systems. **Design case studies**: Design case studies dealing with Transmissibility of forces and motion, Vehicular suspension, Analysis of Vehicles as single degree of freedom systems -vibration transmitted due to unevenness of the roads, preliminary design of automobile suspension. Design of machine foundations and isolators.
Unit III
Two degree of freedom systems: Introduction, Formulation of equation of motion: Equilibrium method, Lagrangian method, Case studies on formulation of equations of motion, Free vibration response, Eigen values and Eigen vectors, Normal modes and mode superposition, Coordinate coupling, decoupling of equations of motion, Natural coordinates, Response to initial conditions, coupled pendulum, free vibration response case studies, Forced vibration response, Automobile as a two degree of freedom system bouncing and pitching modes undamped vibration absorbers, Case studies on identification of system parameters and design of undamped vibration absorbers. Analysis and design of damped vibration absorbers.
Unit IV
Multi degree of freedom systems: Introduction, Formulation of equations of motion, Free vibration response, Natural modes and mode shapes, Orthogonally of modal vectors, normalization of modal vectors, Decoupling of modes, modal analysis, mode superposition technique, Free vibration response through modal analysis, Forced vibration analysis through modal analysis, Modal damping, Rayleig damping, Introduction to experimental modal analysis.
Unit V
Continuous systems: Introduction to continuous systems, discrete vs continuous systems,

Exact and approximate solutions, free vibrations of bars and shafts, Free vibrations of beams, Forced vibrations of continuous systems Case studies, Approximate methods for continuous systems and introduction to Finite element method.

Unit VI

Vibration control in structures: Introduction, State space representation of equations of motion. Passive control, active control and semi active control, Free layer and constrained damping layers, Piezo electric sensors and actuators for active control, semi active control of automotive suspension systems.

Course outcomes:

Students will be able to

CO1: analyse the causes and effects of vibrations in mechanical systems and identify discrete and continuous systems.

CO2: model the physical systems into schematic models and formulate the governing equations of motion.

CO3: compute the free and forced vibration responses of multi degree of freedom systems through modal analysis and interpret the results.

CO4: analyse and design systems involving unbalances, transmissibility, vibration isolation and absorption.

CO5: analyse and design to control and reduce vibration effects in machinery.

Reference books:

1. L. Meirovich, Elements of Vibration Analysis, 2nd Ed. Tata Mc-Grawhill, 2007.
2. Singiresu S Rao, Mechanical Vibrations. 4th Ed., Pearson education, 2011.
3. W.T, Thompson, Theory of Vibration, CBS Publishers.
4. Clarence W. De Silva, Vibration: Fundamentals and Practice, CRC Press LLC, 2000.
5. Venkatachalam R., Mechanical Vibrations, PHI Publications, 2014

Course Code	Course Name	Course Category	L-T-P	Credits
21EAD1171	Research Methodologies & IPR	MC	2-0-0	2

Unit I
Research Methodology: Introduction, meaning of research, objectives of research, motivation in research, types of research, research approaches, significance of research, research methods versus methodology, research and scientific method, importance of knowing how research is done, research process, criteria of good research, and problems encountered by researchers in India. **Defining the Research Problem:** Research problem, selecting the problem, necessity of defining the problem, technique involved in defining a problem, an illustration.
Unit II
Reviewing the Literature: Place of the literature review in research, bringing clarity and focus to your research problem, improving research methodology, broadening knowledge base in research area, enabling contextual findings, how to review the literature, searching the existing literature, reviewing the selected literature, developing a theoretical framework, developing a conceptual framework, writing about the literature reviewed. **Research Design:** Meaning of research design, need for research design, features of a good design, important concepts relating to research design, different research designs, basic principles of experimental designs, important experimental designs.
Unit III
Design of Sampling: Introduction, sample design, sampling and non-sampling errors, sample survey versus census survey, types of sampling designs. **Measurement and Scaling:** Qualitative and quantitative data, classifications of measurement scales, goodness of measurement scales, sources of error in measurement tools, scaling, scale classification bases, scaling techniques, multidimensional scaling, deciding the scale. **Data Collection**: Experimental and surveys, collection of primary data, collection of secondary data, selection of appropriate method for data collection, case study method.
Unit IV
Testing of Hypotheses: Hypothesis, basic concepts concerning testing of hypotheses, testing of hypothesis, test statistics and critical region, critical value and decision rule, procedure for hypothesis testing, hypothesis testing for mean, proportion, variance, difference of two mean, for difference of two proportions, for difference of two variances, p-value approach, power of test, limitations of the tests of hypothesis. **Chi-square Test:** Test of difference of more than two proportions, test of independence of attributes, test of goodness of fit, cautions in using chi square tests.
Unit V
Interpretation and Report Writing: Meaning of interpretation, technique of interpretation, precaution in interpretation, significance of report writing, different steps in writing report, layout

of the research report, types of reports, oral presentation, mechanics of writing a research report, precautions for writing research reports.
Unit VI
Intellectual Property: The concept, intellectual property system in India, development of TRIPS complied regime in India, Patents Act, 1970, Trade Mark Act, 1999, The Designs Act, 2000, The Geographical Indications of Goods (Registration and Protection) Act1999, Copyright Act,1957, The Protection of Plant Varieties and Farmers "Rights Act, 2001, The Semi-Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention on Biological Diversity (CBD) 1992, Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation (WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO.
Course outcomes: At the end of the course the student will be able to: CO1: Discuss research methodology and the technique of defining a research problem CO2: Explain the functions of the literature review in research, carrying out a literature search, developing theoretical and conceptual frameworks and writing a review. CO3: Explain various research designs, sampling designs, measurement and scaling techniques and also different methods of data collections. CO4: Explain several parametric tests of hypotheses, Chi-square test, art of interpretation and writing research reports. CO5: Discuss various forms of the intellectual property, its relevance and business impact in the changing global business environment and leading International Instruments concerning IPR.
Reference books:
1. Research Methodology: Methods and Techniques, C.R. Kothari, Gaurav Garg,New Age International,4th Edition, 2018 2. Research Methodology a step-by-step guide for beginners. (For the topic Reviewing the literature under module 2), RanjitKumar,SAGE Publications,3rd Edition, 2011 3. Research Methods: the concise knowledge base, Trochim, Atomic Dog Publishing, 2005 4. Study Material (For the topic Intellectual Property under module 5), Professional Programme Intellectual Property Rights, Law and Practice, The Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament, September 2013

Course Code	Course Name	Course Category	L-T-P	Credits
21EAD1181	Advanced Analysis and Simulation Laboratory	PCC	0-0-3	2

Week	Exercises
	Simulation
1	Introduction to MATLAB and practice
2	Practice session on handling basic arithmetic etc.
3	Writing codes with control loops, functions and scripts
4	Developing codes for visualization and plotting
5	Solving problems involving linear and nonlinear equations, curve fitting and interpolations.
6	Solving problems involving ordinary and partial differential equations, numerical differentiation and integrations
7	Solving problems involving numerical differentiation and integrations
8	Case studies and working on projects
	Analysis
9	Force and Stress analysis using link elements in Trusses, cables etc.
10	Stress and deflection analysis in beams with different support conditions
11	Stress analysis of flat plates and simple shells, Stress analysis of axi-symmetric components
12	Thermal stress and heat transfer analysis of plates
13	Thermal stress analysis of cylindrical shells
14	Vibration analysis of spring-mass systems
15	Model analysis of Beams
16	Harmonic, transient and spectrum analysis of simple systems.

Course outcomes:

Students will be able to

CO1: apply built-in functions in MATLAB/ SCILAB to solve numerical problems.

CO2: develop code for solving problems involving different types of mathematical models and equations (ODE, PDE, Linear and nonlinear equations).

CO3: Solve simulation problems encountered in mechanical design, vibration analysis and CAD.

CO4: Model, analyse, and simulate experiments and evaluate the performance.

Reference: Lab manual

I Year II Semester

Course Code	Course Name	Course Category	L-T-P	Credits
21EAD1205	Engineering Failure Analysis	PCC	3-0-0	3

Unit I
Introduction: Need and scope of failure analysis and prevention, engineering disasters and understanding failures, common causes of failures, principles of failure analysis.
Unit II
Fundamental sources of failure: Deficient design, imperfections in base metals, improper manufacturing, improper service conditions, poor assembly, service and maintenance.
Unit III
Prognostics and health management: Extraction of health-relevant features from sensor data; model-based prognostics; data-driven prognostics; uncertainty management in prognostics. **Tools for design and process failure analysis**: Pareto diagram, fishbone diagram, FMEA, fault tree analysis, reliability.
Unit IV
Failure Analysis: Steps, back ground information collection, preliminary examination, NDT for failure analysis, destructive testing, determination of type of fractures, micro and macroscopy of fractured surfaces, metallography of failed components and chemical analysis.
Unit V
Ductile and brittle fracture, fatigue failure, wear failure, hydrogen induced failure, environment induced failures, high temperature failure, faulty heat treatment and design failures, processing failure (forging, casting, machining etc.).
Unit VI
Failure problems in joints and weldments, case studies for failure analysis of structural components and mechanical system.
Course Outcomes: At the end of course, students will be able to CO1: understand and be able to identify the common modes of failure of engineering components CO2: recognize the failure mechanism and identify alternate materials and/or service conditions that prolong component life CO3: incorporate the materials failure knowledge in selecting appropriate materials for engineering applications
Reference books:
1. James J. Scutti, Introduction to Failure Analysis and Prevention, ASM International. 2. ASM Handbook, Editor: W.T. Becker and R.J. Shipley, Volume 11: Failure Analysis and Prevention Fractography, ASM Handbook, Vol. 12.

Course Code	Course Name	Course Category	L-T-P	Credits
21EAD1206	Product Design and Development	PCC	2-0-1	3

Unit I

Introduction to course, Product life-cycle, Product policy of an organization. Selection of a profitable product, Product design process, Product analysis.

Unit II

Value engineering in product design; Advantages, Applications in product design, Problem identification and selection, Analysis of functions, Anatomy of function.

Unit III

Primary versus secondary versus tertiary/unnecessary functions, Functional analysis: Functional Analysis System Technique (FAST), Case studies.

Unit IV

Introduction to product design tools, QFD, Computer Aided Design, Robust design.

Unit V

Design for X (DFX), Design for Manufacturing (DFM), Design for Assembly (DFA), Ergonomics in product design, DFMA Guidelines.

Unit VI

Product design for manual assembly, Design guidelines for metallic and nonmetallic products to be manufactured by different processes such as casting, machining, injection molding etc., Rapid prototyping, needs, advantages, working principle of SLA, LOM and SLS.

Course Outcomes:

At the end of the course, student will be able to

CO1: gain the practical knowledge regarding conceptualization, design and development of a new product

CO2: describe an engineering design and development process

CO3: Demonstrate individual skill using selected manufacturing techniques

Reference books:

1. Anita Goyal, Karl T Ulrich, Steven D Eppinger, “Product Design and Development “, 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9
2. Kevin Otto, Kristin Wood, “Product Design”, Indian Reprint 2004, Pearson Education, ISBN 9788177588217
3. Clive L.Dym, Patrick Little, “Engineering Design: A Project-based Introduction”, 3rd Edition, John Wiley & Sons, 2009, ISBN 978-0-470-22596-7
4. George E.Dieter, Linda C.Schmidt, “Engineering Design”, McGraw-Hill International Edition, 4th Edition, 2009, ISBN 978-007-127189-9 4.
5. Yousef Haik, T. M. M. Shahin, “Engineering Design Process”, 2nd Edition Reprint, Cengage Learning, 2010, ISBN 049566814

Course Code	Course Name	Course Category	L-T-P	Credits
21EAD1282	Mechanical Behavior of Materials Laboratory	PCC	0-0-3	2

Week	Exercises
1	Tensile test with and without extensometer, stress-strain curve and Young's modulus determination
2	Tensile testing of polymer
3	Compression test of material
4	Fracture behavior of materials, ductile and brittle failure and define their fracture toughness values
5	Low cycle fatigue of materials
6	High cycle fatigue of materials
7	Effect of microstructure on mechanical properties (verify Hall-Petch formula)
8	Define fracture toughness using impact test
9	High temperature behavior (creep) of material
10	Scanning electron microscope to analyze fracture behavior

Course outcomes:

Students will be able to

CO1: know the microstructural aspects of fracture behavior.

CO2: know the effect of cyclic loading on the life of a component.

CO3: analyse the fracture surface of the material and reasons for the probable failure.

CO4: apply concepts to real-life situations by using appropriate mechanical tests.

Reference: Lab manual

Professional Elective Courses
Product Design Stream

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX11	Computer Applications in Design	PEC	3-0-0	3

Unit I
Points, lines and planar curves: Vector algebra shapes inside a computer: review of geometry and trigonometry, points in a plane: position vectors, angles between lines - introducing the third dimension: scalar products, finding normal to planes: vector products.
Unit II
Lines in space: Vector equations: Lines in two-dimensional space, in three-dimensional space, different parametric forms; lines and common curves; parametric and Cartesian forms; linearity and non-linearity, functions, the parabola, the circle, the ellipse, the circular helix transformations: matrix algebra, tools for transformations, matrices, adding and subtracting matrices, multiplying matrices; moving in a plane: scaling, reflection and rotation; matrices as geometric operators, scaling position vectors, reflecting position vectors in the axes, rotating position vectors about the origin, transforming polygons.
Unit III
Combining transformations: Translations, order in combining transformations, specific combinations of transformations, translations, (3x3) matrices for transformations in a plane sizing things up, homogeneous vectors, simple homogeneous vectors, general homogeneous vectors, matrix operations using homogeneous vectors, non-standard rotations and reflections, the viewing transformation, rotation about an arbitrary point, reflection in an arbitrary line, the viewing transformation. **The third dimension**: Moving along rays, points at infinity and three-dimensional transformations: geometrical insights using homogeneous vectors, completing consideration of (3*3) matrices, points at infinity, three dimensional transformations, some specific (4x4) matrices, local scaling, reflections in the coordinate planes, rotations about the coordinate axes, translation, overall scaling.
Unit IV
Points of view: Projection and single point perspective: Projection from three dimensions onto a plane, Orthographic projection, The need for perspective, Single point perspective, Perspective projection, Tunnel perspective, To improve realism A greater sense of perspective: Two point and three point perspective: Improving perspective, Translation then single point perspective, Rotation then single point perspective, giving two points perspective, Rotation, translation then single point perspective improved two point perspective, Two rotations, translation then single point perspective, giving three point perspective, The three types of perspective-projection, Vanishing points and trace points Space curves and surfaces: Differentiation, Slopes of lines and planar curves: Gradient functions: Lines and curves, Slope of a straight line from its Cartesian equation, Slope of a curve from its Cartesian equation, Practical rules for differentiation, Slope of a straight line from its vector equations **Slopes of space curves**: Tangents and normal, Space curves, the tangent vector to a space curve,

Tangents and normal for curves in a plane, Tangents and normal in three dimensions.
Unit V
Curve fitting: Interpolation and shape function: Lines and curves from real objects, Linear interpolation, Quadratic interpolation, Uniqueness Planes and surfaces: Bi parametric forms: sweeps and revolutions, Surface formulae and two parameters, Vector equations of planes, The vector equation of a plane, given two vectors in the plans, The vector equation of a plane, given two unit vectors in the plane, The vector equation of a plane, given three points in a plane, Parameter lines and parameter planes, Plotting a plane, The implicit form of equation of a plane, Generating a swept surface, Generating a surface of revolution Wire frame surfaces surface Tangents and normal: Partial differentiation: General surfaces, Forming a wire frame, Carved surfaces from the, Partial differentiation, Surface tangents and surface normal. Piecewise surfaces Quadrilateral patches: Dividing up surfaces, A quadrilateral patch on a sphere, Bilinear patches, Linear Coons patches.
Unit VI
Fundamentals of solid modeling, boundary representation (B-rep), Constructive Solid Geometry (CSF), sweep representation, Analytic Solid Modeling (ASM), other representations; solid manipulations, solid modeling based applications: mass properties calculations, mechanical tolerancing, etc.
Course outcomes: At the end of the course the student will be able to: CO1. Develop expertise in generation of various curves, surfaces and volumes used in geometric modeling systems. CO2. Design, implements, and evaluates a computer-based system, process, component, or program to meet desired needs. CO3. Analyze a problem, and identify and define the computing requirements appropriate to its solution.
Reference books:
1. Computer Graphics, Mathematical first steps, P A Eagerton and W S Hall, Prentice Hall, Europe,1998, ISBN: 0-13-599572-8 2 CAD/CAM Concepts and Applications. 2. CAD/CAM Principles and Applications, P.N. Rao, 3rd Ed., McGraw Hill, Education Pvt Ltd., New Delhi ISBN 0-07-058373-0. 3. Mastering CAD/CAM, Ibrahim Zeid, 2nd Ed., TMH Publishing Company Limited., New Delhi, ISBN 0-07-0634334-3. 4. Chennakesava R Alavala, 1st Ed PHI, New Delhi, 2009 ISBN 978-81-203-3340-63.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX12	Design Optimization and Decision Theory	PEC	3-0-0	3

Unit I

Engineering Design Practice: Evolution of design technology, introduction to design and the design process, design versus analysis, role of computers in design cycle, impact of CAE on design, numerical modeling with FEA and correlation with physical tests.
Applications of optimization in engineering design: automotive, aerospace and general industry applications, optimization of metallic and composite structures, minimization and maximization problems, MDO and MOO.

Unit II

Optimum Design Problem Formulation: Types of optimization problems, the mathematics of optimization, design variables and design constraints, feasible and infeasible designs, equality and inequality constraints, discrete and continuous optimization, linear and non-linear optimization.
Optimization theory–fundamental concepts, global and local minimum, gradient vector and Hessian matrix, concept of necessary and sufficient conditions, constrained and unconstrained problems, Lagrange multipliers and Kuhn Tucker conditions.

Unit III

Sensitivity Analysis: Linear and non-linear approximations, gradient based optimization methods– dual and direct.
Optimization Disciplines: Conceptual design optimization and design fine tuning, combined optimization, optimization of multiple static and dynamic loads, transient simulations, equivalent static load methods, internal and external responses, design variables in each discipline.

Unit IV

Manufacturability in Optimization Problems: Design for manufacturing, manufacturing methods and rules, applying manufacturing constraints to optimization problems.

Unit V

Design Interpretation: Unbound problems, over constrained problems, problems with no of multiple solutions, active and inactive constraints, constraint violations and constraint screening, design move limits, local and global optimum.

Unit VI

Dynamic Programming: Introduction, multistage decision processes, principle of optimality, computational procedure in dynamic programming, initial value problem, examples.

Course outcomes:
At the end of the course the student will be able to:
CO1. Identify and apply relevant problem solving methodologies.
CO2. Design components, systems and/ or processes to meet required specification.

CO3. Optimize an existing design with single or multiple objective functions.

CO4. Apply decision-making methodologies to evaluate solutions for efficiency, effectiveness and sustainability

Reference books:

1. S.S.Rao, Engineering Optimization: Theory and Practice, John Wiley, 2009
2. Jasbir Arora, Introduction to Optimum Design, McGraw Hill, 2011
3. Optimisation and Probability in System Engg-Ram, Van Nostrand.
4. Optimization methods -K. V. Mital and C. Mohan, New age International Publishers

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX13	Product Reliability	PEC	3-0-0	3

Unit I

Introduction: Concepts of quality and reliability, a brief history, terms, definitions, reliability function, MTTF, Hazard rate function, bath tub curve, conditional reliability.

Constant failure rate models: Exponential reliability, failure modes, failure modes with exponential distribution, applications, two parameter exponential distribution, Poisson process.

Unit II

Time dependent failure models: Weibull distribution, burn-in screening for Weibull, three parameter Weibull distribution, normal and lognormal distributions.

Unit III

Reliability of systems: Series, parallel configurations, combined systems, k-out-of-n systems, complex configurations, common failure modes, minimal cuts and minimal paths.

Unit IV

State dependent systems: Markov analysis, load sharing, standby systems, degraded systems Physical reliability models: static models- random stress and random strength, dynamic models, periodic models, random loads.

Unit V

Design for reliability: Reliability specification, lifecycle costs, reliability allocation, design methods, failure analysis, FTA.

Unit VI

Reliability testing: Life testing, burn-in testing, acceptance testing-binomial acceptance testing.

Reliability growth testing: Reliability growth process, idealized growth curve, Duane growth model.

Reference books:

1. Introduction to Reliability and Maintenance engineering by Charles E Ebeling, Tata McGrawhill, India.
2. Introduction to Reliability Engineering by E.E. Lewis, John Wiley& Sons, NewYork
3. Reliability based design by S.S.Rao, McGraw-Hill, New York

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX14	Design and Analysis of Thermal Systems	PEC	3-0-0	3

Unit I

DESIGN CONCEPTS: Design principles, workable systems, optimal systems, matching of system components, economic analysis, depreciation, gradient present worth factor.

Unit II

MATHEMATICAL MODELLING: Equation fitting, nomography, empirical equation, regression analysis, different modes of mathematical models, selection, computer programs for models.

Unit III

MODELLING THERMAL EQUIPMENTS: Modeling heat exchangers, evaporators, condensers, absorption and rectification columns compressors, pumps, simulation studies, information flow diagram, solution procedures.

Unit IV

OPTIMIZATION: Objective function formulation, constraint equations, mathematical formulation, calculus method, dynamic programming, search methods, ANN and Genetic algorithm.

Unit V

DYNAMIC BEHAVIOUR: Steady state simulation, Laplace transformation, feedback control loops, stability analysis, non-linearities.

Reference books:

1. Stoecker W. F., Design of Thermal Systems, McGraw Hill Edition, 1989.
2. Bejan A., George Tsatsaronis , Michael J. Moran , Thermal Design and Optimization, Wiley,1996.
3. Kapur J. N., Mathematical Modelling , Wiley Eastern Ltd , New York , 1989.
4. Yogesh Jaluria , Design and Optimization of Thermal Systems , CRC Press , 2007.
5. Rao S. S., Engineering Optimization Theory and Practice, New Age Publishers, 2000.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX15	Mechatronics Product Design	PEC	3-0-0	3

Unit I

Introduction: Definition and introduction to mechatronic systems, modelling & simulation of physical systems, overview of mechatronic products and their functioning, measurement systems, control systems, simple controllers, study of sensors and transducers, pneumatic and hydraulic systems, mechanical actuation systems, electrical actuation systems, real time interfacing and hardware components for mechatronics.

Unit II

Electrical Actuation Systems: Electrical systems, mechanical switches, solid state switches, solenoids, DC & AC motors, stepper motors. System Models: Mathematical models, mechanical system building blocks, electrical system building blocks, thermal system building blocks, electro-mechanical systems, hydro-mechanical systems, pneumatic systems.

Unit III

Signal Conditioning: Signal conditioning, the operational amplifier, protection, filtering, Wheatstone bridge, digital signals, multiplexers, data acquisition, introduction to digital system processing, pulse-modulation.

Unit IV

MEMS and Micro systems: Introduction, working principle, materials for MEMS and Micro systems, micro system fabrication process, overview of micro manufacturing, micro system design, and micro system packaging.

Unit V

Data Presentation Systems: Basic system models, system models, and dynamic responses of system.

Unit VI

Advanced Applications in Mechatronics: Fault finding, design arrangements and practical case studies, design for manufacturing, user- friendly design.

Reference books:

1. W. Bolton, “Mechatronics” - Addison Wesley Longman Publication, 1999
2. HSU “MEMS and Microsystems design and manufacture” - TataMcGraw-Hill Education,2002
3. Kamm, “Understanding Electro-Mechanical Engineering an Introduction to Mechatronics” - IEEE Press, 1 Edition, 1996
4. Shetty and Kolk “Mechatronics System Design” - Cengage Learning, 2010
5. Mahalik “Mechatronics” - Tata McGraw-Hill Education, 2003
6. HMT “Mechatronics” - Tata McGraw-Hill Education, 1998
7. Michel .B. Histand& David. Alciatore, “Introduction to Mechatronics & Measurement Systems”–. Mc Grew Hill, 2002
8. “Fine Mechanics and Precision Instruments” - Pergamon Press, 1971.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX16	Design of Robotic System	PEC	3-0-0	3

Unit I

History of service robotics, present status and future trends, need for service robots, applications examples and specifications of service and field robots. Non-conventional industrial robots, Classification, applications, sensing and perception, social and ethical implications of robotics.

Unit II

Autonomous Mobile robots: Kinematics, locomotion, perception, motion planning and control, localization and mapping, road map path planning, intelligent unmanned vehicles, wheeled and legged, legged locomotion and balance, arm movement, gaze and auditory orientation control, facial expression, hands and manipulation, sound and speech generation, motion capture/learning from demonstration, human activity recognition using vision, touch, sound, vision, tactile sensing, models of emotion and motivation, performance, interaction, safety and robustness.

Unit III

Field Robots: Collision avoidance-robots for agriculture, mining, exploration, underwater, civilian and military applications, nuclear applications, space applications, industrial applications like cleaning robots, wall painting robots, wall plastering robots, vehicle equipment and building robots etc, load carrying robots, IDE detection and diffusion robots.

Unit IV

Underwater robots: Kinematics and dynamics, modeling and simulation, navigation, guidance and control, marine data collection (Temperature, other environment parameters).

Unit V

Aerial robots: Basics of aerial robots, sensors and actuators, modelling and control of small unmanned aerial vehicles, guidance and navigation of small range aerial robots, autonomous indoor flight control air defence robots.

Unit VI

Programming Languages: Introduction to various types such as RAIL and VAL II etc, features of type and development of languages for recent robot systems.

Course outcomes:

At the end of the course the student will 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 manipulator.

CO4. Analyze robots for underwater application.

CO5. To select type of robot for specific application.

Books for Reference:

1. Roland Siegwart, Illah Reza Nourbakhsh, DavideScaramuzza, Introduction to Autonomous Mobile Robots, Bradford Company Scituate, USA, 2004
2. RiadhSiaer, The future of Humanoid Robots- Research and applications, Intech Publications, 2012.
3. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India P Ltd., 2006.
4. Kelly, Alonzo; Iagnemma, Karl; Howard, Andrew, Field and Service Robotics, Springer, 2011

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX17	Design of Automobile Systems	PEC	3-0-0	3

Unit I

Body Shapes: Aerodynamic Shapes, drag forces for small family cars.
Fuel Injection: Spray formation, direct injection for single cylinder engines (both SI & CI), energy audit.

Unit II

Design of I.C. Engine I: Combustion fundamentals, combustion chamber design, cylinder head design for both SI & C. I. Engines.

Unit III

Design of I.C. Engine II: Design of crankshaft, camshaft, connecting rod, piston &piston rings for small family cars (max up to 3 cylinders).

Unit IV

Transmission System: Design of transmission systems – gearbox (max of 4- speeds), differential suspension System: Vibration fundamentals, vibration analysis (single & two degree of freedom, vibration due to engine unbalance, application to vehicle suspension.

Unit V

Cooling System: Heat exchangers, application to design of cooling system (water cooled).

Unit VI

Emission Control: Common emission control systems, measurement of emissions, exhaust gas emission testing.

Course outcomes:

At the end of the course the student will be able to:

CO1. Gain an insight into aspects of vehicle design, operation and maintenance, which will be useful for taking up a position in the automotive industry.
CO2. Apply the knowledge in creating a preliminary design of automobile subsystems.
CO3. Identify construction, working, preventive maintenance, trouble shooting and diagnosis of various Automobile Systems.
CO4. Identify Modern technology and safety measures used in Automotive Vehicles.

Reference books:

1. Design of Automotive Engines, -A.Kolchin &V. Demidov, MIR Publishers, Moscow.
2. The motor vehicle, Newtonsteeds &Garratte-Iliffee&sonsLtd.,London.
3. I.C. Engines -Edward FObert,International text book company.
4. Introduction to combustion-Turns.
5. Automobile Mechanic-, N.K.Giri, Khanna Publications, 1994
6. I.C. Engines -Maleev, McGraw Hill book company, 1976
7. Diesel engine design- HeldtP.M.,Chilton companyNew York.
8. Problems on design of machine elements- V.M. Faires &Wingreen, McMillan Company.,1965 Design of I.C.Engines -John Heywood, TMH.

Engineering Mechanics Stream

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX21	Experimental Mechanics	PEC	2-1-0	3

Unit I

Introduction: Definition of terms, calibration, standards, dimension and units, generalized measurement system, Basic concepts in dynamic measurements, system response, distortion, impedance matching, experiment planning.

Analysis of Experimental Data: Cause and types of experimental errors, error analysis. Statistical analysis of experimental data-probability distribution, Gaussian, Normal distribution. Chi-square test, method of least square, correlation coefficient, multivariable regression, standard deviation of mean, graphical analysis and curve fitting, general consideration in data analysis.

Unit II

Data Acquisition and Processing: General data acquisition system, signal conditioning revisited, data transmission, Analog-to-Digital and Digital-to-Analog conversion. Basic components (storage and display) of data acquisition system. Computer program as a substitute for wired logic.

Force, Torque and Strain Measurement: Mass balance measurement, elastic element for force measurement,torquemeasurement.Straingages,Strainsensitivityofgagemetals,gageconstruction,gag esensitivityandagefactor,performancecharacteristics,environmentaleffects,Straingagecircuits,Poten tiometer,WheatStone'sbridges,Constantcurrentcircuits.Strainanalysismethods-two element and three element, rectangular and delta rosettes, correction for transverse strains effects, stress gage-planes hear gage, stress intensity factor gage.

Unit III

Stress Analysis: Two Dimensional Photoelasticity, nature of light, wave theory of light, optical interference, polariscopes stress optic law effect of stressed model in plane and circular polariscopes, isoclinic, isochromatic fringe order determination, fringe multiplication techniques, calibration photo elastic model materials. Separation methods shear difference method, analytical separation methods, model to prototype scaling.

Unit IV

Three Dimensional Photoelasticity: Stress freezing method, general slice, effective stresses, stresses separation, shear deference method, oblique incidence method, secondary principals stresses, scattered light photoelasticity, polariscope and stress data analyses.

Unit V

Coating Methods:

a) Photoelastic coating method, Birefringence coating techniques, sensitivity reinforcing and thickness effects, data reduction, stress separation techniques, photo elastic strain gauges.

b) Brittle Coatings Method: Brittle coating technique, principles data analysis, coating materials, coating techniques.

c) Moiré technique, geometrical approach, displacement approach, sensitivity of Moiré data reduction, In-plane and out-plane Moiré methods, Moiré photography, Moiré grid production.

Unit VI

Holography: Introduction, equation for plane waves and spherical waves, intensity, coherence, spherical radiator as an object (record process), Hurter-Driffeld curves, reconstruction process, holograpic interferomerty, real time and double exposure methods, displacement measurement, isopachics.

Course outcomes:

At the end of the course the student will be able to:

C01: Mount strain gages, take measurements and analyze the obtained data.

C02: Design strain gage-based transducers for measuring specific loads.

C03: Describe the different methods photo elasticity for strain measurement viz, stress freezing, and Moirés method.

C04: Undertakeexperimentalinvestigationstoverifypredictionsbyothermethods.

C05: Apply the principles and techniques of brittle coating analysis.

C06: Apply the principles and techniques of holographic interferometry.

Reference books:

1. Holman, "Experimental Methods for Engineers" 7th Edition, Tata McGraw-Hill Companies Inc, NewYork, 2007.
2. R.S.Sirohi, H.C. Radha Krishna, "Mechanical measurements" New Age International Pvt. Ltd., New Delhi, 2004.
3. Srinath, Lingaiah, Raghavan Gargesa, Ramachandra and Pant, "Experimental Stress Analysis",Tata McGraw Hill,1984.
4. Nakra & Chaudhry, BC Nakra KK Chaudhry, "Instrumentation, Measurement And Analysis", Tata Mc Graw- Hill Companies Inc, NewYork, Seventh Edition, 2006.
5. DoeblinE.A., "Measurement Systems Application and Design", 4th (S.I.) Edition, McGraw Hill, NewYork 1989.
6. Montgomery D.C., "Design and Analysis of Experiments", John Wiley & Sons, 1997.
7. Dally and Riley, "Experimental Stress Analysis", McGraw Hill, 1991.
8. Sadhu Singh, "Experimental Stress Analysis", Khanna publisher, 1990.
9. M.M.Frocht, "Photoelasticity Vol-I and Vol-II", John Wiley and sons, 1969.
10. Perry and Lissner,"Strain Gauge Primer", McGraw Hill, 1962.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX22	Dynamics and Mechanisms Design	PEC	2-1-0	3

Unit I
Geometry of Motion: Introduction, analysis and synthesis, mechanism terminology, planar, spherical and spatial mechanisms, mobility, Grashoff's law, equivalent mechanisms, unique mechanisms. **Kinematic analysis of plane mechanisms**: Auxiliary point method using rotated velocity vector, Hall - Ault auxiliary point method, Goodman's indirect method, numerical examples.
Unit II
Generalized Principles of Dynamics: Fundamental laws of motion, generalized coordinates, configuration space, constraints, virtual work, principle of virtual work, energy and momentum, work and kinetic energy, equilibrium and stability, kinetic energy of a system, angular momentum, generalized momentum. **Lagrange's Equation**: Lagrange's equation from D'Alembert's principles, examples, Hamiltons equations, Hamiltons principle, Lagrange's, equation from Hamiltons principle, derivation of Hamiltons equations, numerical examples.
Unit III
Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, path generation and body guidance, precision positions, structural error, Chebychev spacing, two position synthesis of slider crank mechanisms, crank-rocker mechanisms with optimum. **Transmission angle Motion Generation**: Poles and relative poles, location of poles and relative poles, curvature, inflection circle, numerical examples.
Unit IV
Graphical Methods of Dimensional Synthesis: Two position synthesis of crank and rocker mechanisms, three position synthesis, four position synthesis (point precision reduction) overlay method, coupler curve synthesis, cognate linkages. **Ana1ytical Methods of Dimensional Synthesis**: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, analytical synthesis using complex algebra.
Unit V
System Dynamics: Gyroscopic action in machines, Euler's equation of motion, phase plane representation, phase plane analysis, response of linear systems to transient disturbances.
Unit VI
Spatial Mechanisms: introduction, position analysis problem, velocity and acceleration analysis, Eulerian angles, numerical examples.
Course outcomes: At the end of the course the student will be able to: CO1. Apply the tools of analytical dynamics with the main goal of developing mathematical

models that describe the dynamics of systems of rigid bodies. CO2. Formulate equations of motion for complicated mechanical systems /linkages and hods for solving these equations. CO3. Understand multi body dynamics in mechanical engineering design.
Reference books:
1. K.J.Waldron & G.L.Kinzel , "Kinematics, Dynamics and Design of Machinery", Wiley India, 2007. 2. Greenwood, "Classical Dynamics", Prentice Hall of India, 1988. 3. J E Shigley, "Theory of Machines and Mechanism" -McGraw-Hill, 1995 4. A.G.Ambekar , "Mechanism and Machine Theory", PHI, 2007. 5. Ghosh and Mallick , "Theory of Mechanism and Mechanism", East West press.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX23	Theory of Plates and Shells	PEC	2-1-0	3

Unit I

Introduction: Space curves, surfaces, shell co-ordinates, strain displacement relations, assumptions in shell theory, displacement field approximations, stress resultants, equation of equilibrium using principle of virtual work, boundary conditions.

Unit II

Static Analysis of Plates: Governing equation for a rectangular plate, Navier solution for simply- supported rectangular plate under various loadings, levy solution for rectangular plate with other boundary conditions.

Unit III

Circular Plates: Analysis under Axi- Symmetric loading, governing differential equation in polar co-ordinates, approximate methods of analysis- Rayleigh-Ritz approach for simple cases in rectangular plates.

Unit IV

Static Analysis of Shells: Membrane Theory of Shells - Cylindrical, Conical and Spherical Shells.

Unit V

Shells of Revolution: with Bending Resistance - Cylindrical and Conical Shells, Application to Pipes and Pressure Vessels.

Unit VI

Thermal Stresses in Plate/ Shell

Course Outcomes:

At the end of the course, students will be able to

CO1. Use analytical methods for the solution of thin plates and shells.

CO2. Use analytical methods for the solution of shells.

CO3. Apply the numerical techniques and tools for the complex problems in thin plates.

CO4. Apply the numerical techniques and tools for the complex problems in shells.

Reference books:

1. Theory of Plates and Shells, Timoshenko S. and KriegerW., McGraw Hill.
2. Stresses in Plates and Shells, UguralAnsel C., McGraw Hill
3. Thin Elastic Shells, Kraus H., John Wiley and Sons.
4. Theory of Plates, Chandrashekhara K., Universities Press.
5. Design and Construction of Concrete Shells, Ramaswamy G.S

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX24	Mechanics of Composite Materials	PEC	2-1-0	3

Unit I
Introduction to Composite Materials: Definition, classification, types of matrices material and reinforcements, characteristics & selection, fiber composites, laminated composites, particulate composites, pre-pegs, and sandwich construction **Metal Matrix Composites**: Reinforcement materials, types, characteristics and selection, base metals, selection, applications, macro mechanics of a lamina: Hooke's law for different types of materials, number of elastic constants, derivation of nine independent constants for orthotropic material, two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - numerical problems, invariant properties, stress-strain relations for lamina of arbitrary orientation, numerical problems.
Unit II
Micro Mechanical Analysis of a Lamina: Introduction, evaluation of the four elastic moduli, rule of mixture, numerical problems, experimental characterization of lamina- elastic moduli and strengths. **Failure Criteria**: Failure criteria for an elementary composite layer or ply, maximum stress and strain criteria, approximate strength criteria, inter-laminar strength, Tsa-Hill theory, Tsai, Wutensor theory, numerical problems, practical recommendations.
Unit III
Macro Mechanical Analysis of Laminate: Introduction, code, Kirchhoff hypothesis, classical lamination theory, A, B, and D matrices (detailed derivation), special cases of laminates, numerical problems. Shear deformation theory, A, B, D and E matrices (detailed derivation).
Unit IV
Analysis of Composite Structures: Optimization of Laminates, composite laminates of uniform strength, application of optimal composite structures, composite pressure vessels, spinning composite disks, composite lattice structures. **Applications:** Aircrafts, missiles, space hardware, automobile, electrical and electronics, marine, recreational and sports equipment-future potential of composites.
Unit V
Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion.
Unit VI
Manufacturing and Testing: Layup and curing - open and closed mould processing, hand lay-up techniques, bag moulding and filament winding, pultrusion, pulforming, thermoforming, injection moulding, cutting, machining, joining and repair. NDT tests– purpose, types of defects, NDT method - ultrasonic inspection, radiography, acoustic emission and acoustic ultrasonic method.

Course outcomes:

At the end of the course the student will be able to:

CO1. Understand the use of fibre-reinforced composites in structural applications.

CO2. Develop a basic understanding of the use of composite materials, micro-mechanics of layered composites, analysis and design of composite structures and failure analysis of laminated panels.

CO3. Apply the basic micro-mechanics theories in the design of fibre reinforced composites.

CO4. Analyze the performance of composites in engineering applications.

Books for Reference:

1. Autar K. Kaw, Mechanics of Composite materials, CRC Press, 2nd Ed, 2005.
2. Madhijit Mukhopadhay, Mechanics of Composite Materials& Structures, Universities Press,2004.
3. J.N.Reddy, Mechanics of Laminated Composite Plates & Shells,CRDPress,2ndEd,2004.
4. Mein Schwartz, Composite Materials handbook, McGraw Hill, 1984.
5. Rober M. Jones, Mechanics of Composite Materials, Taylor & Francis, 1998.
6. MichaelW, Hyer,Stress analysis of fiber Reinforced Composite Materials, McGraw Hill International, 2009.
7. Composite Material Science and Engineering, Krishan K.Chawla, Springer,3e, 2012.
8. P.C. Mallik, Fibre Reinforced Composites, Marcel Decker, 1993.
9. P.C. Mallik, Hand Book of Composites, Marcel Decker, 1993.

Materials and Manufacturing

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX31	Modern Engineering Materials	PEC	3-0-0	3

Unit I
Elastic moduli, coefficient of thermal expansion: how properties are related with the bonding between the atoms, packing of atoms in solids, and crystal structure.
Unit II
Plastic deformation of materials: yield strength, tensile strength, ductility and toughness of materials, perfect crystal, role of dislocations, strengthening methods, and continuum aspects of plastic flow.
Unit III
Fatigue, fracture and creep of materials, ductile and brittle failure, micro mechanism of failure, fatigue failure, creep deformation and failure, mechanism of creep, and oxidation and corrosion of materials.
Unit IV
Carbon steels, alloy steels, TRIP steel, dual-phase steel, bainitic steel, martensitic steel, aluminum alloys, titanium alloys, and carbon nanotubes.
Unit V
Structure and properties of novel engineering materials: polymers, ceramics, composite materials, hybrid materials, metal foams, nanocrystalline materials, and smart materials.
Unit VI
Introduction to electronic and opto electronic materials, electronic polymers, biomaterials, and energy materials
Course outcomes: At the end of the course the student will be able to: CO1: describe the crystal structures and atomic packing in solids. CO2: describe the strengthening methods of materials. CO3: identify the type of failure of the material it undergoes whether it is a ductile or brittle and fatigue or creep failure. CO4: identify the difference between various engineering materials and their properties.
Reference books:
1. M. F. Ashby, D. R. H. Jones, Engineering Materials I and II, 4th Ed., Butterworth Heinemann, 2013. 2. Dieter, G. E., Mechanical metallurgy, McGraw Hill. **3.** Garofalo, F., Fundamentals of creep and creep rupture in metals, McMillan.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX32	Microstructural Characterization of Materials	PEC	3-0-0	3

Unit I
Optical Microscopy: techniques, polarised and interferometry phase contrast. In-situ metallography, color metallography, inclusion characterization.
Unit II
Quantitative Microscopy: techniques diffraction Techniques: X-ray diffraction technique for phase identification, strain & particle size, phase diagram and texture determinations, synchrotron radiation, neutron diffraction.
Unit III
Scanning electron microscopy and Electron probe micro analysis: principles of image formation in SEM and application, energy dispersive X-ray analysis and wavelength dispersive X-ray analysis, electron probe micro analysis and its application for chemical analysis, scanning transmission electron microscopy.
Unit IV
Transmission and analytical electron microscopy: formation of image and selection area diffraction patterns, theories of image contrast and their application to perfect and imperfect crystalline specimens, high resolution electron microscopy, analytical electron microscopy, convergent beam electron diffraction, micro diffraction, composition analysis by EELS.
Unit V
Surface probe microscopy: scanning tunneling microscopy, atomic force microscopy.
Unit VI
Spectroscopy: atomic absorption spectroscopy, UV/Visible spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy.
Course outcomes: Students will be able to CO1: apply appropriate characterization techniques for microstructure examination at different magnification level and use them to understand the microstructure of various materials CO2: choose and appropriate electron microscopy techniques to investigate microstructure of materials at high resolution CO3: determine crystal structure of specimen and estimate its crystallite size and stress CO4: use appropriate spectroscopic technique to measure vibrational / electronic transitions to estimate parameters like energy band gap, elemental concentration, etc.
Reference books:
1. Cullity, B.D., Elements of X- Ray diffraction, Addison Wesley 2. Sridhar, G., Ghosh Choudhary, S., and Goswami, N. G., Materials characterization techniques (ed) NML, Jamshedpur. 3. Williams, D.B., and Carter, C.B., Transmission electron microscopy: A Text Book of

Materials Science.

4. Krishna, R., Anantraman, T.R., Pande, C.S., Arora, O.P., Advanced techniques for microstructural characterization (ed), Trans Tech Publication.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX33	Advanced material technology	PEC	3-0-0	3

Unit I
Introduction: Classification of materials with special reference to advanced materials, ceramics, refractory materials, abrasives, and cements.
Unit II
Polymer materials: Introduction, mechanical characteristics of polymers, semicrystalline polymers, elastomers, plastics, fibers, applications, advanced polymeric materials, polymerization, polymer additives, forming techniques for plastics, fabrication of elastomers, fibers and films.
Unit III
Composites: Introduction, fiber phase, matrix phase, polymer matrix composites, metal matrix composites, ceramic matrix composites, carbon-carbon composites, hybrid composites, processing of fiber reinforced composites, laminar composites, sandwich panels, liquid state methods and solid state methods. Surface composite materials, applications and manufacturing methods.
Unit IV
Functional materials: Processing of functionally graded materials, magnetic materials, piezoelectric materials, semiconductors, smart materials, applications and future scope**.**
Unit V
Biomaterials: History of biomaterials, classification of biomaterials: materials perspective – metallic, ceramic, polymer and composite based materials; based on functioning – bonier, bioactive, bioresorbable, regenerative. Steps involved in developing novel biomaterials, designing new biomaterials, designing medical devices and implants, manufacturing processes, materials for hip joints, knee joints, orthopedic implants, cardiovascular implants, challenges and future scope.
Unit VI
Nanomaterials: Introduction, properties of nanomaterials, effect of size reduction on properties, Synthesis techniques for preparation of nanoparticle – Bottom Up Approach –Top Down Approach Graphene, and carbon nanotubes, applications of nano technology.
Course outcomes: Students will be able to CO1: understand the various composite materials CO2: describe the manufacturing techniques to prepare the composites. CO3: understand about various types of composites.
Books for Reference:
1. William D. Callister, Jr. ,Materials science and engineering an introduction, John Wiley & Sons, Ltd., Singapore.

2. Sam Zhang, Lin Li, Ashok Kumar., Materials Chracterization Techniques, Taylor & Francis Group, CRC Press, New York.
3. Advanced Materials Source Book by Jon Binner, Paul Hogg and John Murphy, Elsevier publishers
4. Biomaterials – An Introduction, Joon Park and R.S. Lakes by Springer publishers
5. Nano science and nano technology by M.S Ramachandra Rao, Shubra Singh, Wiley publishers.
6. Textbook of Nanoscience and Nanotechnology by B.S. Murty, P. Shankar, B. Raj, B.B. Rath, J. Murday, Springer publishers
7. Introduction to Nano Technology by Charles P. Poole, Jr., Frank J.Owens, Wiley publishers.
8. Nanotechnology by Jermy J Ramsden, Elsevier publishers.
9. Nanotechnology the Science of Small by M.A Shah, K.A Shah, Wiley Publishers.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX34	Computational methods in manufacturing processes	PEC	3-0-0	3

Unit I

Design of Experiment Methods in Manufacturing: Basics and Practical applications: Introduction, basic terminology, response, levels of the factors, experimental plan – factorial experiments, resolution level, more specialized designs, strategy and principal steps in using DOE.

Unit II

Stream-of-Variation Based Quality Assurance for Multi-station Machining Processes-Modeling and Planning: Introduction, 3D variation propagation modeling, process planning, case study, conclusions.

Unit III

Finite Element Modeling of Chip Formation in Orthogonal Machining: Introduction, basics of machining, basics of FEM, brief history of FEM in machining, formulation of Two-Dimensional FE model for machining, case studies in ABAQUS platform.

Unit IV

Single and Multi-objective Optimization Methodologies in CNC Machining:
Introduction, modeling machining optimization, building meta-models for machining processes using artificial neural networks, genetic and evolutionary algorithms, variation of evolutionary algorithms

Unit V

Numerical Simulation and Prediction of Wrinkling Defects in Sheet Metal Forming:
Introduction and State-of-the-Art, constitutive isotropic and anisotropic models, benchmarks' numerical analysis, results and discussions, free-forming of a conical cup, results and discussions, flange-forming of a cylindrical cup.

Unit VI

Manufacturing Seamless Reservoirs by Tube Forming: Finite Element Modeling and Experimentation: Introduction, innovative manufacturing process, mechanical testing of materials, theoretical and experimental background, mechanics of the process, applications.

Reference books:

1. Statistical and Computational Techniques in Manufacturing by J. Paulo Davim
2. Computational Methods for Optimizing Manufacturing Technology: Models and Techniques by J. Paulo Davim.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX35	Material testing and characterization	PEC	2-0-2	3

Unit I

Material Testing: Tensile test of Metals, ceramics and polymers; Hardness testing of materials; Hardness at elevated temperature, Tension and Torsion Tests, Creep.

Unit II

Introduction to surface properties, tribological studies, wear, surface analysis, surface roughness and surface energy measuring techniques.

Unit III

Microstructural observations, introduction to optical microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), scanning tunneling electron microscope (STEM), atomic force microscope (AFM), florescent microscopy.

Unit IV

Introduction to X-Ray diffraction (XRD) method, scanning parameters, indexing, Bragg's Law, phase identification and analysis.

Unit V

Spectroscopy: Atomic absorption spectroscopy, UV/Visible spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy.

Unit VI

Thermal Analysis: Thermogravimetric analysis, Differential thermal analysis, Differential Scanning calorimetry, and Thermomechanical analysis and dilatometry.

Course outcomes:

Students will be able to

CO1: Identify the microstructural based dependencies of mechanical failure in engineering materials, including yielding, fracture, fatigue, and creep; and apply these principles to design and process failure-resistant materials.

CO2: Apply appropriate characterization techniques for microstructure examination at different magnification level.

CO3: Understand the crystal structure determination and phase analysis of the materials.

CO4: Able to examine the thermal behavior of the materials.

Reference books:

1. An Introduction to Materials Characterization, P. R. Khangaonkar; Penram Publishers, 2010.
2. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Yang Leng; 2nd ed., Wiley, 2013.
3. Scanning Electron Microscopy and X-Ray Microanalysis, Joseph Goldstein, Eric Lifshin, Charles E. Lyman, David C. Joy and Patrick Echlin; 3rd ed., Springer, 2003.
4. Physical Methods for Materials Characterisation, P.E.J.Flewitt, R.K.Wild ; Institute of Physics Publishing Ltd., 1994.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX36	Additive Manufacturing	PEC	2-0-2	3

Unit I
Introduction Additive Manufacturing: Additive Manufacturing Process, Generic Additive Manufacturing Process, Distinction Between Additive Manufacturing and CNC Machining, Benefits and Applications. **Development of Additive Manufacturing Technology**: Computer-aided design technology, laser technology, printing technologies, programmable logic controllers, materials, computer numerically controlled machining, classification of additive manufacturing processes, metal systems, hybrid systems.
Unit II
Eight Steps in Additive Manufacturing, Metal Systems: Use of substrates, energy density, weight, accuracy, speed; maintenance of equipment, materials handling issues, design for additive manufacturing. **Vat Polymerization Processes**: Introduction, vat photopolymerization materials, reaction rates, laser scan vat polymerization, photopolymerization process modelling, scan patterns.
Unit III
Powder Bed Fusion Processes: Introduction, materials: metals, polymers, ceramics, and composites; powder fusion mechanisms: solid state sintering, chemically induced sintering, lps and partial melting, full melting, part fabrication; process parameters and modeling, powder handling: powder handling challenges, powder handling systems, powder recycling; advantages and limitations.
Unit IV
Direct Energy Deposition (DED) Processes: Introduction, general DED process description, material delivery: powder feeding, wire feeding; DED systems: laser based metal deposition processes, electron beam based metal deposition processes, process parameters, typical materials and microstructure, processing-structure-properties relationships, advantages and limitations.
Unit V
Extrusion-Based Systems: Introduction, material loading, liquification, extrusion, solidification, positional control, bonding, support generation, plotting and path control, fused deposition modeling (FDM), limitations of FDM, bioextrusion. **Sheet Lamination Processes**: Introduction, bond-then-form processes, form-then-bond processes, materials, material processing, ultrasonic additive manufacturing (UAM), UAM process parameters and process optimization, microstructures and mechanical properties of UAM parts, UAM applications.
Unit VI
Post-Processing: Introduction, support material removal: natural support post-processing, synthetic support removal; surface texture improvements, accuracy improvements: sources of inaccuracy, model pre-processing to compensate for inaccuracy; machining strategy, preparation for use as a pattern, property enhancements using non-thermal techniques, property enhancements

using thermal techniques.
Course outcomes: Students will be able to CO1: know various additive manufacturing processes. CO2: know the type of additive manufacturing process one has to adopt for producing a component. CO3: know the advantages and limitations of a given process to produce a component.
Reference books:
1. Gibson, D. Rosen, B. Stucker, Additive Manufacturing Technologies, Springer, 2015. 2. Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications 3. Gebhardt, Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing, LAP LAMBERT Academic Publishing, 2012.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX37	Analysis and Modeling of Welding	PEC	3-0-0	3

Unit I
Introduction to fusion welding processes, Heat sources, Heat removal.
Unit II
Thermal modelling, zones in a weldment, phase change.
Unit III
Fluid flow in the weld pool, fusion zone, conduction mode and keyhole mode.
Unit IV
Introduction to micro segregation, solute redistribution – microscale, microstructure evolution.
Unit V
Solute transfer – macroscale, defects in fusion welds, effects of dilution, weld cladding.
Unit VI
Distortion in welding, dissimilar welding, solutions to dissimilar welding, integrated approach.
Course outcomes: Students will be able to CO1: know the modelling of fusion welding processes. CO2: know the modelling of weld pool with various issues. CO3: know the modelling of dissimilar joints.
Reference books:
5. Sindo kou, "Welding metallurgy", Wiley Interscience, 2nd Edition (2002). 6. Welding processes and technology, *R. S. Parmar, Khanna publications*, India. 7. Richard Little, Welding and Welding Technology.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX38	Materials Joining Technology	PEC	3-0-0	3

Unit I

Introduction to welding, classification, welding arc, structure and characteristics, types, arc blow, methods of arc initiation, arc stability and efficiency, welding machine characteristics (arc and solid state) – volt ampere characteristics, duty cycle, AC welding, DC welding power source, rectified D.C. welding power sources.

Unit II

Arc welding processes: manual metal arc welding, gas metal arc welding, TIG welding, flux cored arc welding, plasma welding
Resistance spot welding, resistance seam welding , resistance projection welding
High energy density welding processes – Electron beam welding, Laser beam welding
Solid phase techniques – Forge welding, friction welding, friction stir welding, explosive welding, ultrasonic welding.

Unit III

Heat flow in welding – temperature distribution in welding, efficiency of heat sources, heat flow and cooling rates in welding, welding stresses– causes, measurement and calculations, method of relieving and controlling, distortion in welding.
Weldability – weldability assessment, weldability tests – hot cracking tests, cold cracking tests, actual welding tests.

Unit IV

Welding metallurgy of ferrous alloys: problems in low carbon steels, problems in low alloy steels, problems in high alloy steels.

Unit V

Aluminum alloys: solidification cracking, liquation cracking, welding problems in heat-treatable alloys.

Unit VI

Titanium alloys: issues in α-alloys, α+β alloys, and β alloys.
Nickel base super alloys: strain age cracking, HAZ micro fissuring, poor fusion zone toughness & ductility, solidification cracking.

Course outcomes:

Students will be able to
CO1: understand the various welding processes.
CO2: know the issues of welding of various materials.
CO3: know the various weldability tests.

Reference books:

1. Principles of welding, Robert W. Messler Jr., Weley-VCH.
2. Welding processes and technology, *R. S. Parmar*, *Khanna publications*, India.
3. P N Rao, *Manufacturing Technology: Foundry, Forming and Welding*.
4. Richard Little, Welding and Welding Technology.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX39	Design for Manufacturing	PEC	3-0-0	3

Unit I

Introduction: Need identification and problem definition, concept generation and evaluation, embodiment design.

Unit II

Selection of materials and shapes: Properties of engineering materials, selection of materials-I, selection of materials-II, case studies-I, selection of shapes, co-selection of materials and shapes, case studies-II.

Unit III

Selection of manufacturing processes-I: Review of manufacturing processes, design for casting, design for bulk deformation processes, design for sheet metal forming processes.

Unit IV

Selection of manufacturing processes-II: Design for machining, design for powder metallurgy, design for polymer processing, co-selection of materials and processes, case studies-III.

Unit V

Design for assembly: Review of assembly processes, design for welding-I, design for welding-II, design for brazing and soldering, design for adhesive bonding, design for joining of polymers, design for heat treatment, case studies-IV.

Unit VI

Design for reliability and quality: Failure mode and effect analysis, design for quality, design for reliability, approach to robust design, design for optimization.

Course outcomes:

Students will be able to

CO1: know the design of various manufacturing processes.

CO2: select the correct engineering material for a given application.

CO3: know the design of various joining techniques.

Reference books:

1. M.F. Ashby and K. Johnson, Materials and Design - the art and science of material selection in product design, Butterworth- Heinemann, 2003.
2. G Dieter, Engineering Design - a materials and processing approach, McGraw Hill, NY, 2000.
3. M F Ashby, Material Selection in Mechanical Design, Butterworth- Heinemann, 1999.
4. T H Courtney, Mechanical Behavior of Materials, McGraw Hill, NY, 2000.
5. K G Swiftk and J D Booker, Process selection: from design to manufacture, London: Arnold, 1997.

6. S S Rao, Engineering Optimization: theory and practice, John Wiley, NY, 1996.
7. G Boothroyd, P Dewhurst and W Knight, Product design for manufacture and assembly, John Wiley, NY: Marcel Dekkar, 1994.
8. J G Bralla, Handbook for Product Design for Manufacture, McGraw Hill, NY, 1998.
9. Houldcroft, Which Process – an introduction to welding and related processes and guide to their selection, Cambridge, Abington Pub, 1990.
10. ASTM Design handbook.

Energy and Fluid Systems

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX41	Advanced Fluid Mechanics	PEC	2-1-0	3

Unit I

Kinematics of Flow: Equation of continuity in Cartesian, polar and cylindrical coordinates.

Unit II

Standard 2D Flow Patterns: Source, sink, doublet and their combinations, construction of flows by superposition, D'Alembert's paradox.

Unit III

Laplace Equation: Solution by graphical and relaxation methods, conformal mapping, solution by separation of variables.

Unit IV

Laminar Flow: Derivation of Navier-Stokes equations – exact solutions for flow between parallel plates, Couette flow, flow near a suddenly accelerated plate and an oscillating plate.

Unit V

Boundary Layers: Similarity solutions of boundary layer equations, Falkner-Skan wedge flows, Karman's momentum integral equations, Karman-Pohlhausen approximate solution, separation in boundary layer under adverse pressure gradient, turbulent boundary layer.

Unit VI

Turbulent Flows: Reynolds equations of motion, semi-empirical theories of turbulence, velocity profiles for inner, outer and overlap layers, equilibrium boundary layers.

Measurement of Turbulence and Statistical Theory of Turbulence: Isotropic and homogeneous turbulence, probability density functions, correlation coefficients, decay of isotropic turbulence.

Course outcome:

CO1. To have mathematical and physical background to analyse real life problems in fluid mechanics.

CO2. To possess skills to take up research activities involving fluid motions.

Reference books:

1. White, F.M., "Fluid Mechanics", McGraw-Hill. 1979
2. Schlichting, H., "Boundary Layer Theory", McGraw-Hill. 1979
3. Garde, R.J., "Turbulent Flow", Wiley Eastern Limited. 1994
4. Pope, S. B., "Turbulent Flows", Cambridge University Press. 2000
5. Rouse, H., "Advanced Mechanics of Fluids", John Wiley and Sons. 1959
6. Ojha, C.S.P., Berndtsson, R. and Chandaramouli, P.N., "Fluid Mechanics", Oxford University Press. 2010

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX42	Advanced Heat and Mass Transfer	PEC	2-1-0	3

Unit I
Introduction: Introduction to Heat Transfer – different modes, governing laws, quasi linearization of the Stefan-Boltzmann law, applications to heat transfer, simple problems for recapitulation of the above. **General Heat Conduction Equation :** general heat conduction equation in (i) Cartesian, (ii) Polar, and (iii) Spherical Co-ordinate Systems – derivation of all the equations from first principles, solution to heat conduction equation – initial and boundary conditions, different kinds of boundary conditions.
Unit II
Steady-state one-dimensional heat conduction problems in Cartesian System: Steady-state one-dimensional heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in Cartesian system with various possible boundary conditions, numerical problems. **Steady-state radial heat conduction problems in Polar System:** Steady-state radial heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in cylindrical system with various possible boundary conditions, numerical problems. **Steady-state radial heat conduction problems in Spherical System:** Steady-state radial heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in spherical system with various possible boundary conditions, numerical problems.
Unit III
Steady-state two-dimensional heat conduction problems: Steady-state two-dimensional heat conduction problems in Cartesian and cylindrical co-ordinates, use of Bessel's functions, numerical problems. **Transient [Unsteady-state] heat conduction:** Transient heat conduction, Different cases - negligible internal thermal resistance, negligible surface resistance, comparable internal thermal and surface resistances, lumped body, infinite plate of finite thickness and semi-infinite solid, numerical problems, Heisler and Grober charts for transient conduction – solution to (i) one dimensional, (ii) Two-dimensional and (iii) Three-dimensional problems using the charts, numerical problems.
Unit IV
Forced Convection: Forced convection flow over a flat plate, boundary layer theory, velocity

and thermal boundary layers, Prandtl number, governing equations – continuity, Navier-Stokes and energy equations, boundary layer assumptions, integral and analytical solutions to above equations, turbulent flow, various empirical solutions, numerical problems concerning the above topics, forced convection flow over cylinders and spheres, internal forced convection flows – constant wall temperature and constant wall heat flux boundaries, laminar and turbulent flow solutions, numerical problems. **Free convection:** Laminar and Turbulent flows, analytical and empirical solutions, numerical problems.
Unit V
Thermal Radiation : Prevost's theory, Theories of propagation of thermal radiation, Fundamentalprinciples - White, Opaque, Transparent, Black and Gray bodies, Spectral and Total emissivepowers, Wien's, Rayleigh-Jeans and Planck's laws, Spectral energy distribution of a black body,Stefan-Boltzmann law for the total emissive power of a black body, Emissivity – types of emissivity, Numerical Problems, View factor, View factor algebra, Summation rule, Reciprocity Theorem,Hottel's crossed-string method, Electrical resistance concept to tackle two-body enclosures, Numerical problems
Unit VI
Mass Transfer: Definition, examples, Fick's law of diffusion, Fick's law as referred to ideal gases, steady-state isothermal equi-molar counter diffusion of ideal gases, mass diffusivity, Gilliland's equation, isothermal evaporation of water and its subsequent diffusion into dry air, mass transfer coefficient, numerical problems.
Reference books:
1. Principles of Heat Transfer by Kreith Bohn 2. Heat Transfer by J.P. Holman 3. Heat Transfer / Nellis& Klein / Cambridge University Press / 2012. 4. Heat Transfer/ P.S. Ghoshdastidar/ Oxford Press

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX43	Computational Fluid Dynamics	PEC	2-1-0	3

Unit I

Illustration of the CFD approach: CFD as an engineering analysis tool, derivation of flow governing equations, initial and boundary conditions; well posed ness, turbulence modeling.

Unit II

Discretization: Discretization of the governing equations using finite difference/ volume methods. Concepts of consistency, stability and convergence. Template for the discretization of a generic unsteady transport equation. Spectral analysis of errors and TVD schemes.

Unit III

Solution of discretized linear algebraic equations: Direct methods; classical iterative methods; convergence analysis.

Unit IV

Advanced methods for the solution of discretized equations: Solution of coupled equations: methods for compressible flows, on evaluation of pressure in incompressible flows, pressure-velocity coupling algorithms.

Unit V

Template for the solution of governing equations: Structured and unstructured grids, structured grid generation methods, unstructured grid generation methods, benchmarking and calibration.

Reference books:

1. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, McGraw-Hill.
2. T. J. Chung, Computational Fluid Dynamics, Cambridge University Press.
3. H. K. Versteeg & W. Malalasekera, an Introduction to Computational Fluid Dynamics, Longman Scientific Technical.
4. J. H. Ferziger and M. Peric, Computational Methods for Fluid Dynamics, Springer.
5. John C. Tannehill, Dale A. Anderson and Richard H. Pletcher, Computational Fluid Mechanics and Heat Transfer, Taylor & Francis.
6. John D. AndersonJr, Computational Fluid Dynamics, McGraw Hill Book Company.
7. J. Blazek, Computational Fluid Dynamics: Principles and Applications, Elsevier.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX44	Non-conventional Energy Sources	PEC	3-0-0	3

Unit I

Renewable energy technologies, energy usage by humans: estimate of impact on atmosphere, conventional sources of energy, non-conventional sources of energy: an overview, energy consumption, details of energy usage in each sector.

Unit II

Consequences of energy consumption, solar energy: the sun to earth transaction, the solar energy budget, electromagnetic radiation: the solar spectrum, solar flat plate collector, solar radiator.

Unit III

Solar Energy: Semiconductor, solar energy: p-n junction, solar cell: growing the single crystal and making the p-n junction, solar energy: interaction of p-n junction with radiation, solar energy: solar cell characteristics and usage, solar energy: solar cell construction, solar energy: solar photo-catalysis.

Unit IV

Wind energy: overview, wind energy: energy considerations, wind energy efficiency, wind energy: parts and materials, wind energy design considerations.

Unit V

Ocean Thermal Energy Conversion (OTEC), geothermal energy, geothermal energy technological aspects, biomass usage and issues, battery basics, battery testing and performance, lithium ion batteries, common battery structures and types.

Unit VI

Types of fuel cells, fuel processing for PEM fuel cells, fuel cells concept to product, characterization of electrochemical devices, fuel cells: parts and assembly, super capacitors, flywheels, magneto hydrodynamic power generation.

Course outcomes:

Students will be able to
CO1: know the design of various manufacturing processes.
CO2: select the correct engineering material for a given application.
CO3: know the design of various joining techniques.

Reference books:

1. B.H. Khan, "Non-conventional energy sources", 3rd Edition, McGraw Hill Education
2. N.K. Bansal, "Non-conventional energy sources", Vikas publishing house pvt. Ltd.
3. A. Chandra, T. Chandra, "Non-conventional energy sources", 2nd Edition, Khanna book publishing (p) ltd.

Open Elective Courses

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX65	Business Analytics	OEC	3-0-0	3

Unit I

Business analytics: overview of business analytics, scope of business analytics, business analytics process, relationship of business analytics process and organization, competitive advantages of business analytics.

Statistical Tools: Statistical notation, descriptive statistical methods, review of probability distribution and data modelling, sampling and estimation methods overview.

Unit II

Trendiness and Regression Analysis: Modelling relationships and trends in data, simple linear regression, important resources, business analytics personnel, data and models for business analytics, problem solving, visualizing and exploring data, business analytics technology.

Unit III

Organization structures of business analytics, team management, management issues, designing information policy, outsourcing, ensuring data quality, measuring contribution of business analytics, managing changes, descriptive analytics, predictive analytics, predicative modelling, predictive analytics analysis, data mining, data mining methodologies, prescriptive analytics and its step in the business analytics process, prescriptive modelling, nonlinear optimization.

Unit IV

Forecasting Techniques: Qualitative and judgmental forecasting, statistical forecasting models, forecasting models for stationary time series, forecasting models for time series with a linear trend, forecasting time series with seasonality, regression forecasting with casual variables, selecting appropriate forecasting models.

Monte Carlo Simulation and Risk Analysis: Monte Carle simulation using analytic solver platform, new-product development model, newsvendor model, overbooking model, cash budget model.

Unit V

Decision Analysis: Formulating decision problems, decision strategies with the without outcome probabilities, decision trees, the value of information, utility and decision making.

Unit VI

Recent Trends in: Embedded and collaborative business intelligence, visual data recovery, data storytelling and data journalism.

Course Outcomes:

CO1: Students will demonstrate knowledge of data analytics.

CO2: Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.

CO3: Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.

CO4: Students will demonstrate the ability to translate data into clear, actionable insights.
Reference books:
1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press. 2. Business Analytics by James Evans, persons Education.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX66	Industrial Safety	OEC	3-0-0	3

Unit I
Introduction: Concept of an accident, reportable and non-reportable injuries, unsafe act and condition – principles of accident prevention, supervisory role - role of safety committee – accident causation models – domino theory, swiss cheese accident models, cost of accident, overall accident investigation process - response to accidents, calculation of accident indices - frequency rate, severity rate, frequency severity incidence, incident rate, accident rate, salient points of factories act 1948 for health and safety.
Unit II
Hazard and risk assessment Techniques: Understanding of hazard and risk, hazard evaluation techniques, checklist analysis, preliminary hazard analysis (PHA), fault tree analysis & event tree analysis, logic symbols, methodology, various indices – what-if analysis/checklist analysis - hazard operability studies (HAZOP) - hazard analysis (HAZAN) - failure mode and effect analysis (FMEA), reliability: basics concepts, reliability of systems – series, parallel. hazard evaluation software aids – risk phast V 6.6 (DNV), hazard review LEADER, HAZOP manager, PHA manager, LOPA manager, FEME-Pro, ALOHA (mentioned software demo version only).
Unit III
Safety in Workplace: Plant / work area design, hand tools and portable power tools, manual and mechanical material handling, ergonomics, machine guarding, work permits for working at height and working in confined spaces. Safety in construction industry: parameters governing the safety in construction - site planning and layout, safety work permit and checklist, precautions from falling of materials, safety in the use of construction machinery and equipment.
Unit IV
Safety in industries: Safety in chemical industries: types of chemical hazards, storage hazards, material hazards and their controls, electricity safety: electrical hazards, effect of electrical parameters on human body, safety measures for electric work, over load and other protection, statutory provisions, Fire safety: fire chemistry and its physics, fire triangle, fire protection, prevention and control, laws and regulations – relevant provisions of factories act and rules.
Unit V
Maintenance Engineering: Definition and aim of maintenance engineering, primary and secondary functions and responsibility of maintenance department, types of maintenance, Periodic and preventive maintenance: Periodic inspection - concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, definition, preventive maintenance - need, steps and advantages. Steps/procedure for periodic and preventive maintenance of: i. machine tools, ii. pumps, iii. air compressors, repair cycle concept and importance and applications of tools used for maintenance, maintenance cost & its relation with replacement economy, service life of equipment.

Unit VI
Safety standards: Personal protection, concepts of personal protective equipment, selection of PPE, ergonomic considerations in PPE design. Housekeeping – concept of 5S and its significance. OHSAS 18000: structure and features of OSHAS 18001, benefits of certification, certification procedure, guidelines (18002:2000) for implementing OHSAS 18001, factories act and rules, workmen compensation act, manufacture, storage and import of hazardous chemical rules 1989, Indian Electricity act and rules.
Reference books:
1. Heinrich H.W. "Industrial Accident Prevention" McGraw-Hill Company, New York, 1980. 2. John Ridley, "Safety at Work", Butterworth & Co., London, 1983. 3. Petersen D. Techniques for safety management - A systems approach, ASSE 1998 4. K.C. Arora, ISO 9000 to OHSAS 18001, S.K. Kataria and Sons, Delhi 5. H. P. Garg, Maintenance Engineering, S. Chand and Company. 6. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services. 7. Probabilistic Risk Assessment for Engineering and Scientists, Komamoto and Henley, IEEE Press, 1995. 8. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX67	Operations Research	OEC	3-0-0	3

Unit I
Formulation of a LPP - graphical solution, revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming.
Unit II
Goal programming: problem formulation, weighting method, primitive method. Integer programming: problem formulation, zero-one problem, branch-and-bound algorithm, cutting plane algorithm
Unit III
Nonlinear programming problem, classical optimization techniques and Kuhn Tucker conditions, one dimensional minimization, unconstrained and constrained minimization methods, geometric programming.
Unit IV
Scheduling and sequencing, deterministic inventory models, probabilistic inventory control models.
Unit V
Elements of queuing model: Single channel infinite population model, finite queue length, pure birth and death model, multichannel queuing model. Dynamic Programming: Characteristics of dynamic programming problems, single and multistage models, applications to inventory and cargo loading problems.
Unit VI
Network models: CPM/PERT - Crashing of project network - min cost flow problem - max flow problem.
Course Outcomes: At the end of the course, the student should be able to CO1: apply the dynamic programming to solve problems of discreet and continuous variables. CO2: apply the concept of non-linear programming CO3: carry out sensitivity analysis CO4: model the real world problem and simulate it.
Reference books:
1. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982. 2. H.A. Taha, Operations Research, An Introduction, PHI, 2008 3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008 4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009 5. Pannerselvam, Operations Research: Prentice Hall of India 2010 6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX68	Aptitude and Reasoning	MC	2-1-0	3

Unit I
Number system: Base system, exponents, factorials, LCM & HCF, properties of numbers, remainders, successive divisions. **Sequence & Series:** Arithmetic progression, harmonic progression, geometric progression.
Unit II
Arithmetic: Averages, clocks & calendars, simple interest & compound interest, mixture & allegations, percentages, profit, loss & discounts, ratio & proportion, speed, time & distance, time & work. **Algebra:** Binomial theorem, complex numbers, functions, higher degree equations, inequalities, linear equations, logarithm, quadratic equations.
Unit III
Geometry: Mensuration, lines & angles, circles, polygons, triangles, co-ordinate geometry, trigonometry. **Probability & Statistics:** Mean, median & mode, permutation & combination, probability set theory & Venn diagram.
Unit IV
Logical Reasoning: Logical sequence, premise, assumption & conclusion, binary logic, blood relations, linear & matrix arrangement, seating arrangement, coding & decoding, statements & assumptions puzzles. **Analytical Reasoning**: Course of action fact, inference & judgement, logical deduction, statement & assumption, strong & weak arguments, syllogism.
Unit V
Data Interpretation: Charts (column, pie & bar), tables graphs (line & area), Venn diagram, data sufficiency, reading comprehension.
Unit VI
Verbal Ability: Cloze Test Error Spotting, Fill in the blanks, Sentence Correction, Word Usage, Para jumbles, Paragraph Completion, Paragraph Summary.
Reference books:
1. Sarvesh K Verma, “Quantitative Aptitude Quantum CAT”, arihant publications 2. Arun Sharma, Meenakshi Upadhyay, “Verbal Ability and Reading Comprehension” McGraw Hill publications 3. Arun Sharma, “Data Interpretation”, McGraw Hill publications 4. Arun Sharma, “Logical Reasoning”, McGraw Hill publications 5. Nishit K Sinha, “Logical Reasoning and Data Interpretation”, Pearson publications 6. Arun Sharma, “Quantitative Aptitude”, McGraw Hill publications

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX69	Cost Management of Engineering Projects	MC	2-1-0	3

Unit I
Introduction and Overview of the Strategic Cost Management Process: Cost concepts in decision-making; relevant cost, differential cost, incremental cost and opportunity cost.
Unit II
Objectives of a Costing System: Inventory valuation; creation of a database for operational control; provision of data for decision-making.
Unit III
Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.
Unit IV
Cost Behavior and Profit Planning Marginal Costing; Distinction between marginal costing and absorption costing; break-even analysis, cost-volume-profit analysis, various decision-making problems, standard costing and variance analysis.
Unit V
Pricing strategies: Pareto analysis, target costing, life cycle costing, costing of service sector, just-in-time approach, material requirement planning, enterprise resource planning, total quality management and theory of constraints, activity-based cost management, bench marking; balanced score card and value-chain analysis, budgetary control; flexible budgets; performance budgets; zero-based budgets, measurement of divisional profitability pricing decisions including transfer pricing.
Unit VI
Quantitative techniques for cost management: Linear programming, PERT/CPM, transportation problems, assignment problems, simulation, learning curve theory.
Reference books:
1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi 2. Charles T. Horngren and George Foster, Advanced Management Accounting 3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting 4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher 5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

Audit Courses

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX73	**Python Programming**	MC	2-0-2	3

Unit I
Introduction: Introduction to Python, Program Development Cycle, Input, Processing, and Output, Displaying Output with the Print Function, Comments, Variables, Reading Input from the Keyboard, Performing Calculations, Operators. Type conversions, Expressions, More about Data Output. Data Types, and Expression: Strings Assignment, and Comment, Numeric Data Types and Character Sets, Using functions and Modules. Decision Structures and Boolean Logic: if, if-else, if-elif-else Statements, Nested Decision Structures, Comparing Strings, Logical Operators, Boolean Variables. Repetition Structures: Introduction, while loop, for loop, calculating a Running Total, Input Validation Loops, Nested Loops.
UNIT II
Control Statement: Definite iteration for Loop Formatting Text for output, Selection if and if else Statement Conditional Iteration The While Loop Strings and Text Files: Accessing Character and Substring in Strings, Data Encryption, Strings and Number Systems, String Methods Text Files.
UNIT III
List and Dictionaries: Lists, Defining Simple Functions, Dictionaries Design with Function: Functions as Abstraction Mechanisms, Problem Solving with Top Down Design, Design with Recursive Functions, Case Study Gathering Information from a File System, Managing a Program's Namespace, Higher Order Function. Modules: Modules, Standard Modules, Packages.
UNIT IV
File Operations: Reading config files in python, Writing log files in python, Understanding read functions, read, read line and read lines, Understanding write functions, write and write lines, Manipulating file pointer using seek, Programming using file operations Object Oriented Programming: Concept of class, object and instances, Constructor, class attributes and destructors, Real time use of class in live projects, Inheritance , overlapping and overloading operators, Adding and retrieving dynamic attributes of classes, Programming using Oops support Design with Classes: Objects and Classes, Data modeling Examples, Case Study An ATM, Structuring Classes with Inheritance and Polymorphism
UNIT V
Errors and Exceptions: Syntax Errors, Exceptions, Handling Exceptions, Raising Exceptions, User-defined Exceptions, Defining Clean-up Actions, Redefined Clean-up Actions. Regular Expressions – REs and Python Plotting using PyLab Networking and Multithreaded Programming – Sockets, Threads and Processes, Chat Application

UNIT VI
Graphical User Interfaces: The Behavior of Terminal Based Programs and GUI -Based Programs, Coding Simple GUI-Based Programs, Other Useful GUI Resources. Programming: Introduction to Programming Concepts with Scratch.
Books for Reference:
1. Fundamentals of Python First Programs, Kenneth. A. Lambert, Cengage. 2. Python Programming: A Modern Approach, Vamsi Kurama, Pearson. 3. Introduction to Python Programming, Gowrishankar.S, Veena A, CRC Press. 4. Introduction to Programming Using Python, Y. Daniel Liang, Pearson. 5. John V Guttag. "Introduction to Computation and Programming Using Python", Prentice Hall of India 6. R. Nageswara Rao, "Core Python Programming", dreamtech 7. Wesley J. Chun. "Core Python Programming - Second Edition", Prentice Hall 8. Michael T. Goodrich, Roberto Tamassia, Michael H. Goldwasser, "Data Structures and Algorithms in Python", Wiley

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX73	Machine Learning and Artificial Intelligence	MC	2-0-1	3

Unit I
Introduction: What Is AI?, The Foundations of Artificial Intelligence, The History of Artificial Intelligence, The State of the Art, Agents and Environments, Good Behavior: The Concept of Rationality, The Nature of Environments, The Structure of Agents.
Unit II
Problem Solving: Problem-Solving Agents, Example Problems, Searching for Solutions, Uninformed Search Strategies, Informed (Heuristic) Search Strategies, Local Search Algorithms and Optimization Problems, Searching with Nondeterministic Actions.
Unit III
Introduction to ML: A brief introduction to Machine Learning, Supervised Learning, Unsupervised Learning, Reinforcement Learning, Statistical decision theory – Regression, Classification, Bias-variance, Linear Regression, Multivariate Regression, Dimensionality Reduction: Subset Selection, Shrinkage Methods, Principal Component Regression, Partial Least Square.
Unit IV
Statistical Models: Naïve Bayes, Bayesian Classifier, Gaussian Multivariate model, Gaussian Mixture model, Parameter Estimation: Maximum Likelihood Estimation, Expectation and Maximization, Priors & MAP Estimation, Bayesian Parameter Estimation.
Unit V
Artificial Neural Networks and SVM: Feed forward network, Perceptron Learning, Back propagation, SVM – Formulation, SVM – Interpretation & Analysis, SVMs for Linearly Non-Separable Data, SVM Kernels, SVM – Hinge Loss Formulation.
Unit VI
Decision Trees and Ensemble method : Introduction, Entropy, Information gain, Decision Trees, Stopping Criteria, Loss-Function for Classification, Missing Values ,Multi-way splits, Imputations & Surrogate Splits, Instability, Smoothness & Repeated Subtrees, Ensemble Methods: Bagging, Boosting
Books for Reference:
1.Stuart Russell and Peter Norvig, “Artificial Intelligence: A Modern Approach” , 3rd Edition, Pearson 2.Tom M. Mitchell, Machine Learning, McGraw Hill Edition, 2013

3. Saroj Kaushik, “Artificial Intelligence”, Cengage Learning India, 2011
4. Elaine Rich and Kevin Knight, “Artificial Intelligence”, Tata McGraw Hill
5. David Poole and Alan Mackworth, “Artificial Intelligence: Foundations for Computational Agents”, Cambridge University Press 2010.
6. Trivedi, M.C., “A Classical Approach to Artifical Intelligence”, Khanna Publishing House, Delhi.
7. Christopher Bishop, Pattern Recognition and Machine Learning (PRML) , Springer, 2007.
8. ShaiShalev-Shwartz and Shai Ben-David, Understanding Machine Learning: From Theory to Algorithms (UML) , Cambridge University Press, 2014.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX75	English for Research Paper Writing	MC	3-0-0	3

Unit I

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

Unit II

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

Unit III

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

Unit IV

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature.

Unit V

Kills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions.

Unit VI

Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission.

Course outcomes:

Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title Ensure the good quality of paper at very first-time submission

Books for Reference:

1. Goldbort R (2006) Writing for Science, Yale University Press
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX76	Disaster Management	MC	3-0-0	3

Unit I

Introduction to Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.

Unit II

Repercussions Of Disasters And Hazards: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.

Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man- made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

Unit III

Disaster Prone Areas In India

Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics.

Unit IV

Disaster Preparedness And Management

Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.

Unit V

Risk Assessment

Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.

Unit VI

Disaster Mitigation

Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.

Course outcomes:

Students will be able to:

1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations. 4. critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in
Books for Reference:
1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company. 2. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi. 3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep & Deep Publication Pvt. Ltd., New Delhi.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX77	Personality Development through Life Enhancement Skills	MC	3-0-0	3

Unit I

Neetisatakam-Holistic development of personality

- Verses- 19,20,21,22 (wisdom)
- Verses- 29,31,32 (pride & heroism)
- Verses- 26,28,63,65 (virtue)
- Verses- 52,53,59 (dont's)
- Verses- 71,73,75,78 (do's)

Unit II

- Approach to day to day work and duties.
- Shrimad BhagwadGeeta : Chapter 2-Verses 41, 47,48,
- Chapter 3-Verses 13, 21, 27, 35,

Unit III

- Shrimad BhagwadGeeta : Chapter 6-Verses 5,13,17, 23, 35,
- Chapter 18-Verses 45, 46, 48.

Unit IV

Statements of basic knowledge.

- Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68

Unit V

Statements of basic knowledge.

- Shrimad BhagwadGeeta: Chapter 12 -Verses 13, 14, 15, 16,17, 18

Unit VI

- Personality of Role model. Shrimad BhagwadGeeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,
- Chapter 4-Verses 18, 38,39
- Chapter18 – Verses 37,38,63

Course outcomes:

Students will be able to:

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life.
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity.
3. Study of Neetishatakam will help in developing versatile personality of students.

Books for Reference:

1. "Srimad Bhagavad Gita" by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX78	Constitution of India	MC	3-0-0	3

Unit I
History of Making of the Indian Constitution: History Drafting Committee, (Composition & Working).
Unit II
Philosophy of the Indian Constitution: Preamble Salient Features.
Unit III
Contours of Constitutional Rights & Duties: Fundamental Rights, Right to Equality, Right to Freedom,Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.
Unit IV
Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.
Unit V
Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation, Pachayati raj: Introduction, PRI: ZilaPachayat, Elected officials and their roles, CEO ZilaPachayat: Position and role, Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy.
Unit VI
Election Commission: Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and Functioning, Institute and Bodies for the welfare of SC/ST/OBC and women. **Course outcomes:** Students will be able to: 1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics. 2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India. 3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.

4. Discuss the passage of the Hindu Code Bill of 1956.
Books for Reference:
1. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015. 2. The Constitution of India, 1950 (Bare Act), Government Publication. 3. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015. 4. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014. 5. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Course Code	Course Name	Course Category	L-T-P	Credits
21EADXX79	Pedagogy Studies	MC	3-0-0	3

Unit I

Introduction and Methodology: Aims and rationale, Policy back ground, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education, Conceptual framework, Research questions**,** Overview of methodology and Searching.

Unit II

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries, Curriculum, Teacher education.

Unit III

Evidence on the effectiveness of pedagogical practices

Methodology for the in depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies.

Unit IV

Professional development: alignment with classroom practices and follow-up support, Peer support, Support from the head teacher and the community.

Curriculum and assessment, Barriers to learning: limited resources and large class sizes.

Unit V

Research gaps and future directions: Research design, Contexts, Pedagogy, Teacher education, Curriculum and assessment, Dissemination and research impact.

Course outcomes:

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

Books for Reference:

1. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell
2. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.

3. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
4. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
5. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.