MATERIALS & METALLURGICAL ENGINEERING

Course Name	**:**	**INTRODUCTION TO MATERIALS & METALLURGICAL ENGINEERING**
Course Code	**:**	**MTN 101**
Credits	**:**	**2**
L T P	**:**	**2 0 0**

Course Objectives:	
1.	The student should be able to understand and classify the sub branches and domains of Materials & Metallurgical Engineering stream.
2.	The student should be able to analyze the possible opportunities in the domains of Materials & Metallurgical Engineering.
3.	The student should be able to understand all basic principles involved in the theory of Elasticity and Plasticity.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**HISTORY AND EVOLUTION** Definition, concept, scope and nature of materials and metallurgy industries associated to Metallurgical Engineering and allied fields.	4
2	**BASICS OF MATERIAL DEVELOPMENT** Principles of production of Ferrous and Non ferrous metals; overview of alloy making and units involved in such process.	4
3	**OVERVIEW OF MATERIALS PROCESSING TECHNOLOGIES** Principle and overview of Heat treatment industry, Metal casting units, Material joining technology etc.	4
4	**BASICS OF MATERIALS SELECTION** Basics and principles involved in material selection for special applications like high temperature exposure, nuclear reactor materials; corrosion resistant materials etc	4
5	**SPECIAL AND NEW MATERIALS** Introduction to newer materials such as smart materials, biomaterials and their applications.	4
6	**FUTURE TRENDS IN MATERIALS TECHNOLOGY** Overview of recent advances in materials industry and metallurgical technologies which guides the direction and progress of material technology.	4
7	**ENTREPRENEURSHIP IN METALLURGY, AND ROLE OF INTELLECTUAL PROPERTY RIGHTS** Concept, scope and challenges	4

Course Outcomes:	
1	The student will be able to understand and create the areas and domains in Materials & Metallurgical Engineering on the basis of his/her interest and opportunity available in present industrial scenario.
2	The student will be able to understand the basic principles of selection of materials and challenges to entrepreneurs in metallurgy

Suggested Books:		
Sr. No.	**Reference Book**	**Author/Publisher**
1.	Metallurgy for non metallurgists	Harry Chander, ASM International,1998
2.	Extraction of Non-ferrous metals	H.S.Ray, R. Sridhar, K.P. Abraham
3.	Introduction to Physical Metallurgy	Sidney H. Avner, , Mcgraw-Hill
4.	Materials Science & Engineering	William D. Callister, , Wiley India
5.	Principles of Blast Furnace (Iron Making)	A.K. Biswas,

Course Name	**:**	**PHYSICAL METALLURGY**
Course Code	**:**	**MTN102**
Credits	**:**	**04**
L T P	**:**	**3 1 2**

Course Objectives:	
1.	To describe the basic elements of material science and its application to engineering fields.
2.	To explain the concept of phase diagrams, solidification principles and engineering of ferrous, non-ferrous, ceramics and polymers.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**STRUCTURE OF METALS AND ALLOYS**: Nature of metallic bonding, crystal structure of metals-Miller indices, Miller-Bravais indices, structure of alloys-Types of solid solutions, Hume Rothery Rules, Free energy of solid solutions, Intermediate phases, Numerical problems.	8
2	**IMPERFECTIONS IN CRYSTALS:** Point imperfections, Dislocations, High angle boundaries, Interaction between crystal imperfections.	4
3	**EQUILIBRIUM DIAGRAMS**: The Phase rule, Isomorphous systems, Lever rule, Coring, Eutectic system, Eutectoid, Peritectic, Peritectoid, Monotectic and Syntectic reactions, Micro structural changes during cooling-slow and non-equilibrium cooling, Study of Fe-Fe_3C, Cu-Zn, Al-Si Binary diagrams, Numerical problems.	12
4	**SOLIDIFICATION IN METALS:** Energetics of solidification, Nucleation and Growth, Homogeneous Nucleation, Heterogeneous Nucleation, Growth of solid, Smooth or Stable interface growth, Temperature inversion in pure metals-Dendritic growth in pure metals, Constitutional Supercooling, Dendritic Growth in Alloys, Freezing of Ingots, Segregation, Porosity.	8
5	**DIFFUSION IN SOLIDS:** Diffusion mechanisms, Fick's laws and their applications in various Metallurgical phenomena, Kirkendall effect, Numerical problems.	4
6	**ENGINEERING ALLOYS:** Ferrous Alloys and Nonferrous Alloys.	6

List of Experiments:	
1	To study design, principle and application of basic tools of wide use to a Metallurgist such as A Metallurgical microscope, A Hardness Tester, A Image Analyzer.
2	To study design, principle and application of Furnace and Thermocouple.
3	To study design, principle and application of Scanning Electron Microscope.
4	T study and compare the difference between solidification behavior of pure metal and an alloy.
5	To observe the segregation of solute rich phase in the casting.
6	To carry out Homogenization annealing for removal of segregation in casting.
7	Qualitative and Quantitative Metallographic analysis and establishing correlation with phase diagram of the given alloy system: a. Recognition of the phase and state of material from the microstructure. b. Finding out the weight % of carbon in ferrous alloys from the microstructure w.r.t Hypo-, Hyper- phases and their morphologies.
8	Alloy Development: a. To study the effect on microstructure and mechanical property. b. To study the solidification defects such as Segregation, Porosity etc.
9	To observe the Line Defects in given samples.
10	To observe the Surface Defects in given samples.
11	To observe the Volume Defects –Metallographic observation of Dislocations, Grain Boundaries, Twin Boundaries, Inclusions and precipitates in given samples.

Course Outcomes:

1	The student is able to establish his understanding for crystal structure, phase diagrams and their applications, principles of solidification of metal, polymers and inorganic glasses.
2	Student will be able enough to apply these concepts in various application areas.

Text Books:	
1	Physical Metallurgy Principles. Reza Abbaschian, Lara Abbaschian and Robert Reed-Hill, Cengage Learning India, 2013.
2	Fundamentals of Materials Science and Engineering, 5th Edition, W D Callister Jr., John Wiley and sons, 2001.

Reference Books:	
1	S. H. Avner, Introduction to Physical Metallurgy, McGraw Hill, 1987.
2	V. Raghavan, Materials Science and Engineering, Prentice Hall, New Delhi, 2004.
3	W.F.Hosford, Physical Metallurgy, CRC Press, Taylor and Francis Group, London, 2005.
4	Physical Metallurgy, Prof. Vijendra Singh, Standard Publishers Distributors, 2005.
5	Essentials of Materials for Science and Engineering by Donald R. Askeland and Pradeep P. Phule, 2004.

Course Name	**:**	**THERMODYNAMICS OF MATERIALS**
Course Code	**:**	**MTN103**
Credits	**:**	**04**
L T P	**:**	**3-1-0**

Course Objectives:	
1.	To apply the Laws of Thermodynamics (energy balance) to open and closed material systems and to analyze the spontaneity of a chemical reaction.
2.	To derive the combined statement of the First and Second Laws of Thermodynamics.
3.	To calculate the configurational entropy of a multicomponent system, the standard enthalpy change, standard free energy change and standard entropy change of a phase change or chemical reaction at any temperature using appropriate heat capacity and heat of formation data and Hess's Law.
4.	Use LeChatelier's principle to determine the direction of shift in reaction equilibrium.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION AND BASIC CONCEPTS:** Scope, application, importance in Metallurgical Engineering, state of system, thermodynamic equilibrium, properties of system.	4
2	**FIRST LAW OF THERMODYNAMICS:** Internal Energy, Enthalpy, Heat Capacity, Cp&Cv, Hess Law, Kirchoff's Law, Numerical Problems	6
3	**SECOND LAW OF THERMODYNAMICS:** Limitations of First Law, Various statements of 2nd law, Carnot theorem, Carnot cycle, Entropy, free energy, Gibbs Helholtz equations, Maxwell's relationships, Statistical concept of entropy, Numerical problems.	9
4	**THIRD LAW OF THERMODYNAMICS**	2
5	**THERMODYNAMIC VARIABLES:** Activity, fugacity & Equilibrium Constant, Chemical Potential and Numerical problems involving thermodynamic variables.	4
6	**SINGLE COMPONENT SYSTEMS: CLAUSIS –**Clapyron equations, Numerical Problems.	2
7	**PHASE RULE & ELLINGHAM DIAGRAMS:** Temperature/free energy diagrams for Oxides, Sulphides& Halides.	3
8	**SOLUTIONS:** Partial Molal properties, Gibbs Duhem equation, Ideal-Non Ideal solutions, Raoult's Law, Henry law, Sieverts law, Regular solutions, Interaction parameter, Interaction coefficient and Numerical problems.	6

9	**KINETICS OF METALLURGICAL PROCESSES:** Basics, first, second, third, zero order reactions, collision theory, theory of Absolute Reaction rates, Activation Energy, Reduction of Oxide Ores,Kinetics of Roasting, Smelting, Numerical Problems.	6

Course Outcomes:	
1	The graduate is able to explain metallurgical thermodynamics concepts to perform equilibrium calculations and to perform thermodynamic calculations.
2	The graduate will be capable to read binary phase diagrams and formulate / solve thermodynamic problems for real material and processes.

Text Books:	
1	Gaskel, Introduction to Metallurgical Thermodynamics, Mcgraw Hill, 2004

Reference Books:	
1	Glasstone, Thermodynamics for Chemists, East West(P), 2002
2	Dehoff, Thermodynamics in Material Science, Mcgraw Hill, 199
3	Darken Gurry, Physical Chemistry of Metal, Mcgraw Hill, 1980
4	Dubey&Upadhay, Numerical Problems in Thermo, Pergamon Press, 1985
5	Lewis & Randall, Thermodynamics, Mcgraw Hill, 1995
6	AhindraGhosh, Metallurgical Thermodynamics, Printice hall India(P) Ltd. 2008

Course Name	**:**	**EXTRACTIVE METALLURGY FOR NON FERROUS METALS**
Course Code	**:**	**MTN 201**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
To explain various techniques, unit process and operations used in metal extraction and refining applying the fundamental knowledge for design of a reactor and process flow sheets. To develop design and analysis capability in student to enable them to bring new and economic technologies for metal extraction for future.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**SCOPE OF MINERAL PROCESSING AND PRE-CONCENTRATION TECHNIQUES** Concept for mineral, ore and gangue. Classification and their processing for enrichment, Physiochemical principles of concentration techniques. Froth floatation, Electrostatic and magnetic separators, Pre-concentration techniques. Fused salt technology, Non aqueous technology.	7
2	**SCENERIO OF NON FERROUS INDUSTRY** Present and future position on non-ferrous metallurgical industry in India -resources, Production and consumption. Economic importance of non-ferrous metallurgical industries.	7
3	**UNIT OPERATIONS IN EXTRACTIVE METALLURGY** Industrial units used in metallurgical industry for roasting, calcinations and smelting furnaces, Their design, constructions, advantages and disadvantages	5
4	**GENERAL METHODS OF EXTRACTION** Pyrometallurgy: Calcination, Roasting, Predominance area diagram, Smelting, Roasting and Smelting furnaces. Hydrometallurgy: Leaching techniques and its variables, Types of leaching. Role of oxygen in leaching operations. Electro Metallurgy: Principal and applications	5

5	**GENERAL METHODS OF REFINING** Sublimation, Distillation, Fractional Distillation, Crystallization, Ion exchange, Solvent Extraction, Liquation, Fire refining, Electrolytic Refining, Zone refining	5
6	**EXTRACTION OF METALS** Refining of metals with reference to Physio-chemical principles. Different methods of purification of metal from bulk. The various flow sheets of the production of Aluminum, Copper, Nickel, Lead, Zinc, Tin, Gold, Silver, Magnesium and Titanium.	6 8

Course Outcomes:
The graduate will be able **1.** to explain process flow-sheet for an extractive process. **2.** to analysis and interpret significance of the results for the extraction of non-ferrous metals like Al, Cu, Mg, Sn, Ni, Zn, Ag, Au, Pb etc.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Non ferrous Metallurgy/ Dennis/ Pitman Publishing	1998
2	Extraction of Non-ferrous metals/H.S. Ray, R. Sridhar, K.P. Abraham/Affiliated East West Press.	2008
3	Non Ferrous Extractive Metallurgy/Charles Burroughs Gill/Krieger Pub Co	1988(First Edition)
4	Non-Ferrous Extractive Metallurgy - Industrial Practices/ Roger Rumbu /Create Space Independent Publishing Platform	2014

Course Name	**:**	**ELECTRO-METALLURGY AND CORROSION**
Course Code	**:**	**MTN 202**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
At the end of this course, the student will be able to impart the theory for degradation and corrosion of materials in various environments. The student will be able to solve corrosion problems and design corrosion protection mechanisms.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**ELECTROLYTIC CONDUCTANCE** Electrolytic conductance of Aqueous, Electrolytic and Fused Salt Solutions - its Measurement, Transport numbers. Electrochemical cells -types of electrochemical cells formed during corrosion. Electrodes potential of half-cell, Standard electrodes potential, Electrochemical series, Nernst equation, Galvanic series, Potential-pH diagrams.	7
2	**ELECTROLYTIC CELL AND ELECTRODEPOSITION** Faraday's law, Current efficiency, Over voltage, Decomposition voltage, Cell voltage, Electro deposition of metals-throwing power, structure of deposited metals. Electrodeposition of Alloys: Control of properties of Electrodeposits e.g. Brightness of electrodeposit, Hydrogen absorption, Mechanical properties, Adhesion and Porosity. Electrodeposition of metal powder and Electrocrystallisation**.**	7
3	**ELECTRODE KINETICS AND PASSIVITY**	7

	Electrical double layer, Exchange current density, Mixed potential theory, Different types of Polarization, Evan diagrams, Passivity- its curve.	
4	**CORROSION** Its relevance, classification of corrosion processes e.g. Intergranular corrosion, Pitting, Stress corrosion etc. Their characteristics, metallurgical and other factors influencing them, Mechanism involved for each of these corrosion types.	7
5	**PROTECTION AGAINST CORROSION** Protection by design and fabrication procedure, Control of environment, Protective coatings, Heat treatment, Cathodic and anodic protection, Chromising, Phosphatizing, Zinc and Tin coatings. High temperature oxidation, Introduction of corrosion resistant materials.	7
6	**PRINCIPLES OF ELECTROMETALLURGICAL PROCESSES** Electropolishing, Electrolytic cutting, Machining and Grinding, Electrocleaning, Electroforming, Electromining, Electrorefining, Electromelting and Electroetching. Decorative applications: Rhodium, Platinum and Gold plating.	7

List of Experiments:		**Number of Turns**
1	To study, perform and observe the following corrosion phenomenon (a) Stress Corrosion Cracking IN Brass/Mild Steel. (b) Crevice Corrosion of Stainless steel in chloride solution. (c) Pitting of Stainless Steel.	3
2	Determine corrosion rate of given mild steel samples and study the effect of various factor on it like. (a) Concentration of acetic/alkaline solution (b) Composition and condition of the sample	3
3	Study the effect of passive film for following systems (a) Al in $CuSO_4$ Solution (b) Stainless Steel in HNO_3	2
4	To perform electrolytic deposition and study effect of parameters.	2
5	To study the concentration polarization phenomenon.	1
6	To perform Galvanic corrosion on various metals and prepare galvanic series.	2
7	Effect of heat treatment on corrosion.	1

Course Outcomes:
The student will be able 1. to apply the concept of electrochemical and electrolytic processes. 2. to compare the electrode benefits using Evan's diagram. 3. to analyse corrosion phenomenon in a given practical application. 4. to design for corrosion protection, minimization.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Corrosion Engineering/Fontana/Tata McGraw Hill	2008
2	An Introduction to Electrometallurgy/ SatyaNarain, RajendraSharan/ Standard Publishers Distributors	1991
3	Electrochemistry and Corrosion Science/Nestor Perez/Kluwer Academic Publishers New York, Boston, Dordrecht, London, Moscow	2004
4	Fundamental aspects of Electro Metallurgy/ K. Popov, B. Grgur, S.S. Djokic/Springer	2013

Course Name	**:**	**PHASE TRANSFORMATIONS**

Course Code	**:**	**MTN 203**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
At the end of this course the student will able to explain how time and temperature influences microstructure, apply the TTT diagram and design heat treatment for given structural or property requirement.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Phase transformations : An overview, concepts of surface and interface energy	2
2	**THE THERMODYNAMICS OF PHASE TRANSFORMATION** Revision of phase diagrams of metal alloys, Gibbs free energy, equilibrium and chemical potential, Gibbs phase rule, Single component systems-dG(T), Clausius-Clapeyron equation, Binary (two component) systems-Ideal solutions, Regular solutions, Activity, Real solutions, ordered phases and Intermediate phases, Binary phase diagrams-Miscibility gap, Ordered alloys, Eutectics and peritectic, Additional useful relationships, Ternary diagrams, Kinetics of Phase transformations.	3
3	**SOLIDIFICATION** Liquid to solid transformation, Nucleation- Homogeneous nucleation, Heterogeneous nucleation, Turnbull's approximation, nucleation barrier, Melting point, undercooling, freezing point in the realm of nucleation, atomic perspective of nucleation-nucleation rate, Heterogeneous nucleation,Choice of heterogeneous nucleating agent, Growth	4
4	**TTT CURVES** From 'Rate' to 'time': the origin of Time – Temperature – Transformation (TTT) diagrams,Derivation off(T,t): Avrami Model, Cellular Transformations, Derivation off(T,t): Johnson-Mehl Model, applicationsof the concepts of nucleation & growth, and TTT/CCT diagrams	6
5	**PHASE TRANSFORMATIONS IN STEELS** Eutectoidtransformations, The pearlite reaction in Fe-C alloys, The bainite transformation, The effect of alloying elements, Continuous cooling diagrams, Fibrous and interphase precipitation in alloy steels.	9
6	**PRECIPITATION** Precipitationin age hardening- precipitation in Al-Cu-alloys, precipitation in Aluminium, Silver alloys, Quenched in vacancies, Age hardening, Spinodal decomposition, particle coarsening**,** The precipitation of ferrite from Austenite, Cellular Precipitation.	5
7	**DIFFUSIONLESS TRANSFORMATIONS** Characteristics of diffusionless Transformations,Martensite Crystallography, Theories of Martensite Nucleation, Martensite Growth, Pre-martensite Phenomena.	6
8	**TEMPERING OF FERROUS MARTENSITES** Carbon segregation, ε- Carbide, Cementite, Alloy carbides, Effect of retained austenite, Recovery, Recrystallization and grain growth, Temper embrittlement	4
9	**CASE STUDIES** Carbon and low alloy connected and tempered steel, Controlled transformation steels, The shape- memory metal : Nitinol	3

Course Outcomes:
Student will be able to **1.** Establish Heat Treatment or a suitable process to achieve desired structure and establish structure property correlation. **2.** Design a process involving phase transformation to meet a property requirement for an engineering application

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Phase Transformations in Metals and Alloys/D.A. Porter ,K.E. Easterling, Mohamed Sherif/ CRC Press; 4th Indian Reprint	2009
2	Heat treatment of Steels/ Vijendra Singh/ Standard Publishers Distributors	2009
3	Phase Transformation of Materials/ R.C. Sharma/ CBS Publishers	2002
4	Materials science and engineering an introduction/W. D. Callister, David G. Rethwisch/John Wiley & Sons.	2007

Course Name	**:**	**CERAMICS**
Course Code	**:**	**MTN 204**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
At the end of the course the student will be able to recognize and describe common ceramic crystal structures, to use defect notation/thermodynamics to explain the point defect chemistry of ceramics, including the use of Brouwer (Kroger-Vink) diagrams, to describe the basics of ceramic processing, including sintering theory and grain growth, to relate the basics of the properties of advanced ceramic materials with their structure, relate electrical, magnetic and optical applications of ceramic materials with structure and properties.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**CHARACTERISTICS OF CERAMIC SOLIDS** Structure and Bonding in Ceramics. Bonding in Solids and discussion of Potential energy Vs Separation curve; Grouping of ions and Pauling rules and how pauling rules Determine structure. Critical Radius ratio and coordination number. Discussion of Structure of NaCl, CsCl, ZnS, Diamond and silicates	5
2	**IMPERFECTIONS IN CERAMICS** Frenkel disorder, Schottky Disorder, Defect Association and Electronic Structure, Non stoichiometric Solids	4
3	**GLASSES (AMORPHOUS CERAMICS)** Sume glass basics, glass ceramics, examples	4
4	**FORMATION OF GLASSES** Structure of Glasses, Properties of Glasses	4
5	**THERMODYNAMIC AND KINETIC ASPECTS OF CERAMIC MATERIALS** Free energy considerations and Gibb's phase rule. Phase diagrams of one and two component ceramic systems. Introduction to ternary phase diagrams specifically MgO-Al_2O_3- SiO_2 and information obtained from it. Diffusion in Ceramics. Temperature and impurity dependence of Diffusion. Diffusion in Crystalline Oxides. Nucleation and Growth	8
6	**PROPERTIES OF CERAMICS** Thermal Properties: Thermal Conductivity and thermal expansion, Thermal shock and thermal Spalling. Mechanical Properties: Strength, Elasticity and Anelasticity, Creep of Ceramics. Electrical Properties: Electrical Conduction and Ionic Conduction. Electronic Conduction: Polarisation, Dielectric loss and Dielectric Breakdown of Ceramics Magnetic Properties: Para, Ferro, Anti-ferromagnetism and Ferrimagnetism. Magnetic Domain and Hysterisis curve. Optical Properties: Refractive index, Dispersion, Opacity and translucency. Fiber Optics	12
7	**APPLICATIONS OF CERAMICS**	5

	Applications of the ceramics if different fields e.g.:,in Refractory, Biomedical, Electronics, Aerospace etc.	

List of Experiments:		**Number of Turns**
1	Synthesize a crystalline ceramic powder using solid state reaction method (Preparation, calcination, consolidation and sintering).	2
2	Synthesize a glass ceramic (Raw material selection, melting, pouring and annealing).	2
3	To study the effect of sintering temperature on the phase formation and microstructure of a ceramic material.	2
4	To study the effect of sintering temperature on density of a prepared ceramic and to calculate their porosity.	2
5	To study the frequency and temperature dependence dielectric behaviour of a prepared ceramic. (Dielectric constant, Dielectric loss, Dielectric strength).	2
6	To study the resistivity of a prepared ceramic material using four-probe method.	1
7	To synthesize the thin film using spin coating/thermal evaporation and to study their electrical behaviour.	2
8	To study the polarization-electric field hysteresis loop of a prepared ceramic material.	1
9	To synthesize the ceramic using slip casting and to study the effect of internal defects and imperfections on the properties of a ceramic.	2
10	To Study Various Characteristics of copper Powders and Evaluate Green Density as well as Strength Characteristics (hardness) of Cold-compacted and sintered (Conventional) compact.	2

Course Outcomes: The student will be able to	
1	explain the manufacturing defects and application of ceramics.
2	calculate the thermodynamic and kinetics of ceramics processing.
3	design to any ceramics for various engineering applications.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Introduction to Ceramics, Kingery, Bowen and Uhlmann, John Wiley and Sons	2012
2	Advanced Structural Ceramics/ BikramjitBasu and KanteshBalani/ John Wiley and Sons	2011
3	Indian Pottery/Ted Roller and Toni Roller/Sunstone Press.	2011
4	The complete book on glass and Ceramics Technology/ NIIR Board of Consultants and Engineers, Asia Pacific Business Press Inc.	2005
5	Ceramic Microstructures : Property control by Processing / W.E. Lee and Mark Rainforth, Springer Science and Business Media	1995

Course Name	**:**	**ENGINEERING ANALYSIS AND DESIGN**
Course Code	**:**	**MTN 206**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
All the end of this course, the student should be able to the objective of the subject is to uphold a steadiness between theory, numerical computation, and problem setup for solution by optimization, and applications to engineering system.

Total No. of Lectures – 42

Lecture wise breakup		Number of Lectures
1	**INTRODUCTION** Introduction to Design and the Design Process, Evolution of Design Technology, Engineering design versus analysis, conventional versus optimum design process, optimum design versus optimal control, basic terminology and notation. Design variables, cost function, design constraints; A general mathematical model for optimum design, Design optimization model, maximization problem treatment, treatment of "Greater than type" constraints, constraint set.Active/ Inactive/Violated constraints. Discrete and integer design variable, graphical optimization, Role of Computers in Design Cycle.	6
2	**SOLUTION TECHNIQUES FOR DESIGN OPTIMIZATION PROBLEM** Introduction, single variables, optimality criteria, bracketing methods: Exhaustive search method. Bounding phase method. Region elimination methods Interval halving method. Fibonacci Search method, golden section method, point estimation methods and gradient based methods: Newton raphson method, Bisection method, Secant method, cubic search method. Multi variables Optimization, Unidirectional search, direct search methods, gradient based methods, liner programming methods for optimum design.	10
3	**PLANNING OF EXPERIMENTS AND OPTIMIZATION** Strategy of experimentation, basic principles, guidelines for designing experiments, sampling and sampling distribution, Inference about the difference in means for randomized design, Inference about the difference in means for paired comparison design, inference about the variance of normal distribution, Design of experiments with a single factor Multi factor design, analysis of variance (ANOVA), introduction to factorial design. Life cycle estimation, Learning from failure, Case studies in the field if Metallurgical processes.	8
4	**TAGUCHI METHODOLOGY** Design of experiments- The Taguchi Approach, Taguchi Philosophy, Concept of the loss function, experimental design strategy, Areas of application, Quality characteristics, Taguchi quality strategy, Selecting design parameters for reduced variation, Signal to Noise ratio, Analysis of Variance(ANNOVA), confirmation test, F-ratio.	8
5	**SPECIAL OPTIMIZATION TECHNIQUES** Integer programming, Geometrical Programming, genetic algorithms, simulated Annealing, Stochastic programming, Particle swan optimization, Ant colony optimization, optimization of fuzzy systems, Neural Network optimization	10

Course Outcomes: The student will be able to	
1	Understand basic theoretical principles in optimization..
2	Formulation of optimization models.
3	Solution methods in optimization
4	Applications to a wide range of engineering problems.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Introduction to Optimal Design-Jasbir S Arora- McGraw Hill	2008
2	Optimization for Engineering Design –Kalyanmoy Deb-PH1	2010
3	Design and Analysis of Experiments-Douglas C Montgomery-Wiley	2005
4	A primer on Taguchi Methodology-Ranjit K Roy	2011

Course Name	**:**	**MECHANICAL BEHAVIOUR OF MATERIALS**
Course Code	**:**	**MTN 207**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
At the end of this course, the student will be able to use the concepts of stress and strain to explain the elastic and plastic behaviour of the material. The student will be able to relate the mechanical behaviour of materials to dislocation theory and presence of surface defects and volume defects. The student will be able to design a process based on strengthening mechanisms for a given application. The student will be able to apply mechanisms of material failures fracture, fatigue and creep for failure analysis.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**CONCEPTS OF STRESS AND TYPES OF STRESS** Concepts of Stress and types of Stresses, Concepts of Strain and types of Strain, Units of stress and other quantities.	2
2	**ELASTIC, ANELASTIC AND VISCOELASTIC BEHAVIOR** Elastic behaviour: Atomic model of elastic behaviour, The modulus as a design parameter, Rubber like elasticity. Anelastic behavior: Relaxation Processes. Viscoelastic behaviour: spring dashpot models.	4
3	**STRESS AND STRAIN RELATIONSHIPS FOR ELASTIC BEHAVIOUR** Description of stress at a point, state of stress in two dimensions, state of stress in three dimensions, Description of strain at a point, Hydrostatic component of stress, Elastic Stress – Strain relations, Calculation of Stresses from Elastic Strains, Strain Energy, Anisotropy of Elastic behaviour, Stress Concentration	3
4	**PLASTICITY OF MATERIALS** The Flow Curve, True Stress and True Strain, Yielding and plastic flow, Dislocations the basis for yield.	2
5	**DISLOCATION THEORY** Dislocation during growth of crystals; Theoretical and observed yield stress, geometry of dislocations. Burgers Vector, Right hand convention - Types of dislocations loops and motion out of crystals strain energy of mixed dislocation two hard particles; simple relationship for forces between dislocation vector notation of dislocation in crystal systems; combination of dislocation stacking fault energy; motion of extended dislocation; construction Frank dislocation; Cross slip; double jump; Geometrical characteristics of dislocation; Interaction of dislocations (simple cases); Motion of kinked and Jogged dislocation; Non conservation method Motion creation of vacancies, Frank Read source, Sessile dislocations Lomer-Cotrell, stair-rod; width of dislocation; Pile up of dislocation, solid solution strengthening anti-phase boundary; Yield unit; Luder bands.	14
6	**MICRO-PLASTICITY OF CRYSTALS** Slip planes and slip directions, Resolved shear stress, strain hardening and recovery of single crystals, Twinning, Grain boundary sliding and diffusional creep.	5
7	**PLASTIC DEFORMATION** Grain boundaries, Strain hardening, strain aging, The tensile stress strain curve: temperature dependence, strain rate, strain rate and temperature, Creep.	3
8	**COLD WORKED STRUCTURE** Recovery, Recrystallization and Grain Growth.	2
9	**STRENGTHENING MECHANISMS** Cold working and annealing: Recovery, Recrystallization and Grain Growth, dynamic recovery, strain/ work hardening, solute hardening or solid solution strengthening, precipitation hardening, dispersion hardening, grain refinement.	3
10	**FRACTURE** Types of fracture- ductile fracture, brittle fracture; Theoretical fracture stress, Griffith theory, Orowan Theory, Comparison with equation based on stress concentration Crack velocities; Inglis equation; Dislocation model of crack nucleation Zener model, Cotrell-Hull model in BCC metals. Fracture toughness, The ductile to brittle transition. Methods of protection against fracture- surface treatment, compressive stresses.	4

Course Outcomes: The student will be able to	
1	explain concepts of stress and strain, analyse dislocation interactions with other defects.
2	To apply dislocation theory to explain various plastic deformation phenomena, strengthening mechanisms and fracture mechanisms.
3	Solve numerical problems based on this course and engineering applications.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	The structure and properties of materials, volume III, Mechanical Behaviour/H.E Hayden, William G Moffatt, John Wulff /Willey Eastern Ltd.	1986
2.	Mechanical Metallurgy/G.E Dieter adapted by David Bacon/ McGraw-Hill Book Company	1988
3.	Dislocations and mechanical behavior of materials/ M.N.Shetty/ PHI Learning Pvt. Ltd.	2013
4	Mechanical Behavior of Materials/ Marc André Meyers, Krishan Kumar Chawla/Cambridge University Press	2009

Course Name	**:**	**METAL CASTING**
Course Code	**:**	**MTN 208**
Credits	**:**	**05**
L T P	**:**	**3 1 2**

Course Objectives:
At the end of the course the student will be able to explain basics of metal casting, its types, designing patterns cores and molding. To describe sand casting process, foundry melting furnaces. To do feeding and gating design calculations, to establish structure properties. Co-relation with casting process and casting defects.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Casting, a process of shaping, Casting vis a vis other manufacturing processes, Properties of cast products vis a vis properties of products made by other processes, History of casting practices, Basic steps involved in the making of sand casting, Process chart of casting, Lay out of a foundry.	3
2	**PATTERNS and CORE BOXES** Types, allowances, functions, materials used for pattern/core making	2
3	**MOLDING PROCESSES** Types and materials used	2
4	**MOLDING MACHINES, EQUIPMENTS AND MECHANIZATION**	2
5	**MOLDING SANDS** General properties of molding sands, basic ingredients, additives, testing of molding sands - moisture content, strength/GCS, permeability, clay content, mold hardness, clay content, AFS No. etc., role of computers	4
6	**CORES AND CORE MATERIALS** Core making and machine used, various core making processes, venting, core assembly, core setting, core prints and chaplets, Chills, core knock out and disposal, testing of core sand and core coatings, cores and casting defects. Core Dryer and Air circulation.	4
7	**SOLIDIFICATION OF METALS** Freezing of pure metals and alloys, shrinkage, fluidity and spiral test, hot tearing and cracking, inoculation, metal filtration	5

8	**POURING AND FEEDING OF CASTING** Pouring ladles, gating system, progressive and directional solidification, types of gates, design of gating system, fluid flow, factors involved in gating design, pouring time, choke area, sprue-runner- gate ratios, Riser-theoretical considerations, function, shape, location, types.	5
9	**MELTING OF METALS** Cupola furnace- construction and operation, coke bed height, Various types of cupolas- cold/hot/divided blast, coke bed and stack gases, melting rate, combustion and melt temp., Induction and furnaces.	5
10	**CASTING DESIGN** Factors affecting casting design, Common design rules	2
11	**SHAKE OUT, FETTLING, CLEANING AND INSPECTION OF CASTING**	2
12	**CASTING DEFECTS AND DIAGNOSIS BY NDT** Inclusions blow holes, pin holes and porosity, Shrinkage, misrun, cold shut and cold lap, Metal penetration, scab and rat tails, parting line shift and mismatch, Sand drops and mold brake, Defect diagnosis by radiography, ultrasonic, magnetic methods and Eddy Current Techniques.	3
13	**ENERGY CONSERVATION AND ENVIRONMENT PROTECTION**	1

List of Experiments:		**Number of Turns**
1	To study the charge and heat balance of the cupola/arc and induction melting furnaces.	3
2	Sand Testing i. To study the size, shape and distribution of pure dry silica sand sample. ii. To find out the AFS Number of given sand sample. iii. To find out the clay content in the given sand sample by washing. iv. To find out the active and dead clay content in the given sand sample. v. To find out the permeability of the given moulding sand. vi. To study the effect of clay and water content on strength(gcs) of moulding sand by preparing sands of different clay and moisture contents. vii. To find out the water content by conventional and rapid moisture teller in the given sand sample. viii. To find out the mold and core hardness using mould and core hardness testers.	6
3	i. To prepare a green sand mould in foundry workshop. ii. To melt and cast ferrous and non-ferrous metals.	3
4	To study the layout of an industrial casting unit.	1
5	To study the various casting defects by visiting a nearby foundry.	1

Course Outcomes: The student will be able to	
1	Apply fundamentals of sand and other castings and apply theory of solidification on cast metals and alloys.
2	Design gating and feeding system.
3	To develop choice of proper casting method for different products. To design moulds and pattern for making castings, to inspect a casting

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Principles of Metal Casting/Heine, Loperand Rosenthal/Tata McGraw Hill	2010
2	Casting Technology and Cast Alloys/A. K Chakrabarti /PHI	2008
3	Fundamentals of metal casting technology/ Dr. P C Mukhrjee/ Oxford and IBH publishing Co.	1998
4	Principles of Metal Casting/ P L Jain/ Tata Mcgraw Hill	2003
5	Metal Casting & Joining by K C John/ PHI	2015

Course Name	**:**	**IRON MAKING TECHNOLOGY**
Course Code	**:**	**MTN 209**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
The student will able to apply the principles of physical chemistry and transport phenomena (heat, mass and momentum) to the process steps in Iron making as practiced in integrated steel plants. To reproduce and to understand basic layout of blast furnace, steelmaking shop and continuous casting process. To discuss the design of iron making technology in an integrated steel plant/corporate center and R&D venture.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO PROCESS DETAILS** Iron ores-classification its type and characteristics. Scope of iron making industry in India and nature of the indigenous raw materials. Quality parameters of iron ore.	7
2	**CONSTRUCTIONAL DETAILS** Design and description of various parts of B.F. and their function. Refractories at different locations of Blast furnace.	7
3	**RECENT ADVANCES IN PROCESS AND ITS CONTROL** Recent improvements in the blast furnace design, operation i.e. high top pressure, humidity control, oxygen enrichment and fuel and lime injection through tuyeres. Irregularities in the blast furnace and their prevention. Advances to the control of the process.	8
4	**FUEL FEED FOR BLAST FURNACE AND TESTING** 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	5
5	**AGGLOMERATION OF FEED FOR BLAST FURNACE** Mechanism and processing variable for optimization of process of agglomeration-Pallelization, Sintering, Nodulizing Process	5
6	**PHYSIO CHEMICAL CHANGES IN BLAST FURNACE** Smelting of Iron Ore in the B.F., various reactions. The analysis of Solid-Gas and Slag-Metal Reactions on the basis of Physio Chemical Principles. Mechanism and rates of these reactions. The behaviour of impurities and the nature of B.F. Slags.	7
7	**ALTERNATIVE TECHNOLOGIES FOR IRON MAKING** Sponge iron technology, Production of DR iron and its	3

Course Outcomes: The graduate will be capable to	
1	Assign the relevance to different variables of Iron making to the productivity of the blast furnace.
2	To understand and undertake any technical assignment in Iron making Industry.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	The manufacture of iron and steel (Vol. I and II) / Bashforth, R.G/ Chapman and Hall Limited.	2005
2	Principles of Blast Furnace (Iron Making)/ A.K. Biswas/ Cootha.	2003
3	Iron Making and Steelmaking: Theory and Practice / AhindraGhosh, AmitChatterjee/PrenticeHall India	2008

4	Iron and Steel Production/K. Bugayev, Y. Konovalov/Books for Business	2001
5	Making, Shaping and Treating of Steel (Iron Making) / David H. Wakelin/ The AISE Steel Foundation	1999(First Edition)

Course Name	**:**	**POLYMER TECHNOLOGY**
Course Code	**:**	**MTN 210**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
The graduate will be able to describe properties of polymer, analyse electrical, thermal, optical and elastic behavior of polymers and design of polymeric materials for given applications.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Basic concept, Classification, Chemical bonding and molecular forces in polymers, Thermoplastics and thermosets.	2
2	**ELECTRICAL PROPERTIES** Basic concepts, dielectric and relaxation of polymers, Mechanism of relaxation, Experimental methods to study dielectric properties of polymers, Dielectric behavior of polyethylene.	8
3	**OPTICAL PROPERTIES** Conditions of optical activity in macro molecular systems, Prediction of configurations, Dissymmetry in macromolecular structure, Optical testing of polymers.	7
4	**THERMAL PROPERTIES** Heat capacity, Heat capacity of crystalline and amorphous polymers, Thermal conductivity. Thermal analysis of polymers (DTA and TGA).	7
5	**OTHER PROPERTIES** Dynamic modulus of elasticity, Less modulus, Viscosity of propagation and absorption coefficient of elastic waves in polymers, Degradation of Polymers.	7
6	**PROCESSING TECHNIQUE** Compounding and vulcanization.	2
7	**POLYMER FIBER** Natural and synthetic fibers, Criteria for fiber formation, Testing and modification of fibers.	3
8	**APPLICATIONS** Application of polymers in engineering and industry.	4
9	**HIGH TEMPERATURE POLYMER** High temperature conducting polymers, crystalline polymers.	2

Course Outcomes:	
1	The graduate will be capable of designing a polymeric material for a specific application.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Fundamentals of Polymer Science and Engineering /Anil Kumar, S. K. Gupta/ Tata	1978

	McGraw Hill.	
2	Introduction to industrial polymers/Henri Ulrich/ Carl Hanser Verlag GmbH & Co; 2nd Revised edition.	1993
3	Polymer Science and Technology / Fried Joel R/, PHI	2005
4	Ploymer Science and Technology / Robert O. Ebewele/ CRC Press	2000

Course Name	**:**	**STEEL MAKING TECHNOLOGY**
Course Code	**:**	**MTN 301**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
The student will be able to apply concept to explain new developments in steel making industry. To design the treatment to the liquid steels for attaining better properties.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**PRESENT SCENARIO** Production and quality aspects for different steels and their importance for industrial applications. Application of alloy steels which makes it irreplaceable.	5
2	**PHYSIO CHEMICAL PRINCIPLES FOR STEEL MAKING** Physico chemical aspects of steel making reactions, controlling the removal of carbon, sulphur, phosphorous, silicon and manganese. Slags- their constitution and properties and the theories predicting their behavior	6
3	**PRODUCTION OF STEEL** Constructional details of the Steel making furnaces. Design and description of various parts and their functions. Bessemer converter, Open hearth and Electric arc furnace, their control, constructional and operational details	5
4	**NEW DEVELOPMENTS** Modern pneumatic process viz L.D., Kaldo and Rotor process etc. Secondary processes of steel refining viz. Laddle furnace, AOD, VOD, and ESR.	5
5	**ELECTRIC ARC FURNACE** Its design considerations and other important characteristics, Physicochemical aspects of the reactions.	3
6	**GAS METAL INTERACTION** Mechanism of gas absorption via entertainment during teeming of molten metals, Solubility of oxygen in liquid metals – its estimation, form EMF measurements involving solid electrolytes.	5
7	**DEGASSING PROCESS** Vacuum, Argon and Recycling methods employed for degasification of steel.	3
8	**SOLIDIFICATION OF STEEL** Solidification defects viz. Inclusion, blowholes, cracks and segregation-their causes, effects and remedies. Degassing processes, Teeming practices, Gas Metal interaction during teeming,	5
9	**CONTINUOUS CASTING OF STEELS** Technology involved latest developments, Possible Defects and remedial measures.	5

List of Experiments:		**Number of Turns**
1	To beneficiate chalcopyrite ore by froth flotation and establishing the relation of its operation variables with yield.	1

2	To establish the parameters for reduction kinetics of concentrated Chalopyrite ore.	1
3	To draw washability curve for a sample of coal given	1
4	To produce agglomerate by fines of hametite/ magnetite through Sintering and palletization	1
5	To study and understand the kinetics of reduction of Pallets and Sinter	2
6	Design a process for understanding the solidification defects in steels with the help wax casting.	1
7	**S**tudy, evaluate and plot the volume percent of piping in the steel ingot castings versus the super heats on the in wax casting.	2
8.	Design the experiment on wax casting to understand directional solidifications in steel ingots. Plot the variation.	2
9.	To find the constant temperature zone of a muffle furnace.	1
10	To find viscosity of molten metal/ slag by Brookfield viscometer	1

Course Outcomes: The student will be able to	
1	Analyse the processes in any integrated steel plant and correlate variables with the quality of the product
2	Analyse process continuous casting plant.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	The manufacture of iron and steel (Vol. II and IV) Bash forth, R.G	1951/2005
2	Continuous Casting of steel : Basic principles/Bruce Kozak and Joseph Dzierzawski/ American Iron and Steel Institute	2015
3	Iron Making And Steelmaking: Theory And Practice / AhindraGhosh, AmitChatterjee/ Prentice Hall India	2008
4	Steel Making / A.K. Chakrabarti / Prentice-Hall of India Pvt. Ltd	2007
5	Making, Shaping and Treating of Steel (Iron Making) / David H. Wakelin/ The AISE Steel Foundation	1999(First Edition)

Course Name	**:**	**MATERIALS CHARACTERIZATION**
Course Code	**:**	**MTN 302**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
To explain principles and practice of X-Ray diffraction, SEM, TEM, XRF and analyse results in laboratory methods and reporting of results. To use laboratory methods and reporting of results of materials characterization. To analyse characterization methods for the determination of the result of composition, structure and properties of materials.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Meaning/importance/need/role of examination & testing of materials, Scope of various examination and testing methods available viz Microscopic Examination/Metallography, Macroscopic Examination, Chemical Methods, Mechanical methods, Non-Destructive Testing (NDT) Methods, Spectroscopy etc.	4
2	**METALLOGRAPHY/MICROSCOPIC EXAMINATION OF METALS** Preparation & Etching of Specimens of metals & alloys. Principle, Construction &working of metallurgical microscope, Various Properties of microscope objectives, Defects in lenses & their remedies, Various types of objectives and eye pieces, TEM and SEM	6

	Microscope.	
3	**MACROSCOPIC EXAMINATION OF METALS** Introduction, Importance & scope of Macro etching, Sulphur/Phosphorus/Oxide Printing. Flow Lines	2
4	**CHEMICAL METHODS** Gravimetric, Volumetric, Colorimetric, Electro-gravimetric, Fire Assaying &Polarographic Methods of Analysis	7
5	**MECHANICAL METHODS** Hardness testing, Tensile testing, Impact testing, Creep, Fatigue, Fracture, Nano indentation technique**.**	6
6	**NON-DESTRUCTIVE TESTING** X-ray/Gamma ray radiography, Ultrasonic testing, Magnetic methods- Magnetic particle test/Magna Flux, Zyglo/Die penetration test, Eddy current test, X-ray diffraction.	7
7	**ADVANCED CHARACTERIZATION TECHNIQUES** Scanning probe microscope, X-ray fluorescence technique, Atomic absorption spectroscopy, Differential thermal analysis (DTA), differential scanning calorimeter (DSC), Thermo gravimetric analysis (TGA), Thermo mechanical analysis (TMA)	6
8	**APPLICATIONS OF CHARACTERIZATION TECHNIQUES:** Applications of the different characterization techniques: e.g.: XRD, SEM, TGA, DTA, DSC etc.	4

List of Experiments:		**Number of Turns**
1	To analyse given samples using metascope for different elements and spark test for Carbon content.	1
2	To find Fe content in Fe ore.	2
3	Nickel content in stainless steel by gravimetric analysis method.	1
4	To determine Carbon and Sulphur content in a given sample.	2
5	To study Spectroscopic analysis for Qualitative/ Quantitative analysis	1
6.	To study segregation of sulphur and phosphorus by sulphur printing and phosphorus printing.	1
7.	To study flow lines in a given forged sample.	1
8.	To perform Izod test.	1
9.	To study the wear and friction monitor and to test the given materials.	1
10.	Tensile test and compression test.	1
11.	Fatigue test.	1
12.	To study the Ultrasonic Flow Detector and examine the given sample	1

Course Outcomes: The student will be able:	
1	To analyse results of x-ray and electron diffraction.
2	To analyse optical characterization methods including Raman and infrared spectroscopy.
3	To analyse the result of different characterization required for study characteristics of materials.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Qualitative and Quantitative Analysis/Alexive/MIR Publisher	1982
2	Chemical and Metallurgical Analysis/ Vogel/Longman Scientific and Technical	1999
3	X-ray Diffraction/B D Cullity/Addison-Wesley	1956
4	Testing of Materials/Davis and Troxell/McGraw-Hill	1998
5	Principles of Metallographic Laboratory Practice/G L Kehl/McGraw-Hill	1980
6	Mechanical Metallurgy/Dieter/McGraw-Hill	2009
7	Principles of Physical Metallurgy/Reedhill/ McGraw-Hill	2008

Course Name	**:**	**MECHANICAL WORKING OF METALS**
Course Code	**:**	**MTN 303**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
The student will be able to apply fundamentals of metal working like forging, rolling, extrusion, drawing. To apply the metallurgical aspects for such mechanical operations.To recognize the rolling and forging defects. To calculate the deformation load requirement for processes like rolling and forging.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**FUNDAMENTALS OF METAL WORKING** Classification of forming processes, Mechanics of metal working, Flow stress determination, Temperature in metal working, Strain rate effects, Metallurgical structure, Friction and lubrication, Deformation zone geometry, Workability, Residual Stresses, Experimental Techniques for metal working processes, Computer aided manufacturing	10
2	**FORGING** Classification of Forging, Forging equipments, Forging in plain strain, Open die and close die forging, Calculation of forging loads in closed die forging, Forging die materials, Forging defects, Powder metallurgy forging, residual stresses in forgings, The economics of forging, Problems	6
3	**ROLLING OF METALS** Classification of rolling processes, Rolling mills and the materials used for rolls, hot rolling, cold rolling, rolling of bars and shapes, Forces and geometrical relationships in rolling, simplified relationships in rolling load, rolling variables, Problems and defects in rolled products, Selection of rolling mills and the sequence of rolling operations for a given rolled product, Problems	7
4	**EXTRUSION** Classification of extrusion processes, Extrusion Equipment, die materials, Hot extrusion, Deformation, Lubrication, and defects in the extruded products, Analysis, Coldextrusion, Hydrostatic extrusion, Problems.	5
5	**DRAWING OF RODS, WIRES AND TUBES** Rod and wire drawing, analysis of wire drawing, Tube drawing processes, analysis of tube drawing, Drawing equipments, Defects and Residual stresses in rod, wire and tubes	3
6	**SHEET METAL FORMING** Forming methods, Shearing, Blanking, Bending, Stretch forming, Deep drawing,Rubber forming, Spinning, Super plastic forming, Forming limit criteria, Defects informed parts, Equipments used for sheet metal forming, Production of honey combstructures-Expansion, corrugation process, Dent resistance of sheet metal parts.	5
7	**NON CONVENTIONAL FORMING OPERATION** Explosive forming, Magnetic forming, Electric discharge forming, Super plastic forming for super plastic materials like Zn-22Al and Ti-6Al-4V alloys, combination of super plastic forming and diffusion bonding (SPF/DB), Die materials used for super plastic forming, Peen forming of thin sheet metals, Laser forming	6

Course Outcomes: The students will be able to	
1	Design the mechanical working process for a given application.
2	To mathematically calculate and design the process of mechanical working.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Mechanical metallurgy/ Dieter/ Tata Mcgraw Hill	2012
2	Explosive Forming/SaeedJabalamelian, Aidy Ali/LAP Lambert Academic Publishing	2012
3	Mechanical Working of Metals: Theory and Practice / Pergamon / John Noel Harris	1983(First Edition)
4	Manufacturing Engineering and Technology / Seropekalpakjian , Steven R Schmid/Pearson India	2002
5	DeGarmo's Materials and Processes in Manufacturing/ J. T. Black (Author), Ronald A. Kohser/ Wiley	2011

Course Name	**:**	**ENGINEERING MATERIALS & SELECTION**
Course Code	**:**	**MTN 304**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
The student will be able to apply the fundamentals of selection of materials for practical applications. To apply concepts for failure analysis of engineering applications. To correlate properties of materials with their structure.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION AND MOTIVATION FOR MATERIALS SELECTION** Properties of Materials, Classification and parameter for the material selection, motivation for materials selection	2
2	**COST BASIS FOR SELECTION** Cost effectiveness and value analysis / Analysis of cost	2
3	**ESTABLISHMENT OF SERVICE REQUIREMENTS AND FAILUREANALYSIS** Selection and design in relation to anticipated service, Cause of failure in service, Mechanism of failure, Corrosion	4
4	**SPECIFICATIONS AND QUALITY CONTROL** Roll of standard specification, inspection and quality control	4
5	**SELECTION FOR MECHANICAL PROPERTIES** Strength, toughness, stiffness, fatigue, high temperature resistance and Creep resistance	7
6	**SELECTION FOR SURFACE DURABILITY** Wear and abrasion resistance, corrosion resistance.	4
7	**ELECTRICAL MATERIALS** Selection for electrical, magnetic properties	4
8	**ADVANCED MATERIALS** Smart materials, intelligent materials	4
9	**CO-RELATION**-Relation between Materials selection and Materials processing, Formalization of selection procedures	4
10	**CASE STUDIES IN MATERIAL SELECTIONS** Aerospace, Ship, Engine and Power generation, Automobile, Bearings, springs, Gears, Tools	7

Course Outcomes: The student will be able to	
1	Specify performance requirements of a desired material and the process for making it, in the context of a given application.

2	To analyze quantitatively the Performance Efficiency relationships for an article.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Selection and uses of materials/Charles, Crane and Furness/Butterworth Heinmann publisher	1997
2	Engineering Material Technology/James A Jacobs and Thomas F Kilduff/ Prentice Hall of India	2000
3	Engineering Materials: Properties and selection/ Kenneth G. Budinski, Michael K. Budinski/ Prentice Hall	2009
4	Engineering materials / R K Rajput / S Chand and company Ltd.	2008
5	Engineering materials and metallurgy / R K Rajput / S Chand and company Ltd.	2006

Course Name	**:**	**MATERIAL JOINING TECHNOLOGY**
Course Code	**:**	**MTN 305**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
The student will be able to understand, select and control appropriate joining technologies for industrial applications with emphasis on welding, adhesive bonding, brazing, soldering and weld quality.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**CLASSIFICATION AND SURVEY OF WELDING PROCESSES** Arc Welding Process: Structure, characteristics, efficiency and electrical characteristics of an arc. Type of welding arcs, methods of arc maintenance, role of electrode, polarity and arc stability. Arc welding power source, requirements for an arc welding power source: AC and DC welding power sources, rectified DC welding power source, high frequency units for arc control. Surface requirement for joining (surface structure, preparation and selection requirement).	5
2	**ARC WELDING CONSUMABLES** Coated electrodes, fluxes, filler wires, shielding gases. Arc welding process: Shield Metal Arc (SMAW), Submerged Arc Welding Gas Metal ARC Welding (SAW), Gas Metal Arc (GMAW) and electrogas, Welding equipments, weld joint design, operations, techniques metal fusion, weld penetration, electrodes and their motion. Application of GMAW for welding low steels, structures. Welding of aluminium in automotive, aeronautical and nuclear industry. Weldability, Heat Affected Zone in Arc and Gas Welding, Cold Welding and explosive welding.	7
3	**RESISTANCE WELDING PROCESSES** Basic principle and welding variables and electrodes use, joint design, design and performance of welded structure. Applications, Metal transfer, modes of Metal transfer, parameters affecting it and weld characteristics. Other welding processes viz. solid state welding processes, electron beam and laser welding, joint designs, variables, applications .Case Study	7
4	**ALLIED PROCESSES** Soldering brazing, diffusion bonding, adhesive bonding braze welding, metal surfacing and spraying techniques, selection of a surfacing process, materials of substrate like, low alloy	8

	steels, plain 'C' steels with C-0.45%, classification and characteristics of surfacing materials- iron base, Ni-base, cobalt-base, copper base alloys, carbides of Tungsten chromium. Metal spraying and materials for spraying and substrate, ceramic coatings, composite coating, techniques used, Application, Quality assurance of welded joints (NDT, Safety, Measurement and Control)	6
5	**DEFECTS IN WELDING** Classification of various welding defects, their types and remedies.Case studies on welding defects and its rectifications	4
6	**IS CODES AND SPECIFICATIONS FOR WELDING MATERIALS AND PRACTICES** Principle involved and Adhesives employed for joining of metals and nonferrous materials. Factors effecting strength of joints made and other variable effecting their specific applications.	5

Course Outcomes: The student will be able to	
1	Select appropriate joining methods for different applications.
2	Calculate joint dimensions to resist particular operating conditions.
3	Assess the mechanical and metallographic changes which occur in welding and determining suitability for service.
4	Develop joining processes, process selection procedures and the techniques to quantitatively assess the behavior of joints for new applications.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Welding Engineering and Technology 2nd Edition/RS Parmar/Khanna Publisher New Delhi	2002
2	Welding and Welding Technology/Richard Little/Tata McGraw Hill	2001
3	Welding Metallurgy 2nd edition/Sindo Kou/John Willed USA	2003
4	Welding Technology / Bruce Stirling / DhanapatRai Publishing Company Pvt. Ltd.	2013
5	Welding Technology and Design / Radha Krishnan, VM, Newage International Pvt. Ltd.	2008

Course Name	**:**	**KINETICS AND RATE PROCESSES**
Course Code	**:**	**MTN 401**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
The student will be able to apply the principle of flow fluids, kinetics of processes involving heat and mass transfer. To apply problems and understand boundary layer theory and coupled phenomena and solve numerical problems.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Basic principles of reaction kinetics &transport phenomenon, Units & dimensions, Importance of the subject.	4
2	**FLOW OF FLUIDS** Nature of Fluid Flow, Viscosity, Differential Mass & Momentum Balances, Overall	4

	or Macroscopic Balance, High Speed Flow of Gases, Flow through Packed Beds Flow through Fluidized Beds, Motion of Gas Bubbles in Liquids	
3	**KINETICS** Introduction, Factors affecting rates of processes, Rate Theories, Collision Theory& Theory of Absolute Reaction Rates, Rate Constant, Order &Molecularity of a reaction, Determination of order of a reaction by different methods, Derivation of rate constant/specific reaction rate for different order reaction, Slag Metal Reactions, Numerical Problems	6
4	**HEAT TRANSFER** Conduction, Convection, Radiative heat transfer	6
5	**MASS TRANSFER** Diffusion, Convective Mass Transfer - Natural & Forced Convection, Overall Mass balance, Mass Transfer Coefficient, Interfacial Mass Transfer	6
6	**DIMENSIONAL ANALYSIS & SIMILITUDE** Dimensionless numbers & functional relationships, Methods of dimensional analysis	5
7	**BOUNDARY LAYER THEORY** Velocity boundary layer, Thermal boundary layer, Concentration boundary layer, Boundary layer theory for simultaneous heat	5
8	**COUPLED PHENOMENON** Transport coupling, Reynolds' analogy between heat & momentum transfer and between mass & momentum transfer, Prandtl's analogy between heat &momentum transfer and between mass & momentum transfer, Chilton-colburnanalogy among heat, mass & momentum transfer.	6

Course Outcomes:	
1	The student will be able to apply concept and solve the problems of heat and mass transfer during metallurgical process such as extraction, refining, heat treatment etc.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Transport Phenomena in Materials Processing/Geiger & Poirier/ John Wiley & Sons	1998
2	Rate Processes in Metallurgy/ A K Mohanty/ PHI Learning Pvt. Ltd.	2009
3	A Text Book of Metallurgical Kinetics / AhindraGhosh&Sudip to Gosh / PHI Learning (P) Ltd.	2014
4	Engineering Thermodynamics – work & Heat Transfer by Gordon Rogers & Yon Mayhew / Pearson	2012

Course Name	**:**	**ELECTROCERAMICS**
Course Code	**:**	**MTN 402**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
The student will able to understand structure of ceramic materials, their structural evolution during sintering, including solid-state, viscous flow, and liquid- phase sintering and their electrical, magnetic, thermal and mechanical properties.

Total No. of Lectures – 42

Lecture wise breakup		Number of Lectures
1	**INTRODUCTION** Atomic structure including ionic and covalent bonding, Ceramic crystal structures, Clay structures, and amorphous materials. Atomic defects including intrinsic and extrinsic point defects, Kroger-Vink notation.	6
2	**SYNTHESIS AND MICROSTRUCTURE DEVELOPMENT** Microstructure development in equilibrium and nonequilibrium phases, Solid- state sintering, densification vs. coarsening processes, Grain boundary mobility, Porosity evolution (stability/entrapment), Liquid phase sintering, constrained sintering, Ceramic coatings and their deposition.	7
3	**ELECTRICAL PROPERTIES** Conductors: electrodes, varistors, thermistors, Insulators and Dielectrics: polarization, charge displacement, dielectric strength, dielectric constant and loss, equivalent circuits, Ferroelectricity, Piezoelectrics, Pyroelectrics, actuators and sensors. Classification of superionic solids-Alumina and oxide based superionic conductors and their applications in fuel cells and batteries	9
4	**MAGNETIC PROPERTIES** Spinel, normal and inverse, Weiss domains, ferrites, soft and hard, super-exchange, garnets, permeability, microstructure-property relations, dia, para, ferro and ferrimagnetic materials, chemical substitutions, device performance and applications.	8
5	**THERMAL AND MECHANICAL PROPERTIES** Heat capacity, Thermal conductivity, Thermal expansion, Creep and thermal stresses. Mechanical properties: Strength, Toughness and micro structural design.	7
6	**MULTIFERROIC AND SPINTRONIC MATERIALS AND THEIR APPLICATIONS** Single phase and composite multiferroic material, $BiFeO_3$, $RMnO_3$, Magnetoelectric coupling	5

Course Outcomes: The student will able to	
1	To design a suitable sintering schedule for heat-treating ceramics and understand the effects of existing micro structural features and
2	Apply the principles of physical sciences and engineering to electrical, magnetic and optical magnetic systems.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Electro ceramics: Materials, Properties and Applications/A. J. Moulson and J. M. Herbert/John Wiley & Sons	2003
2	Ceramic Processing and Sintering, 2nd Ed/M. N. Rahaman/CRC Press.	2003
3	Ceramic Fabrication Processes/F. F. Y. Wang/Academic Press.	1976
4	Ceramic Science and Technology/W. D. Kingery, H. K. Bowen and D. R. Uhlman/John Wiley and Sons, Singapore.	1991
5	Transition Metal Oxides/C.N.R. Rao and B. Raveau/Wiley-VCH	1999

Course Name	**:**	**ADVANCED FOUNDRY TECHNOLOGY**
Course Code	**:**	**MTN 403**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:

The student will be able to insight into various principles of gating system design, die pattern design, mechanization of foundry for production of sound castings and recent trends in foundry technology w.r.t manufacturing, inspection and testing.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**TRENDS & SCOPE IN FOUNDRY INDUSTRY** Position of foundry industry worldwide and in India, analysis of data in respect of production and demand, recent trends in quality specifications like dimensional accuracy, surface finish and property requirements, specifications, properties and applications of modern cast alloys- SG iron. Al- alloys, Mo- alloys, Ti- alloys.	5
2	**PRINCIPLES OF GATING AND RISERING** Elements and types of gating systems, pressurised& unpressurised gating ratios, systems-applications, Risers – types and functions of risers, directional solidification – factor affecting and significance, use of exothermic sleeves, bricks, chills and their types, and uses of filters, computer aided design for gating and risering systems.	8
3	**DESIGN IN CASTING** Factors to be considered in casting design. Design consideration in pattern making, moulding techniques, core making and assembly. Cooling stresses and hot spots in casting and modification in casting geometry to overcome them. Computer Aided pattern design and manufacture, pattern making machines and equipments, Heat transfer phenomena in casting, Computer aided design of dies in die casting and centrifugal casting, materials used and allowances in patterns and dies.	6
4	**FURNACE TECHNOLOGY** Study of various furnaces used in foundry, construction and operation of crucible and hearth furnaces. Resistance, Arc and Induction furnaces-their construction. Operation and application. Heat treatment furnaces and drying ovens used in foundry. Energy saving in melting practices. Melting practices and furnaces for ferrous and non- ferrous alloys.	5
5	**MODERN MOLDING AND CORE MAKING PROCESSES AND EQUIPMENTS** Various types of sands used for moulding and core making, testing of sand, high pressure line molding, Dissamatic, chemically bonded sands; shell molding binder, hardener and type of sand used in shell molding, procedure used for making shell sand, plants used, properties and tests on shell sand, stick point strength, advantages and applications; Resin bonded sands, alkyl resins, phenolic resins and furnace sands, cold box method of core making – advantages and applications, ceramic molding, vacuum molding, sand reclamation – importance, methods and plants.	6
6	**SPECIAL, NET SHAPE CASTING AND HIGH PERFORMANCE PROCESSES** Evaporative Pattern Casting, Shell Sand Casting, Vacuum Casting, Thixoforming, Ceramic Shell Casting, Die Casting and High Pressure Die Casting, Centrifugal Casting, Slush Casting, Rheo Casting, Investment Casting, Continuous Casting ,Micro Casting etc.	6
7	**CASTING QUALITY CONTROL** Casting defects and factors responsible for them. Different inspection and testing methods to evaluate the casting. Quality control activities in a foundry. Salvaging methods of defective casting. Use of Cause and Effect or Fish Bone Diagrams, Application of S.Q.C. in foundries, control charts (SPC), Kaizen, Kanban, Six Sigma, Quality Control & Quality Assurance in Foundries.	6

Course Outcomes: The student will able to	
1	To know the furnaces used in the production of metal & alloys. To describe moulding, casting and solidification processes.
2	To differentiate between the different casting processes and their end products.
3	To develop designs for engineering components produced via against defects.
4	To produce sound castings without defects

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Principles of Metal Casting 2nd Edition/ RWheine, CR Loper& PC Rosenthal/ Tata McGraw Hill	1976
2	Foundry Technology 2nd Edition/PR Beelely/Butterworth Heinemann Ltd.	2001
3	A text book of Foundry Technology/LalM,Khanna/DhanpatRai& Sons Publications	2007
4	Principles of Foundry Technology / P. Jain/ McGraw Hill Education Pvt. Ltd.	2009
5	Casting Technology and Cast Alloys / AK Chakrabati / PHI Learning Pvt. Ltd.	2005

Course Name	**:**	**THIN FILM TECHNOLOGY**
Course Code	**:**	**MTN 404**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
To introduce the students the concept and method for thin film coating starting from source materials to transportation and depositions Techniques to analyze and characterize thin films in terms of optical, electrical and mechanical properties. The applications to Science and technology.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Physical Vapor Deposition - Hertz Knudsen equation; mass evaporation rate; Knudsen cell, Directional distribution of evaporating species Evaporation of elements, compounds, alloys.	5
2	**RAOULT'S LAW** E-beam, pulsed laser and ion beam evaporation, Glow Discharge and Plasma, Sputtering - mechanisms, Bias sputtering, magnetically enhanced sputtering systems, reactive sputtering, Hybrid and Modified PVD- Ion plating, reactive evaporation, ion beam assisted deposition.	7
3	**DEPOSITION TECHNIQUES** Chemical Vapor Deposition - reaction chemistry and thermodynamics of PVD, CVD Methods of producing thin films: PVD, CVD, sputtering, epitaxial films, film thickness measurement growth of thin films.	7
4	**CHEMICAL TECHNIQUES** Spray pyrolisis, Electrodeposition, Sol-gel and Langmuir Blodgett techniques	6
5	**NUCLEATION & GROWTH** Capillarity theory, atomistic and kinetic models of nucleation, basic modes of thin film growth, stages of film growth & mechanisms, amorphous thin films.	5
6	**EPITAXY** Homo, hetero and coherent epilayers, lattice misfit and imperfections, epitaxy of compound semiconductors, scope of devices and applications	4
7	**MECHANICAL PROPERTIES** Adhesion and stress measurements, electrical properties, resistivity variation, Hall Effect, Optical properties: reflection, refraction, ellipsometry, reflecting and anti-reflecting films	8

Course Outcomes: At the end of the course students are expected to show ability to:	
1	Understand the difference in the deposition techniques, their advantages and disadvantages. Select the appropriate technique for a given application.
2	To assess the environmental impact of synthesis methods.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Handbook of Thin Film Technology/Maissel and Glange/McGraw Hill.	1970
2	Vacuum Technology: A. Roth (North Holland).	1982
3	Thin Film Phenomemna/ Kasturi. L. Chopra. Malabar/Robert E. Krieger Publishing Company	1979
4	Handbook of Thin Film Materials: Deposition and processing of thin films/HariSingh alwa, Academic Press	2002
5	Handbook of Chemical Vapor Deposition: Principles, Technology and Applications/Hugh O/ Pierson, Technology and Engineering	2012

Course Name	**:**	**FAILURE ANALYSIS**
Course Code	**:**	**MTN 405**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
Acquire fundamental understanding of the fracture of solid materials. Develop detailed understanding of fracture mechanics, creep, and fatigue. Acquire basic understanding of the techniques used to perform failure analysis.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**FAILURE OF METALS:** Basic reasons for the failure of metals, various types of theories of failure.	3
2	**REVIEW OF BASIC CONCEPTS OF MECHANICAL BEHAVIOR OF MATERIALS:** Stress-Strain curve, Engineering design versus failure, Types of fracture- ductile fracture, brittle fracture; Theoretical fracture stress, Griffith theory, The ductile to brittle transition.	6
3	**FAILURE MODES:** Failure in tension, compression, torsion, impact, wear, fatigue, creep, oxidation, corrosion, erosion. Metallurgical factors (such as structure, composition, processing) influencing failure mechanism.	9
4	**TECHNIQUES OF FAILURE ANALYSIS :** History, data collection, sampling, testing- Destructive and Non-destructive Testing, Macro- examination, Microscopic examination, TEM, SEM, X-Ray diffraction techniques, analysis of results, report preparation, conclusions, recommendation of remedial actions.	10
5	**QUALITY ASSURANCE :** A strong link to failure analysis, Quality control concept, quality assurance.	4
6	**CASE STUDIES –** at least one case study representing each failure mode given in serial number 3. For example- Failure of a low-pressure turbine rotor (LPTR) blade (Fatigue), Failure of an aircraft engine fuel pump (wear), Failure of a stabilizer link rod in an aircraft (over load, tension and bending) etc.	10

List of Experiments:		**Number of Turns**
1	Failure analysis of any sample which fail during to fatigue test	2
2	Failure analysis of any sample which fail during to wear test	2

3	Failure analysis of any sample which fail during to tensile test	2
4	Failure analysis of any sample which fail during to impact test	2
5	Failure analysis of sample which fail due to corrosion	2
6	Case study of the samples collected from the casting unit.	2
7	Case study of the samples collected from the automobile industry	2

Course Outcomes: Student will be able to	
1	Demonstrate knowledge of mechanics analysis for a variety of component.
2	Demonstrate recognition of failure mechanism and identify the alternate materials and/or service condition that prolong component life.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Deformation and Fracture Mechanics of Engineering Materials/R. W. Hertzberg/ John Wiley & Sons.	1996
2	Failure Analysis of Engineering Materials/C. R. Brooks and A. Choudhury/ McGraw-Hill.	2002
3	Materials Science and Engineering/ W. D. Callister/John Wiley & Sons	2010
4	Failure Analysis of Engineering Structures: Methodology and Case Histories/V. Ramachandran, A.C. Raghuram,R.V. Krishnan, and S.K. Bhaumik/ASM International	2005

Course Name	**:**	**HEAT TREATMENT OF METALS**
Course Code	**:**	**MTN 406**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
At the end of this course the student will able to explain the correlation of time and temperature of treatment with microstructure, apply the TTT/CCT diagram for desired microstructure. Design heat treatment cycle for given structural or property requirement

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**PRINCIPLES OF HEAT TREATMENT OF METALS:** Annealing, Normalizing, Hardenability, Hardening, Tempering.	5
2	**THERMO MECHANICAL TREATMENTS:** High temperature treatment with low temperature tempering, Low temperature treatment with low temperature tempering	4
3	**CASE HARDENING OF STEELS:** Carburizing process for their process, advance and challenges. Flame hardening, Nitric process and challenges.	5
4	**HARDENABILITY OF STEELS** Concept of critical diameter, joining-end quench test, effect of parameters viz: alloying elements, carbon content, austenic grain size, section size and quenching media	8
5	**HEAT TREATMENT PROCESSES** Various methods of heat treatments surface hardening treatments, heat treatment of non-ferrous alloys, heat treatment schedules/case studies of some important steels and special types of treatments viz. martempering, austempering and thermo-mechanical treatments and inter critical treatments.	12
6	**DEFECTS**	4

	Defects in heat treated materials and their prevention.	
7	**HEAT TREATMENT OPERATIONS** Design of Heat treatment cycles to achieve required properties.	4

List of Experiments:		**Number of Turns**
1	Normalizing treatment of steel and comparison of the microstructure with annealed structure.	2
2	To perform hardening and study the quenched structures of steel – quenched in oil, water and brine solution.	2
3	(i)To perform hardening and tempering and study the tempered structures of steel for following condition (a) low temperature tempering. (b) medium temperature tempering. (c) high temperature tempering. (ii) Compare the quenched and tempered structure.	2
4	To perform cold working followed by recrystallization and study the recrystallization behaviour of Al/ Fe/ Cu.	2
5	To carry out age hardening of non ferrous alloys. (Al-Cu alloy 2024, Al-Zn-Mg-Cu 7075	2
6	Determination of hardenability of steels using Jominy End Quench Test	2
7	To perform the Carburizing treatment and to study the effect of time on the Case depths of carburized steel.	2

Course Outcomes: Student will be able to	
1	Establish Heat Treatment – Process – Structure – Property correlation.
2	Design Heat Treatment to meet a property requirement for engineering application.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Heat treatment of Steels/ Vijendra Singh/ Standard Publishers Distributors	2009
2	Heat treatment of Steels/ R.C. Sharma/ New Age International (P) Limited	1996
3	Phase Transformation of Materials/ R.C. Sharma/ CBS Publishers	2002
4	Heat Treatment: Principles and Techniques/ T.V. Sharma, C.P. Sharma, Ashok Rajan/PHI	2011
5	Principles of Heat Treatment of Steel / George Krauss /American Society for Metals	1980(First Edition)

Course Name	**:**	**ALLOY STEELS**
Course Code	**:**	**MTN 407**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
To impart knowledge regarding different types of low, high alloy steels, ferro-alloys their properties & methods of production

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO ALLOY STEEL:** History of Alloy Steels/Making, their classifications, Applications & advantages of alloy steels over plain carbon steels, common alloying elements and their influence on properties	10

	of steel, Recovery of Cr, Ni, Mo, V, W , Production of various types of stainless steel, hadfield, tool, die and high speed steel	
2	**STRENGTHENING MECHANISMS IN STEELS** Heat treatment of alloy steels, Thermo-mechanical treatment of steels, Microstructure – property correlation in alloy steels, Effect of nonmetallic inclusions and residual elements on properties of steels, Composition, properties and applications of some low alloy steels. Composition, properties and applications of some high alloy steels. Composition, High strength low alloy steels, Properties and applications of some alloy cast irons.	10
3	**FERRO ALLOYS TECHNOLOGY:** Why ferro alloys, Ferroalloy industries in India and their future prospects, Physico-chemical principles of ferro alloy making, principles of carbothermic and metallo-thermic reduction, Ferro alloys furnaces: Submerged arc furnaces, selection for transformer capacity, secondary voltage and curent, furnace dimensions, size and spacing of electrodes, mechanical equipments, charging devices and dust collection systems,	10
4	**ELECTRODES USED IN FERROALLOY FURNACES:** graphitsed and self baking electrodes, properties and uses, Production of ferro-manganese, ferro-chrome, ferro-silcon and silco-calcium by carbothermy, production of FeCr, FeTi, FeB, FeNb, FeMo, and FeV by metalothermy. Recovery of vanadium from ores and production of FeV.	9
5	**APPLICATIONS OF FERRO ALLOYS:** Use of ferro-alloys in iron and steel industries (deoxidation and alloy making).	3

List of Experiments:		**Number of Turns**
1	Comparative study of low/medium/high carbon steels and alloy steels vizferritic/austenitic/ martensitic stainless/tool/die/hadfield/high speed/low alloy steels by examining their microstructures, hardness and other properties etc.	6
2	Testing wrought/white/grey cast irons and Machine/carbon tool/high speed/manganese /stainless/high speed/die etc steels by Spark Test and to note & record carrier lines, length/volume &colour of stream, quantity & nature of spurts	2
3	To determine the %age of Si in ferro-silicon.	1
4	To determine the %age of Mn in ferro-manganese.	1
5	To study the microstructure of ferro-silicon &ferro-manganese.	1
6	To produce ferro-manganese sintered compacts by powder techniques and to compare its characteristics with cast specimen.	3

Course Outcomes: At the end student will be able to	
1	Know, suggest and use the different alloy steels for different purposes.
2	Analyze the effective/comparative usage of different ferro alloys for the same application.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Laslie, W.C - Physical Metallurgy of Steels, McGraw Hill, NewYork, (Indian Edition)	2001
2	ASM, Metals Handbook: Properties and selection, Vol. 1, 9th Ed.,Metal Park, Ohio.	2002
3	Introduction to Physical Metallurgy/ Avner, Sidney H / McGraw Hill,New York	2005
4.	Engineering Physical Metallurgy and Heat Treatment/ Lakhtin, Yu, M / Mir Publishers	1990
5.	Honeycomb, R.W.K – Steels/ Edwin Arnold, London.	1995
6	Production of Ferroalloys / Riss and Khodorovasky / Mir publishers	1985
7	Making Shaping & Treating of Steel – ASM Publivation	1997

Course Name	**:**	**CAST IRON TECHNOLOGY**

Course Code	**:**	**MTN 408**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
At the end of the course the student will be exposed to melting & casting practices and manufacture of grey, white and malleable iron, SG iron, compacted iron and austempered ductile iron along with metallurgical, mechanical & casting properties of different cast irons.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Cast irons- various types/classification- gray /vermicular gray (VG) or compacted gray iron /white /mottled /chilled /malleable /nodular or ductile or SG iron /ADI ,composition , microstructures, properties, uses & applications, properties of cast irons vis a vis steels, status of cast iron in ferrous metal scenario, cast iron foundry industry & role of gray cast iron metal in the development of metal casting industry	4
2	**MELTING OF CAST IRONS** Various furnaces used viz crucible/rotary/reverberatory/cupola/induction, their types/ construction/ operational details, Recent developments in cupola melting- hot blast cupola/water cooled cupola/divided blast cupola/use of oxygen in cupola/ coke less or gas fired cupola, selection of melting unit for a cast iron foundry, charging & charge balance, Cupola- composition control, coke bed & stack gases; melting rate, combustion & melt temp., chill control	9
3	**GRAY CAST IRON FOUNDRY PRACTICE& METALLURGY OF GREY CAST IRON** Molding, Gating &Risering, Fluidity of gray iron, shrinkage, gating design & pouring rate, dirt prevention, Fe-C-Si phase diagrams & solidification of Fe-C-Si alloys, carbon equivalent, graphitization & factors affecting graphitization during solidification and in solid state, types of flakes & their effect on properties, Inoculation & inoculants used, mechanism of inoculation graphite nuclei/degasification/silicate-slime/under cooling/carbide stability/surface tension & surface energy theories,Techniques of inoculationsladle/stream/mold, Composition, microstructure, properties of gray irons, Heat treatment of gray irons.	12
4	**WHITE & MALLEABLE IRON FOUNDRY PRACTICE** Composition & solidification of white cast iron, microstructure & properties, types & composition of malleable irons, malleablizing process malleable foundry practice	3
5	**S G IRON FOUNDRY PRACTICE** Microstructure, properties of SG iron, composition & melting of base iron, desulphurization, magnesium treatment & post inoculation, solidification of SG iron &mechanism of spheroidal graphite formation, uses & applications, Heat treatment of SG iron castings	6
6	**VERMICULAR/COMPACTED GRAPHITE IRONS** Composition, microstructure, properties & production of VG/CG iron, melt treatment & post inoculation, mechanism of VG formation.	4
7	**AUSTEMPERED DUCTILE IRON** Composition, microstructure, properties & production, Heat treatment of AD irons, uses & application.	4

List of Experiments:		**Number of Turns**
1	Fluidity of grey iron and its determination, Effect of temp & composition	2
2	Shrinkage in grey iron & effect of graphitic carbon	2
3	Production of malleable cast iron both black & white heart (pearlitic&ferritic) from white	2

	cast iron and study of microstructure & hardness	
4	Comparative study of microstructure & hardness of all cast irons	2
5	Austempering of ductile iron and study of ADI	2
6	To melt and cast grey cast iron after preparing a mould	2
7	To study venation in microstructure and hardness along the section thickness of grey cast iron casting	2

Course Outcomes: The students would be able to	
1	Know the melting & casting practices being followed for different cast irons.
2	Know the metallurgical, mechanical as well as casting properties of various cast irons.
3	Capable of calculating heat & charge balance of furnaces.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Cast Iron Technology/ Elliot /Butterworth-Heinemann Publishers	1988
2	Cast iron Technology/S N Tiwari/CBS Publisher	2009
3	Metal Casting & Joining/K C John/PHI	2015
4	Principle of Metal Casting/Richard W.; Carl R. Loper, Jr. & Philip C. Rosenthal Heine/ Mcgraw Hill	1967
5	Principles of Metal Casting/P L Jain/Tata McGraw-Hill Education	2003
6	Fundamentals of Metal Casting Technology/ P.C. Mukherjee/ Oxford& 1BH Pub. Co. Pvt.Ltd., New Delhi.	1988

Course Name	**:**	**SURFACE ENGINEERING**
Course Code	**:**	**MTN 409**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
To describe surface phenomenon of the material like friction, corrosion, surface treatments etc. To apply concepts to design modification of solid surfaces.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1.	**INTRODUCTION** Role of surface on various Engineering phenomena, Technological properties of surfaces, Need for modification of surfaces.	3
2.	**TRIBOLOGY** Surface dependent engineering properties, viz., wear, friction, corrosion, fatigue, reflectivity, emissivity, etc.; common surface initiated engineering failures; mechanism of surface degradation; importance and necessity of surface engineering; classification and scope of surface engineering in metals, ceramics, polymers and composites, tailoring of surfaces of advanced materials.	14
3.	**CHARACTERIZATION TECHNIQUES** Film Thickness Measurements Using Optical Techniques, Corrosion Testing of Coatings, Evaluation of Mechanical Properties of Thin Films, Microstructural Characterization of Coatings and Thin Films, Wear and Erosion Testing of Coatings	7
4.	**PLATING PROCESSES** Fundamentals of electroplating, Electrodeposition from plating baths, Electroless plating,	6

	Mentalliding, Selective plating, Hard anodizing, Other plating processes, Applicability of plating for wear resistance	
5.	**SURFACE COATINGS:** Dip, Barrier and Chemical conversion coatings, Vacuum and controlled- atmosphere coating	6
6.	**SURFACE HARDENING:** Flame hardening, Induction hardening, Electron beam hardening, Laser hardening, Iron implantation.	6

Course Outcomes: The student will be able to	
1	Apply the surface phenomenon to various metallurgical processes.
2	Analyze complex service failure problems and determine the correct surface engineering solution by applying contact mechanics.
3	Select the most suitable surface engineering techniques that would give the required properties

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Friction and Wear of materials/ Ernest Rabinowicz/John Wiley & Sons	2008
2	ASM Handbook Vol 5: Surface Engineering	1994
3	Engineering Tribology/Amandeep Singh Wadhwa/Shalom Akhai/DhanpatRai& Co.	2012
4	Introduction to Tribology /Bharat Bhushan/John Wiley & Sons	2002
5	"Surface Engineering of Metals: Principles, Equipment, Technologies/ TadeuszBurakowskiTadeuszWierzchon:"/CRC	1998

Course Name	**:**	**NANO MATERIALS TECHNOLOGY AND APPLICATIONS**
Course Code	**:**	**MTN 410**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
The student will be able to know the fundamentals of the behavior of materials at the nanometer length scale. The student will learn to fabricate/synthesize nanomaterials and characterize them. The student will be able to correlate the applications of nanomaterials with their structure and properties.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**SCIENCE AND TECHNOLOGY OF NANOMATERIALS:** Introduction to Miniaturization, Fundamentals of nanoscience and Nanotechnology, Size dependence of properties, Bulk to nano transition, Carbon nanostructures, Quantum wells, Quantum wires, and Quantum dots, Mechanical, Electronic and optical properties at nano level, Nanostructured materials	10
2	**SYNTHESIS OF NANOCRYSTALLINE POWDERS** Gas phase synthesis, Plasma chemical technique, Precipitation from colloidal solutions, co-precipitation & sol-gel method, Thermal decomposition and reduction, Milling and mechanical alloying, synthesis by detonation and electric explosion, ordering in Non-stoichiometric compounds	9
3	**PREPARATION OF BULK NANOCRYSTALLINE MATERIALS** Compaction of nanopowders, Film and coating deposition, Crystallization of amorphous alloys, Severe plastic deformation, Disorder-order transformations	8

5	**CHARACTERIZATION OF NANOSYSTEMS** X-ray diffraction, Scanning Electron Microscopy, Scanning Tunneling Microscopy, Electron Microscopy, X-ray absorption spectroscopy, Photoelectron emission spectroscopy, particle size distribution by BET & DLS methods.	9
6	**NANO MATERIALS APPLICATIONS** Nanotubes, nanowires, and nanodevices-introduction – Functional Nanostructures	6

Course Outcomes: The student will be able to	
1	Understand the structure-property relationship at Nanoscale.
2	The attain knowledge about this interdisciplinary field. Students will have the knowledge and skills on the key fundamental and technical aspects of nanomaterial production, characterization, and use.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Nano: The essentials/T Pradeep/McGraw Hill Education	2007
2	Nanomaterials: Synthesis, Properties and Applications/A.S. Edelstein, R C. Cammarata/ (IOP publication), CRC Press	1998
3	Principles of Nanotechnology/ Phani Kumar/ Scitech Publications	2010
4	Nanocrystalline Materials /Gusev and Rempel/Cambridge International Science Publishing	2003
5	Nanostructured Materials: Processing Properties and Applications /Carl C. Koch/ Noyes Publications	2002
6	Introduction to nanotechnology/Charles P. Poole and Frank J Owens/ Wiley Interscience	2003

Course Name	**:**	**POWDER METALLURGY**
Course Code	**:**	**MTN 411**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
The graduate will understand the characteristics and theory of compaction of metal powders. The graduate will understand the compaction techniques like mechanical, thermal or thermo-mechanical compacting. The graduate will understand the theory of sintering and application of powder metallurgical components.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Scope, Potential and Prospects of Powder Metallurgy, Problems in industries, advantages of Powder metallurgy	4
2	**POWDER MANUFACTURE AND CONDITIONING** Mechanical methods Machine milling, Ball milling, atomization, Shotting Chemical methods Condensation, Thermal decomposition, carbonyl. Reduction by gashydride, dehydride process, electro deposition, precipitation from aqueous solution and fused salts Hydrometallurgical method. Physical methods: Electrolysis and automization processes, types of equipment, factors affecting these processes, examples of powders produced by these methods, applications Powder conditioning, Heat treatment, blending and mixing, types of equipment, types of mixing and blending	12
3	**CHARACTERISTICS AND TESTING OF METAL POWDERS**	9

	Sampling, chemical composition purity, surface contamination etc. Particle size and its measurement, Principle and procedure of sieve analysis, microscopic analysis: sedimentation, elutriation, permeability. Adsorption methods and resistivity methods: particle shape, classifications, microstructure. Specific surface area, Apparent and tap density, Green density, Green strength, sintered compact density, porosity, shrinkage**.**	
4	**POWDER COMPACTION** Mechanical, thermal and thermo mechanical compacting processes. Presses used for transmission. Die design and tooling for consolidation of powders. New methods of consolidation. E.g. Powder rolling, Powder forging, Isostatic pressing. Advantages and limitations of these methods. Pressureless Compaction: slip casting and slurry casting. Pressure compaction lubrication, single ended and double ended compaction, Isostatic pressing, powder rolling, forging and extrusion, explosive compaction.	9
5	**THEORIES OF SINTERING** Sintering mechanism, Roll of diffusion, Recrystallization, Pore migration, Poregrowth and coalescence. Liquid phase sintering and related processes. Effect of compacting pressure, sinteringtemperature and time on sintered properties. Type of sintering furnaces. Sintering atmospheres	9
6	**MANUFACTURING AND APPLICATION OF IMPORTANT P/M COMPONENTS** Porous bearing, Electrical contact materials, Metallic filters, Cemented carbides, magnets, Friction materials and Composites. Major applications in aerospace, nuclear and automobile industries. Bearing Materials-types, self-lubrication and other types, methods of production, properties, applications. Sintered Friction Materials-clutches, brake linings, Tool Materials- cemented carbides, oxide ceramics, Cermets- Dispersion strengthened materials	10
7	**METAL INJECTION MOULDING (MIM):** Introduction to MIM, Comparison with Competitive Technologies, MIM Process and Products.	3

Course Outcomes: The student will be able to:	
1	cater any powder metallurgical industry dealing in metal or ceramic powder compactions.
2	analyze and understand the effect of input variables to a powder metallurgical operation on the quality of the product.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Powder Metallurgy: Science, Technology and Application /Angelo &Subramania/ PHI Learning Pvt. Ltd.	2009
2	Powder Metallurgy Technology/ G. S. Upadhyaya/ Cambridge Int Science Publishing	1997
3	Powder Metallurgy: An Advanced Technique Of Processing Engineering Materials/ B. K. DATTA/ PHI Learning Pvt. Ltd.	2011
4	Advances in Powder Metallurgy: Properties, Processing and Applications/ Isaac Chang, Yuyuan Zhao/ Elsevier.	2013

Course Name	**:**	**MATERIALS CHARACTERIZATION**
Course Code	**:**	**MTN 302**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:

Provide a thorough introduction to the principles and practice of X-Ray diffraction, SEM, TEM, XRF etc. Provide practical experience in laboratory methods and reporting. Provide basic descriptions of a range of common characterization methods for the determination of the structure and composition of solids.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Meaning/importance/need/role of examination & testing of materials, Scope of various examination and testing methods available viz Microscopic examination/metallography, macroscopic examination, Chemical methods, Mechanical methods, Non-destructive testing (NDT) Methods, Spectroscopy etc.	4
2	**METALLOGRAPHY/MICROSCOPIC EXAMINATION OF METALS** Preparation & Etching of Specimens of metals & alloys. Principle, Construction &working of metallurgical microscope, Various properties of microscope objectives, Defects in lenses & their remedies, Various types of objectives and eye pieces, TEM and SEM Microscope.	6
3	**MACROSCOPIC EXAMINATION OF METALS** Introduction, Importance & scope of macroetching, Sulphur/Phosphorus/Oxide Printing. Flow Lines	2
4	**CHEMICAL METHODS** Gravimetric, Volumetric, Colorimetric, Electro-gravimetric, Fire Assaying &Polarographic Methods of Analysis	7
5	**MECHANICAL METHODS** Hardness testing, Tensile testing, Impact testing, Creep, Fatigue, Fracture, Nano indentation technique**.**	6
6	**NON-DESTRUCTIVE TESTING** X-ray/Gamma ray radiography, Ultrasonic testing, Magnetic Methods– magnetic particle test/Magna Flux, Zyglo/Die penetration test, Eddy current test, X-ray diffraction.	7
7	**ADVANCED CHARACTERIZATION TECHNIQUES** Scanning probe microscope, X-ray fluorescence technique, Atomic absorption spectroscopy, Differential thermal analysis (DTA), differential scanning calorimeter (DSC), Thermogravimetric analysis (TGA), Thermomechanical analysis (TMA).	6
8	**APPLICATIONS OF CHARACTERIZATION TECHNIQUES:** Applications of the different characterization techniques: e.g.: XRD, SEM, TGA, DTA, DSC etc.	4

Course Outcomes: The student will be able to	
1	Analyse results of x-ray and electron diffraction.
2	Analyse optical characterization methods including Raman and infrared spectroscopy.
3	Analyse the result of different characterization required for study characteristics of materials.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Qualitative and Quantitative Analysis/Alexive/MIR Publisher	1982
2	Chemical and Metallurgical Analysis/ Vogel/Longman Scientific and Technical	1999
3	X-ray Diffraction/B D Cullity/Addison-Wesley	1956
4	Testing of Materials/Davis and Troxell/McGraw-Hill	1998
5	Principles of Metallographic Laboratory Practice/G L Kehl/McGraw-Hill	1980
6	Mechanical Metallurgy/Dieter/McGraw-Hill	2009
7	Principles of Physical Metallurgy/Reedhill/ McGraw-Hill	2008

Course Name	**:**	**ENGINEERING MATERIALS & SELECTION**
Course Code	**:**	**MTN 304**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
The student will be able to apply the fundamentals of selection of materials for practical applications. To apply concepts for failure analysis of engineering applications. To correlate properties of materials with their structure.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION AND MOTIVATION FOR MATERIALS SELECTION** Properties of Materials, Classification and parameter for the material selection, motivation for materials selection	2
3	**COST BASIS FOR SELECTION** Cost effectiveness and value analysis / Analysis of cost	2
4	**ESTABLISHMENT OF SERVICE REQUIREMENTS AND FAILUREANALYSIS** Selection and design in relation to anticipated service, Cause of failure in service, Mechanism of failure, Corrosion	4
5	**SPECIFICATIONS AND QUALITY CONTROL** Roll of standard specification, inspection and quality control	4
6	**SELECTION FOR MECHANICAL PROPERTIES** Strength, toughness, stiffness, fatigue, high temperature resistance and Creep resistance	7
7	**SELECTION FOR SURFACE DURABILITY** Wear and abrasion resistance, corrosion resistance.	4
8	**ELECTRICAL MATERIALS** Selection for electrical, magnetic properties	4
9	**ADVANCED MATERIALS** Smart materials, intelligent materials	4
10	**CO-RELATION**-Relation between Materials selection and Materials processing, Formalization of selection procedures	4
11	**CASE STUDIES IN MATERIAL SELECTIONS** Aerospace, Ship, Engine and Power generation, Automobile, Bearings, springs, Gears, Tools	7

Course Outcomes:	
1	The student will be able to specify performance requirements of a desired material and the process for making it, in the context of a given application.
2	To analyze quantitatively the Performance Efficiency relationships for an article.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Selection and uses of materials/Charles, Crane and Furness/Butterworth Heinmann publisher	1997
2	Engineering Material Technology/James A Jacobs and Thomas F Kilduff/ Prentice Hall of India	2000
3	Engineering Materials: Properties and selection/ Kenneth G. Budinski, Michael K. Budinski/ Prentice Hall	2009
4	Engineering materials / R K Rajput / S Chand and company Ltd.	2008
5	Engineering materials and metallurgy / R K Rajput / S Chand and company Ltd.	2006

Course Name	**:**	**METALLURGY & HEAT TREATMENT**
Course Code	**:**	**MTN 461**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
At the end of this course the student will able to Explain the co relation of time and temperature of treatment with microstructure, apply the TTT/CCT diagram for desired microstructure, design heat treatment cycle for given structural or property requirement.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**PRINCIPLES OF HEAT TREATMENT OF METALS :** Heating of metals, annealing, normalizing, hardening, quenching and quenching medium, tempering and its stages.	5
2	**THERMO MECHANICAL TREATMENTS:** Ausforming, Isoforming, Hot-rolling etc.	4
3	**CASE HARDENING OF STEELS :** Carburising, Nitriding, Carbo-nitriding, Induction Hardening, Flame hardening, Laser Hardening etc.	5
4	**HARDENABILITY OF STEELS:** Concept of critical diameter, joining-end quench test, effect of parameters viz: alloying elements, carbon content, austenitic grain size, section size and quenching media	8
5	**HEAT TREATMENT PROCESSES:** Various methods of heat treatment, surface hardening treatments, heat treatment of non-ferrous alloys, heat treatment schedules/case studies of some important steels and special types of treatments viz. martempering, austempering and thermo-mechanical treatments and inter critical treatments.	9
6	**DEFECTS:** Defects in heat treated materials and their critical process parameters to be considered for their prevention.	5
7	**HEAT TREATMENT OPERATIONS:** Design of Heat treatment cycles to achieve required properties.	6

Course Outcomes:	
1	Establish Heat Treatment – Process – Structure – Property correlation.
2	Design Heat Treatment to meet a property requirement for engineering application.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Heat treatment of Steels/ Vijendra Singh/ Standard Publishers Distributors	2009
2	Heat treatment of Steels/ R.C. Sharma/ New Age International (P) Limited	1996
3	Phase Transformation of Materials/ R.C. Sharma/ CBS Publishers	2002
4	Heat Treatment of Metals/ Zakharov/ CBS Publisher	1998 (First edition)
5	Heat Treatment: Principles and Techniques/ T.V. Sharma, C.P. Sharma, AshokRajan/ Prentice Hall India	2011

Course Name	**:**	**FRACTURE AND FAILURE ANALYSIS**
Course Code	**:**	**MTN 462**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
Acquire fundamental understanding of the fracture of solid materials. Develop detailed understanding of fracture mechanics, creep, and fatigue. Acquire basic understanding of the techniques used to perform failure analysis.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION OF FAILURE OF METALS:** Basic reasons- deformation or fracture, various types of failures, mature and premature failure	3
2	**REVIEW OF BASIC CONCEPTS OF MECHANICAL BEHAVIOR OF MATERIALS:** Stress-Strain curve, Engineering design versus failure.	6
3	**FAILURE MODES:** Failure in tension, compression, torsion, impact, wear, fatigue, creep, oxidation, corrosion, erosion. Metallurgical factors (such as structure, composition, processing) influencing failure mechanism.	9
4	**TECHNIQUES OF FAILURE ANALYSIS :** History, data collection, sampling, testing- Destructive and Non-destructive Testing, Macro- examination, Microscopic examination, TEM, SEM, X-Ray diffraction techniques, analysis of results, report preparation, conclusions, recommendation of remedial actions.	10
5	**QUALITY ASSURANCE :** A strong link to failure analysis, Quality control concept, quality assurance.	4
6	**CASE STUDIES :** at least one case study representing each failure mode given in serial number 3. For example- Failure of a low-pressure turbine rotor (LPTR) blade (Fatigue), Failure of an aircraft engine fuel pump (wear), Failure of a stabilizerlink rod in an aircraft (over load, tension and bending) etc.	10

Course Outcomes: Student will be able to	
1	Demonstrate knowledge of mechanics analysis for a variety of component.
2	Demonstrate recognition of failure mechanism and identify the alternate materials and/or service condition that prolong component life.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Deformation and Fracture Mechanics of Engineering Materials/R. W. Hertzberg/John Wiley & Sons.	1996
2	Failure Analysis of Engineering Materials/C. R. Brooks and A. Choudhury/ McGraw-Hill.	2002
3	Materials Science and Engineering/ W. D. Callister /John Wiley & Sons	2010
4	Failure Analysis of Engineering Structures: Methodology and Case Histories/V. Ramachandran, A.C. Raghuram, R.V. Krishnan, and S.K. Bhaumik/ASM International	2005

Course Name	**:**	**ADVANCED MATERIALS**
Course Code	**:**	**MTN 421**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
Interpret new terms and information on Ultra light materials, Biomaterials, coatings and thin films, composites, and high temperature refractory materials for aerospace applications. Distinguish various classes of shape memory alloys and the advantages of thin film shape memory alloys for micro-electro mechanical systems (MEMS)

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**ULTRA LIGHT MATERIALS AND METALLIC FOAMS:** Material Definition and Processing, Characterization of cellular metals, Material properties	9
2	**BIO-MATERIALS:** Classes of materials used in medicine, Application of materials in medicine and dentistry, Various materials and coatings for implants	9
3	**COMPOSITE MATERIALS:** Material Definition and classifications, Material properties and applications	9
4	**HIGH TEMPERATURE MATERIALS:** Coatings and High- Temperature Materials	5
5	**SHAPE MEMORY ALLOYS:** Thin Film Shape Memory Alloys for MEMS application	8
6	**PROPERTIES OF MATERIALS:** Electronic, dielectric, and optical properties of materials.	2

Course Outcomes: Student will be able to	
1	Suggest and apply the material for specific selection for a specific application,
2	Analyze the comparative use of two materials for same application

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Callister, W.D. Jr., "Material Science and Engineering –An Introduction", 5th Ed. John Wiley and Sons	2000
2	Askland, R.A., "The Science and Engineering of Materials", 2nd Ed., PWS-KENT Publishing Company.	1989
3	Handbook of Cellular metals, Production, processing, Application, Edited by Hans Peter Degischerand Brigitte Kriszt, Wiley - VCH,	2002
4.	Biomaterials Science, An Introduction to Materials in Medicine, Edited by B.D. Ratner, A.S.Hoffman, F.J. Sckoen, and J.E.L Emons, Academic Press, second edition,	2004
5.	Handbook of Materials for Medical Devices, Edited by J. R. Davis, ASM international,	2003

Course Name	**:**	**COMPOSITE MATERIALS**
Course Code	**:**	**MTN 422**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:

Define property enhancement mechanisms. Understand capabilities and limitations of existing materials and processes. Determine opportunities for improvement. Select materials and processes to best suit specific applications.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION**: General introduction and historical development, Concept of Composite materials, Basic definitions, Various types of composites, Classification based on Matrix Material, Classification based on reinforcements, Comparison with Metals, Advantages & limitations of Composites	3
2	**POLYMER MATRIX COMPOSITES (PMCs)** Fabrication of PMCs, Structure and Properties of PMCs, Interface in PMCs and their Applications.	5
3	**METAL MATRIX COMPOSITES (MMCs)** Fabrication of MMCs, interface in MMCs, Discontinuous reinforcement of MMCs, Properties and Applications of MMCs	6
4	**CERAMIC MATRIX COMPOSITES (CMCs)** Fabrication of CMCs, Structure and Properties of CMCs, Interface in CMCs and their Applications.	6
5	**ADVANCES IN COMPOSITES:** Carbon / carbon composites – Advantages of carbon matrix – limitations of carbon matrix Carbon fibre-chemical vapour deposition of carbon on carbon fibre perform. High field Composites Superconductors, In-Situ and Powder Metallurgy Fabrications	5
6	**MICROMECHANICS OF COMPOSITES:** Density, Mechanical Properties, Thermal Properties, Mechanics of Load Transfer from Matrix to Fiber. **MACROMECHANICS OF COMPOSITES:** Elastic Constant, Relation between Engineering Constants and Reduced Stiffness and Compliances, Variation of Lamina properties with orientation, Analysis of Laminated Composites, Stresses and Strains in Laminated Composites.	5
7	**STRENGTH, FRACTURE, FATIGUE AND DESIGN:** Tensile and Compressive Strength of Unidirectional fiber composites, Fracture modes in composites, Effect of Variability of Fiber strength, Strength of Orthotropic lamina, Fatigue of laminated composites, Designing of Composite materials.	8

Course Outcomes: Student will be able to :	
1	Use the ideas developed in the analysis of composites towards using composites in aerospace design.
2	Analysis and resolve the problems related to fracture of composites and environmental degradation of composites.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Composite materials: Engineering and Science /Mathews and Rawlings R.D/Chapman and Hall, London.	1994
2	Composite materials/Chawla K.K/ Springer – Verlag.	1987
3	Composite Materials Hand Book / Mel M.Schwartz / McGraw Hill	1992
4	Engineer Materials Hand Book : Composite Volume I / Cyril A.Dostal	1987

Course Name	**:**	**NON DESTRUCTIVE TESTING**
Course Code	**:**	**MTN 423**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
To introduce the students the concept and method for Non Destructive Testing starting from surface methods to Volumetric methods. Techniques to analyze and characterize defects in a material.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**OVERVIEW** Motivation, Background, Capabilities, Limitations of NDT Methods. Variables in Inspection and Statistical Issues.	4
2	**SURFACE METHODS** Visual Inspection – physical principles, methodology, limitations, applications. Liquid Penetrate Testing – physical principles, methodology, limitations, applications. Magnetic Particle Inspection – Physical Principles, methodology, limitations, applications.	6
3	**ELECTRO-MAGNETIC METHODS:** Maxwell's Equations, Magnetic Flux Leakage, Eddy Current, Low Frequency Eddy Current, Remote Field Eddy Current, Pulsed Eddy Current.	6
4	**ACOUSTICAL METHODS:** Ultrasonic NDT principles, Different types of wave modes, Physics of wave generation, reception, interactions and propagation. Calibration, data collection, quantification, and interpretation, New methods using guided waves, Resonance and other Low Frequency Methods	6
5	**RADIOGRAPHIC METHODS**: Principles of X-ray NDT, Equipment, Calibration, Image Collection, Quantification, and Interpretation. High power sources and high quality films. Digital Radiography, Introduction to Tomography and Laminography, Gamma graphy, Neutrongraphy, Safety precautions.	6
6	**THERMAL METHODS:** Principles of thermography and approaches in NDT, Sources and detectors, capabilities and limitations, measurement of diffusivity and wall thickness.	6
7	**OPTICAL METHODS:** Principles of Shearography and holography, applications in NDT	4
8	**APPLICATIONS:** Nuclear Industry , Aerospace Industry, Transportation Industry, Process Industry	4

Course Outcomes: At the end of the course students are expected to	
1	Show ability to understand the difference in the different methods of nondestructive techniques, their advantages and disadvantages.
2	Select the appropriate technique for a given application

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Nondestructive Evaluation - Theory, Techniques, and Applications/by P.J. Shull/Marcell Decker Inc.	2002
2	Non-destructive Evaluation - A tool in Design, Manufacturing and Service by D.E. Bray and R. K. Stanley/ CRC Press.	1996
3	NDT Handbooks Vol 1-17, ASNT Press, OH, USA	2012

4	Practical Non-destructive Testing / Baldev Raj, T JayaKumar / WoodheadPublishing Ltd.	2002
5	Introduction to NDT : A training guide / Paul E. Mix / John Wiley	2005

Course Name	**:**	**MICROSCOPY & SPECTROSCOPY**
Course Code	**:**	**MTN 424**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
At the end of this course, the student should be able to develop the ability to understand modern characterization techniques and to evaluate and analyze the data obtained by these techniques. They will be able to understand the basics of element analysis, chemical structure analysis, electronic structure measurement, depth profiling, topography imaging, as well as surface and interface analysis.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Ultrahigh vacuum, Surface Science	4
2	**MICROSCOPE** Atomic force microscope (AFM) including contact-mode, tapping-mode and lateral-force AFM, scanning tunneling microscope (STM), electrostatic force microscope (EFM), magnetic force microscope (MFM), AFM-based nano-lithography, surface force and adhesion measurement, as well as molecular recognition	10
3	**SPECTROSCOPE** Basic principle, instrumentation configuration, data interpretation and analysis, chemical shift, quantification and depth-profiling	4
4	**ULTRAVIOLET PHOTON SPECTROSCOPY (UPS)** Basic principle, instrumentation configuration, data interpretation and analysis, valence-band analysis and work function measurement	4
5	**FOURIER-TRANSFORM INFRARED SPECTROSCOPY (FTIR) AND RAMAN SPECTROSCOPY** Basic principle, instrumentation configuration, data interpretation and analysis, and special techniques such as attenuated total reflection (ATR), diffuse reflectance, and Polarization modulation-infrared reflection-adsorption spectroscopy (PM-IRRAS)	6
6	**SCANNING ELECTRON MICROSCOPE (SEM)** Basic principle and instrumentation configuration	5
7	**TRANSMISSION ELECTRON MICROSCOPE (TEM)** Including basic principle and instrumentation configuration	5
8	**APPLICATION OF THE MICROSCOPE AND SPECTROSCOPE:** Application of the above-mentioned instruments**:** • chemical composition • topography • chemical structure • surface roughness • molecular information • electronic structure • depth profile of chemical species • distribution of chemical species (chemical map)	8

Course Outcomes: Upon completion of this course, students will be able to	
1	Understand the microscopic and spectroscopic techniques used for characterization of materials.
2	Make critical selection decisions; conduct characterization measurements; evaluate, analyze and interpret data and identify, formulate, and solve the practical characterization problems by utilizing the techniques, skills, and modern analytical tools.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Scanning Probe Microscopy and Spectroscopy: Theory, Techniques, and Applications/ Dawn Bonnell/Wiley-Blackwell; 2nd Edition	2001
2	Scanning Probe Microscopy and Spectroscopy: Methods and Applications/Roland Wiesendanger/Cambridge University Press	1994
3	Reflection Electron Microscopy and Spectroscopy for Surface Analysis /Zhong Lin Wang	1996
4	Surface Analysis: The Principal Techniques 2nd Edition/ John Wiley & Sons.	2009

Course Name	**:**	**X-ray Crystallography**
Course Code	**:**	**MTN 425**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
The objective of the course is to introduce the students to the basic principles of crystallography and X-ray diffraction with the purpose of understanding the application of the X-ray diffraction method for determination of crystal structure.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** A basic Introduction to X-ray Crystallography, Crystal Growth, Symmetry and Space Group Determination, Crystal structure, lattice directions and planes, Stereographic Projections	5
2	**PROPERTIES OF X-RAYS** Fundamentals of X-ray interaction with matter: scattering from electrons, atoms, molecules, and crystals Effect of lattice vibrations; Debye-Waller factor; Probing disorder in materials, production and detection of X-rays	4
3	**PRICNCIPLE OF X-RAY DIFFRACTION:** Principle of X-ray diffraction, X-ray diffraction of single crystals, thin films (polycrystalline & epitaxial) and powder samples.	3
4	**METHODS OF X-RAY DIFFRACTION** Different types of X-Ray Diffraction Methods; e.g. Powder Diffraction method, Laue's Method etc.	3
5	**SAMPLE PREPARATION FOR X-RAY POWDER DIFFRACTOMETRY** Sample preparation for X-ray powder diffractometry, Sample mounting, Particle size requirement, Sample thickness and uniformity, Effects of sample preparation on powder diffraction data, Data acquisition, Quality of experimental data.	4
6	**XRD ANALYSIS** Measurement of X-ray powder diffraction patterns, Principles of Goinometer design in powder diffractometry, Debye-Scherrer geometry.Preliminary data processing and phase analysis, Phase identification and quantitative analysis, Different methods of quantitative phase analysis, Indexing powder diffraction pattern, Basic relations, Different indexing programs, The Rietveld method, Rietveld method basics, Background contribution, Peak-shape function, profile parameters, Quality of Rietveld refinement.	10
7	**X-RAY SPECTROSCOPY** X-ray Fluorescence, X-ray Emission spectroscopy, X-ray absorption spectroscopy	8
8	**APPLICATIONS OF X-RAY DIFFRACTION** Grain size determination, stress measurements, Phase diagram determination and Chemical	5

	analysis	

Course Outcomes: Student will be able to	
1	The students will get enhanced understanding of the basic theory of X-ray structure determination and its practical application to real problems.
2	Determine and calculate the crystal structure of an unknown material, their phase diagram and chemical composition

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Elements of X-ray Diffraction/B. D. Cullity and S. R. Stock/Prentice Hall	1978
2	Modern Spectroscopy/J. Michael Hollas/John Wiley & Sons, Ltd.	2010
3	An Introduction to X-Ray crystallography / M.M. Woolfson, Cambridge University Publication	1997
4	Structure determination by X-ray Crystallography – Mark Ladd, Rex Palmer / Springer Science & Business Media, New York	2013

Course Name	**:**	**MATERIALS SCIENCE AND ENGINEERING**
Course Code	**:**	**MTN 431**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
The student will be able to know the relation between processing, structure, and physical properties. The student will be able to appreciate the recent developments in materials science & engineering within the framework of this class.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1.	**INTRODUCTION** Materials science and engineering, Classification of materials, Advanced materials, Modern materials needs, Atomic structure and interatomic bonding: atomic structure, atomic bonding in solids	4
2.	**STRUCTURE OF CRYSTALLINE SOLIDS** Crystal Structure, Crystallographic points, directions, and planes, Crystalline and non-crystalline Crystal Structures, Polymer Structures	8
3.	**DIFFUSION** Diffusion mechanisms, Steady State diffusion, Non Steady State diffusion, Numerical on Diffusion in metallic, Ceramic and polymeric materials.	6
4.	**PHASE DIAGRAMS** Basic concepts, Binary phase diagrams, Binary isomorphous system, Binary eutectic system, Equilibrium diagrams having intermediate phase or compounds, Eutectoid and peritetic reactions, Ceramics phase diagrams, Non equilibrium solidification and segregation	12
5.	**PRINCIPLES OF SOLIDIFICATION** Technological Significance, Nucleation, Growth, Solidification time and dendrite size, Cooling Curve, Cast Structure, Solidification defects, Directional Solidification, Single crystal growth, equiaxial growth, Solidification of polymers and Inorganic glass	6
6.	**ENGINEERING MATERIALS** Ferrous alloys-steels and cast irons non ferrous alloys – Al, Magnesium, Copper, Nickel,	6

	Cobalt and Titanium alloys, Ceramic materials- properties and applications, Polymers – classification, structure, properties	

List of Experiments:		**Number of Turns**
1	To study design, principle and application of basic tools of wide use to a Metallurgist such as A Metallurgical microscope, A Hardness Tester, A Image Analyzer.	2
2	To study design, principle and application of Furnace and Thermocouple.	2
3	To study design, principle and applicationof Scanning Electron Microscope.	1
4	To study and compare the difference between solidification behavior of pure metal and an alloy.	2
5	To observe the segregation of soluterich phase in the casting.	1
6	TocarryoutHomogenizationannealingforremovalofsegregationincasting.	1
7	QualitativeandQuantitativeMetallographicanalysisandestablishingcorrelationwithphase diagram of the given alloy system: a. Recognition of the phase and state of material from the microstructure. b.Findingouttheweight%ofcarboninferrousalloysfromthemicrostructurew.r.t Hypo-,Hyper-phases and their morphologies.	2
8	Alloy Development: a. To study the effect on microstructure and mechanical property. b. To study the solidification defects such as Segregation, Porosity etc.	1
9	To observe the Line Defects in given samples.	1
10	To observe the Surface Defects in given samples.	1

Course Outcomes: The student will be be able to	
1	Qualitatively describe the bonding scheme and its general physical properties, as well as possible applications.
2	To correlate the information from phase diagram with solidification and diffusion processes.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Materials science and engineering/ William D. Callister/John Wiley & Sons	2010
2	The science and engineering of materials by Askeland and Phule, Cengage	2006
3	Engineering Materials and Metallurgy/Amandeep Singh Wadhwa and Harwinder Singh Dhaliwal/Laxmi Publications Ltd.	2013
4	"Materials Science and Engineering /Raghavan/ Prentice-Hall of India.	2004
5	The Science and Engineering of Materials/ Askland/ PWS-KENT Publishing Company.	1989

Course Name	**:**	**MATERIALS CHARACTERIZATION**
Course Code	**:**	**MTN 302**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
Provide a thorough introduction to the principles and practice of X-Ray diffraction, SEM, TEM, XRF etc. Provide practical experience in laboratory methods and reporting. Provide basic descriptions of a range of common characterization methods for the determination of the structure and composition of solids.

Total No. of Lectures – 42

Lecture wise breakup	**Number of**

		Lectures
1	**INTRODUCTION** Meaning/importance/need/role of examination & testing of materials, Scope of various examination and testing methods available viz Microscopic examination/metallography, macroscopic examination, Chemical methods, Mechanical methods, Non-destructive testing (NDT) Methods, Spectroscopy etc.	4
2	**METALLOGRAPHY/MICROSCOPIC EXAMINATION OF METALS** Preparation & Etching of Specimens of metals & alloys. Principle, Construction &working of metallurgical microscope, Various properties of microscope objectives, Defects in lenses & their remedies, Various types of objectives and eye pieces, TEM and SEM Microscope.	6
3	**MACROSCOPIC EXAMINATION OF METALS** Introduction, Importance & scope of macroetching, Sulphur/Phosphorus/Oxide Printing. Flow Lines	2
4	**CHEMICAL METHODS** Gravimetric, Volumetric, Colorimetric, Electro-gravimetric, Fire Assaying &Polarographic Methods of Analysis	7
5	**MECHANICAL METHODS** Hardness testing, Tensile testing, Impact testing, Creep, Fatigue, Fracture, Nano indentation technique**.**	6
6	**NON-DESTRUCTIVE TESTING** X-ray/Gamma ray radiography, Ultrasonic testing, Magnetic Methods– magnetic particle test/Magna Flux, Zyglo/Die penetration test, Eddy current test, X-ray diffraction.	7
7	**ADVANCED CHARACTERIZATION TECHNIQUES** Scanning probe microscope, X-ray fluorescence technique, Atomic absorption spectroscopy, Differential thermal analysis (DTA), differential scanning calorimeter (DSC), Thermogravimetric analysis (TGA), Thermomechanical analysis (TMA).	6
8	**APPLICATIONS OF CHARACTERIZATION TECHNIQUES:** Applications of the different characterization techniques: e.g.: XRD, SEM, TGA, DTA, DSC etc.	4

List of Experiments:		**Number of Turns**
1	To determine the elements present in different alloys using Metascope.	2
2	To prepare and standardize a sodium hydroxide solution and determine the molar concentration of a strong acid	2
3	Destructive testing-hardness, impact test etc. and Non-Destructive testing of samples (Dye penetrate test) etc.	2
4	Macroscopic examination of metals and alloys-segregation, Flow lines etc	2
5	To detect crack using Ultrasonic Flaw detector etc. using wear friction monitor.	2
6	Friction and wear study of different metals and alloys.	1
7	To study and perform Fatigue Test	1
8	To study the SEM and to examine the given sample	1
9	To find the copper content in the given sample by electrolytic deposition	1

Course Outcomes: The student will be able to	
1	Analyse results of x-ray and electron diffraction.
2	Analyse optical characterization methods including Raman and infrared spectroscopy.
3	Analyse the result of different characterization required for study characteristics of materials.

Suggested Books:		
Sr.	**Name of Book/ Authors/ Publisher**	**Year of**

No.		Publication/ Reprint
1	Qualitative and Quantitative Analysis/Alexive/MIR Publisher	1982
2	Chemical and Metallurgical Analysis/ Vogel/Longman Scientific and Technical	1999
3	X-ray Diffraction/B D Cullity/Addison-Wesley	1956
4	Testing of Materials/Davis and Troxell/McGraw-Hill	1998
5	Principles of Metallographic Laboratory Practice/G L Kehl/McGraw-Hill	1980
6	Mechanical Metallurgy/Dieter/McGraw-Hill	2009
7	Principles of Physical Metallurgy/Reedhill/ McGraw-Hill	2008

Course Name	**:**	**ENGINEERING MATERIALS**
Course Code	**:**	**MTN 432**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
To impart knowledge of materials used for different engineering applications such as structural, electrical, magnetic and high temperature.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Materials selection and related factors such as design, processing and economics; Case histories related to material selection.	4
2	**HIGH TEMPERATURE MATERIALS** Refractory metals and alloys, Creep resistant alloys, typical creep curve: effect of load, Temperature and composition; super alloys: Fe-base, Ni-base and Co-base super alloys and their composition, Heat treatment, properties and applications.	7
3	**LOW TEMPERATURE MATERIALS (CRYOGENIC MATERIALS)** Concept of ductile to brittle transition, determination of transition temperature; Ni-base low temperature materials, 9% Ni-steel, austenitic stainless steels, their composition, heat-treatment, properties and applications.	8
4	**STRUCTURAL STEELS** Plain carbon, high strength low alloys (HSLA), micro alloyed steels, and dual-phase steels their composition, Heat treatment, properties and applications.	5
5	**TOOL AND DIE STEELS** Plain carbon and alloy tool and die steels: high speed steel, high carbon-high chromium die steel, their composition heat treatment, properties and applications.	5
6	**CU BASE AND AL BASE NON FERROUS METALS AND ALLOYS** Brasses, bronzes, duralumin, and Al-Si alloy their composition, properties and applications.	6
7	**ENGINEERING POLYMERS AND CERAMICS** Thermoplastic, Thermosetting polymers and elastomers; High strength engineering ceramics.	7

List of Experiments:		**Number of Turns**
1	Recognition of the phase in the microstructures and recognition of material from the microstructure.	2
2	To study the microstructure of stainless steels, high alloy steels and HSLA	2
3	Microstructural analysis for Tool Steel.	1

4	Microstructural Analysis of Copper and Aluminium Base materials and their alloys	2
5	To study the effect of time and temperature on grain size of a metal (grain growth) (iron/ copper).	1
6	To study the wear and friction monitor and to test the Fe base, Cu Base and Al Base materials	3
7	To study flow lines in a given forged sample	1
8	To study the degradation of plastics and polymers.	2

Course Outcomes: Student will be able to	
1	Suggest and apply the material for specific selection.
2	Analyze the comparative use of two materials for same application

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	Material Science and Engineering /Callister/John Wiley and Sons.	2000
2.	The Science and Engineering of Materials/ Askland/ PWS-KENT Publishing Company.	1989
3.	Engineering Physical Metallurgy/Lakhtin / Mir Publishers Co.	1992
4.	Introduction to Physical Metallurgy/Avner / McGraw Hill Book	2005
5.	Materials Science and Engineering/Raghavan/ Prentice-Hall of India.	2004

Course Name	**:**	**CORROSION ENGINEERING**
Course Code	**:**	**MTN 433**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
At the end of this course, the student should be able to impart the theory for degradation and corrosion of materials in various environments. The student will be able to solve corrosion problems and design corrosion protection mechanisms.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**ELECTROCHEMISTRY OF CORROSION:** Corrosion – introduction, definitions and types, Electrochemical cells-definitions and principles, Potential measurements - galvanic cells, concentration cells, EMF and Galvanic series - bimetallic couples, Eh-pH diagrams – fundamental aspects, Construction of Eh – pH diagrams, FeH2O-O2 diagram, Copper, Aluminium and general corrosion diagrams.	7
2	**ELECTRODE KINETICS AND POLARIZATION PHENOMENA**: Electrode – solution interface – definition and types of polarization, Exchange current density – polarization relationships, Polarization techniques – corrosion rate determination, Mixed potentials – concepts and Basics, Mixed potential theory – bimetallic couples, Mixed potential theory – activation and diffusion controlled processes	6
3	**FORMS OF CORROSION:** Galvanic corrosion, Crevice corrosion, Pitting, Intergranular corrosion, selective leaching, Errosion corrosion, stress corrosion, hydrogen damage	8
4	**CORROSION TESTING:** corrosion rate determination, galvanic corrosion test, erosion-corrosion test, crevice/gasket corrosion test, Huey test for stainless steel, Streicher test, Warren test, Linear polarization for measuring corrosion rates, cyclic polarization for pitting mechanism, EIS (electrochemical impedence spectroscopy)	10

5	**METHODS OF CORROSION CONTROL:** Prevention strategies – design and coatings, Prevention strategies – inhibitors and surface engineering, Cathodic protection – principles and classification, Cathodic protection – influencing factors and monitoring, Design aspects for cathodic protection, Stray current corrosion, Passivity – definitions and influencing parameters, Passivity – application of mixed potential theory, Passivity – design of corrosion resistant alloys, Anodic protection.	10
6	**CASE STUDIES**	7

List of Experiments:		**Number of Turns**
1	To study, perform and observe the following corrosion phenomenon (a) Stress Corrosion Cracking IN Brass/Mild Steel. (b) Crevice Corrosion of Stainless steel in chloride solution. (c) Pitting of Stainless Steel.	3
2	Determine corrosion rate of given mild steel samples and study the effect of various factor on it like. (a) Concentration of acetic/alkaline solution (b) Composition and condition of the sample	3
3	Study the effect of passive film for following systems (a) Al in $CuSO_4$ Solution (b) Stainless Steel in HNO_3	2
4	To perform electrolytic deposition and study effect of parameters.	2
5	To study the concentration polarization phenomenon.	1
6	To perform Galvanic corrosion on various metals and prepare galvanic series.	2
7	Effect of heat treatment on corrosion.	1

Course Outcomes: At the end of the course students will be able to	
1	Apply the concepts of corrosion science and use them to analyze practical corrosion problems.
2	Design for better corrosion resistance.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Corrosion Engineering/Fontana/Tata McGraw Hill	2008
2	An Introduction to Electrometallurgy/ SatyaNarain, RajendraSharan/ Standard Publishers Distributors	1991
3	Electrochemistry and Corrosion Science/Nestor Perez/ Kluwer Academic Publishers New York, Boston, Dordrecht, London, Moscow	2004

Course Name	**:**	**HEAT TREATMENT OF METALS**
Course Code	**:**	**MTN 406**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
At the end of this course the student will able to explain the correlation of time and temperature of treatment with microstructure, apply the TTT/CCT diagram for desired microstructure, design heat treatment cycle for given structural or property requirement.

Total No. of Lectures – 42

Lecture wise breakup	**Number of**

		Lectures
1	**PRINCIPLES OF HEAT TREATMENT OF METALS** Annealing, Normalizing, Hardenability, Hardening, Tempering.	5
2	**THERMO MECHANICAL TREATMENTS:** High temperature treatment with low temperature tempering, Low temperature treatment with low temperature tempering	4
3	**CASE HARDENING OF STEELS:** Carburizing process for their process, advance and challenges. Flame hardening, Nitric process and challenges.	5
4	**Hardenability of steels:** Concept of critical diameter, joining-end quench test, effect of parameters viz: alloying elements, carbon content, austenic grain size, section size and quenching media	8
5	**Heat treatment processes:** Various methods of heat treatments, surface hardening treatments, heat treatment of non-ferrous alloys, heat treatment schedules/case studies of some important steels and special types of treatments viz. martempering, austempering and thermo-mechanical treatments and intercritical treatments.	12
6	**DEFECTS** Defects in heat treated materials and their prevention.	4
7	**HEAT TREATMENT OPERATIONS** Design of Heat treatment cycles to achieve required properties.	4

List of Experiments:		**Number of Turns**
1	Normalizing treatment of steel and comparison of the microstructure with annealed structure.	2
2	To perform hardeningstudy the quenched structures of steel – quenched in oil, water and brine solution.	2
3	(i)To perform hardening and tempering and study the tempered structures of steel for following condition – (a) low temperature tempering. (b) medium temperature tempering. (c) high temperature tempering. (ii) Compare the quenched and tempered structure.	2
4	To perform cold working followed by recrystallization and study the recrystallization behaviour of Al/ Fe/ Cu.	2
5	To carry out age hardening of non ferrous alloys. (Al-Cu alloy 2024, Al-Zn-Mg-Cu 7075	2
6	Determination of hardenability of steels using Jominy End Quench Test	2
7	To perform the Carburizing treatment and to study the effect of time on the Case depths of carburized steel.	2

Course Outcomes: Student will be able to	
1	Student will be able to establish Heat Treatment – Process – Structure – Property correlation.
2	Design Heat Treatment to meet a property requirement for engineering application.

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Heat treatment of Steels/ Vijendra Singh/ Standard Publishers Distributors	2009
2	Heat treatment of Steels/ R.C. Sharma/ New Age International (P) Limited	1996
3	Phase Transformation of Materials/ R.C. Sharma/ CBS Publishers	2002
4	Heat Treatment: Principles and Techniques/ T.V. Sharma, C.P. Sharma, Ashok Rajan/PHI	2011
5	Principles of Heat Treatment of Steel / George Krauss /American Society for Metals	1980(First Edition)

GENERAL SCIENCE COURSES (GSC)

Course Name	**:**	**ENVIRONMENTAL SCIENCES**
Course Code	**:**	**GSC101**
Credits	**:**	**3**
L T P	**:**	**3 0 0**

Course Objectives:
This course aims to acquaint students with the basics of Environmental Sciences.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	Multi-discipline nature of environmental studies as applied to different engineering streams - Definitions, scopes and explanations.	6
2	Types of Ecosystems – System dynamics – Understanding ecosystems, Ecosystem degradation, Resource utilization, Ecosystem diversity, Habitat classification.	6
3	Natural Resources; Renewable and non-renewable- Natural resources and associated problems, Non-renewable resources, Renewable resources	6
4	Energy and Environment- Fossil fuel, Geothermal, tidal, nuclear, solar, wind, hydropower & biomass.	6
5	Environment pollution- Air Pollution, Water Pollution, Soil Pollution, Marine Pollution, Noise Pollution, Thermal Pollution, Nuclear hazards	6
6	Cleaner Production and life cycle analysis: - LCA methodology, steps and tools, EIA and Environment audit	6
7	Environment Development and Society:- Emerging technology for sustainable development and environment management, public participation and provision in management and legislation.	6

Course Outcomes:	
1	Students will be able to relate the importance of Environmental Sciences for sustainable development of society.
2	Students will be able to understand the problems and remedies of Environmental Sciences.

Text Books:	
Sr. No.	**Name of Book/ Authors/ Publisher**
1	Environmental Science Ceonage Learning Publication, Miller G.T. and Spool Mar
2	Environmental Studies, Tata McGraw Hill Pub., Banny Joseph

BASIC SCIENCE COURSES (BSC)

Course Name	**:**	**MATHEMATICS I**
Course Code	**:**	**MAN 101**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
To make the students understand the behavior of infinite series and their use. To make the students learn the concepts related to functions of several variables and their applications. To make the students learn the methods of evaluating multiple integrals and their applications to various problems. To make the students learn the methods to formulate and solve linear differential equations and apply them to solve engineering problems.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INFINITE SERIES** Infinite series and convergence, alternating series, power series and convergence. Taylor's and Maclaurin's Series. (Scope as in Chapter 8, Sections 8.1, 8.3 – 8.9 of Reference Book 1).	8
2	**MULTIVARIABLE FUNCTIONS** Limit, Continuity and Partial Derivatives; Euler's Theoem for Homogeneous functions; Differentiability, Linearization and Differentials; Chain rule; Extreme values and Saddle Points; Lagrange multipliers; Taylor's Formula**.** (Scope as in Chapter 12, Sections 12.1 – 12.6, 12.8 – 12.10 of Reference Book 1).	10
3	**SOLID GEOMETRY** Cylinders and Quadric surfaces, Cylindrical and Spherical Coordinates. (Scope as in Chapter10, Sections10.6 and 10.7 of Reference Book 1)	4
4	**INTEGRAL CALCULUS** Area between plane curves; Volumes of solids of revolution; Lengths of plane curves; Areas of surfaces of revolution. Double integrals in rectangular and Polar form, Triple integrals in Rectangular, Cylindrical and Spherical coordinates, Substitutions in Multiple Integrals. (Scope as in Chapter 5, Sections 5.1, 5.3, 5.5, 5.6 and Chapter 13 .Sections 13.1, 13.3, 13.4,13.6 and 13.7 of Reference Book 1).	8
5	**ORDINARY DIFFERENTIAL EQUATIONS** First order exact differential equations, Integrating factor, Orthogonal trajectories, Second and Higher order Linear Differential Equations with constant coefficients, Differential Operators, Methods of Variation of Parameters and Undetermined Coefficients, Euler Cauchy Equation, Wronskian. (Scope as in Chapter 1, Section 1.5, 1.8 Chapter 2, 2.1-2.4, 2.6, 2.9-2.10, 2.13- 2.15 of Reference Book 2).	12

Course Outcomes:	
1	The students are able to test the behavior of infinite series.
2	The students are able to analyze functions of several variables and their applications.
3	The students are able to evaluate multiple integrals and apply them to practical problems.
4	The students are able to solve linear differential equations.

Reference Books:	
Sr. No.	**Name of Book/ Authors/ Publisher**
1	G. B. Thomas, R. L. Finney. Calculus and Analytic Geometry, Ninth Edition, Pearson Education.
2	E. Kreyszig. Advanced Engineering Mathematics, Eighth Edition, John Wiley.
3	B. V. Ramana. Higher Engineering Mathematics, Tata McGraw Hill.

Course Name	**:**	**PROBABILITY AND STATISTICS**
Course Code	**:**	**MAN 103**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of this course, the students should be able to use statistical methods to collect and analyze the data. The students should be able to estimate unknown parameters of populations and apply the tests of hypotheses.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**RANDOM VARIABLES AND PROBABILITY DISTRIBUTIONS** Random variables, Discrete, Continuous and Joint Probability distributions, Marginal and Conditional distributions, Independent random variables, Expectation, Variance and Covariance, Means and variances of linear combinations of random variables, Chebyshev's inequality, Binomial, Poisson, Uniform and Normal distributions, Normal and Poisson approximations to Binomial, Moments, Moment generating function.	20
2	**SAMPLING DISTRIBUTIONS & ESTIMATION** Population, Sample, Sampling distributions, Law of large numbers, Central limit theorem, Distribution of sample mean, Difference of means, Proportions and difference of proportions, Chi-square distribution, Student's t-distribution, Estimation of parameters, Point estimate, Confidence interval for mean, difference of means and proportions.	16
3	**TESTS OF HYPOTHESES** Hypothesis, Test statistic, Critical region, Significance level, Single Sample and Two Samples tests for mean.	6

Course Outcomes: By the end of this course, the student will be able to:	
1	Collect and analyze the data statistically.
2	Describe sampling distributions of sample means and sample proportions
3	Estimate unknown parameters of the population from a sample.
4	Construct confidence intervals for mean difference of means and proportions; and perform hypothesis tests for means.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Probability and statistics for Engineers and Scientists, Walpole, Myers, Myers and Ye, Pearson Education	2012
2	Introduction to Mathematical Statistics, Hogg and Craig, Pearson Education	2013
3	Miller and Freund's: Probability and Statistics for Engineers, Richard A. Johnson, Prentice Hall	2010
4	John E. Freund's: Mathematical statistics with Application, Miller and Miller, Pearson Education	2012

Course Name	**:**	**VECTOR CALCULUS, FOURIER SERIES AND LAPLACE TRANSFORM**
Course Code	**:**	**MAN105**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:

At the end of this course, the students should be able to use concepts of vector calculus to analyze scalar and vector fields and compute the gradient, divergence and curl. They should be able to evaluate line, surface and volume integrals. The students should be able to expand functions in a Fourier series and apply Harmonic analysis to numerical data. They should be able to evaluate Laplace transforms and inverse Laplace transform and apply Laplace transforms to solve ordinary differential equations.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**VECTOR CALCULUS** Gradient, Divergence and Curl – their physical interpretation and representation in cylindrical and spherical coordinates. Line, surface and volume integrals; Green's theorem in the plane, Stoke's theorem, Divergence theorem; Irrotational and Solenoidal Fields, Applications to Science and Engineering.	20
2	**FOURIER SERIES** Periodic functions, Trigonometric series, Fourier Series, Euler's formulae, Conditions for existence of Fourier series, Even and odd functions, Half range expansions, Complex Fourier series, Applications of Fourier series, Parseval's identity, Harmonic analysis.	12
3	**LAPLACE TRANSFORM** Laplace transform, Inverse transform, properties, Transforms of derivatives and integrals, Unit step function, Dirac's delta function, Differentiation and integration of transforms, Applications to differential equations.	10

Course Outcomes:	
1	Use vector calculus to analyze scalar and vector fields and compute the gradient, divergence and curl.
2	Evaluate line, surface and volume integrals.
3	Apply Green's Theorem, Divergence Theorem and Stoke's theorem to evaluate integrals..
4	Expand a function in terms of its Fourier series and to apply harmonic analysis to numerical data.
5	Evaluate Laplace transforms and inverse Laplace transforms of functions.
6	Apply Laplace transforms to solve ordinary differential equations arising in engineering problems.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Calculus and Analytic Geometry, G. B. Thomas and R. L. Finney, Pearson Education	2014
2	Advanced Engineering Mathematics, E. Kreyszig, John Wiley	2006
3	Advanced Engineering Mathematics, M.D. Greenberg, Pearson Education Asia	2010
4	Advanced Engineering Mathematics, Wylie and Barrett, McGraw Hill	2003

Course Name	**:**	**PARTIAL DIFFERENTIAL EQUATIONS AND SPECIAL FUNCTIONS**
Course Code	**:**	**MAN 106**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of this course, the students should be able to formulate and solve linear and nonlinear partial differential equations and apply partial differential equations to engineering problems. The students should be able to solve ordinary differential equations using series solutions, describe special functions as solutions to differential equations and expand functions in terms of eigenfunctions and to solve Sturm Liouville's problems.

Total No. of Lectures – 42

Lecture wise breakup		Number of Lectures
1	**PARTIAL DIFFERENTIAL EQUATIONS** Formation and solution of first order partial differential equations, Linear equations of higher order with constant coefficients, Applications to Engineering problems**.**	17
2	**SPECIAL FUNCTIONS** Series solution of differential equations, Power series methods, Series solution of Legendre's differential equation Legendre's polynomial, generating functions, Recurrence relations, Frobenius method, Series solution of Bessel's differential equation, Bessel's functions, Modified Bessel's functions, generating functions, Recurrence relations, Equations reducible to Bessel's equation, Sturm Liouville's problem, Eigen function expansions.	25

Course Outcomes: By the end of the course, the students will be able to	
1	Formulate and solve linear and nonlinear partial differential equations
2	Apply partial differential equations to engineering problems.
3	Solve differential equations using series solutions.
4	Describe special functions as solutions to differential equations**.**
5	Expand functions in terms of eigenfunctions and to solve Sturm Liouville's problems.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Advanced Engineering Mathematics, E. Kreyszig, John Wiley	2006
2	Advanced Engineering Mathematics, Wylie and Barrett, McGraw Hill	**2003**
3	Elements of Partial differential equations, Sneddon, McGraw Hill	**2006**

Course Name	**:**	**NUMERICAL ANALYSIS**
Course Code	**:**	**MAN 109**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of this course, the students should be able to describe errors involved in computations and to estimate these errors. The students should be able to solve equations, apply numerical methods to interpolate, extrapolate, differentiate and integrate functions. They should be able to solve differential equation using numerical methods and solve systems of equations.

Total No. of Lectures – 42

Lecture wise breakup		Number of Lectures
1	**ERRORS** Errors in numerical calculations, Absolute, relative and percentage errors, Round off and truncation errors, Error propagation, Loss of significant digits, Errors in series approximation, Speed of convergence.	5
2	**SOLUTION OF EQUATIONS** Bisection method, Fixed point iteration and its convergence, Acceleration of convergence using Aitken's method; Regula-Falsi, Newton-Raphson, Generalized Newton's, Chebyshev's and Halley's methods.	7
3	**INTERPOLATION** Lagrange Interpolation, Newton's divided difference interpolation, Finite differences, Newton's, Bessel's, Stirling's and Guass' difference formulae.	10

4	**NUMERICAL DIFFERENTIATION & INTEGRATION** Differentiation using differences, Integration using Newton-cote's formulas with errors, Gaussian Quadrature.	8
5	**SOLUTION OF LINEAR SYSTEM OF EQUATIONS** Direct methods - Gauss elimination, Partial pivoting, Complete pivoting, Gauss-Jordan and factorization methods, Iterative methods-Gauss Siedal and Jacobi's methods.	6
6	**NUMERICAL METHODS FOR DIFFERENTIAL EQUATIONS** Solution of first order differential equations using Taylor's series, Euler's, Picard's and Runge-Kutta method upto 4^{th} order, Predictor-Corrector methods (Adam's and Milne's method),	6

Course Outcomes:	
1	Describe errors involved in computations and to estimate the errors.
2	Solve algebraic and transcendental equations using Bisection method Regula-Falsi, Newton-Raphson,
3	Generalized Newton's, Chebyshev's and Halley's methods.
4	Apply numerical methods to interpolate, extrapolate differentiate and integrate functions.
5	Solve systems of equations.
6	Solve differential equation using numerical methods.(Taylor's series, Euler's, Picard's and Runge-Kutta method upto 4^{th} order, Predictor-Corrector methods)

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Advanced Engineering Mathematics, E. Kreyszig, John Wiley	2006
2	Numerical Methods for Mathematics, Science and Engineering, Mathews, Prentice Hall	1992
3	An Introduction to Numerical Analysis, Atkinson, John Wiley	2012

Course Name	**:**	**OSCILLATIONS AND OPTICS**
Course Code	**:**	**PYN101**
Credits	**:**	**4**
L T P	**:**	**3 1/2 2/2**

Course Objectives:
To familiarize the students with Ultrasonics and their applications To acquaint the students with simple harmonic motion along with damping and driving forces To refresh the basics of interference, diffraction and polarization and familiarize the students with their applications through lectures and experiments To teach the students the basic concepts of LASER and to familiarize them various kinds of lasers To acquaint the students with fundamentals of holography

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**ULTRASONICS:** Production, detection and uses of ultrasonics, reverberation, sabine's formula (no derivation)	3
2	**SHM:** Review of basic kinematics (displacement, velocity, acceleration, time period and phase of vibration) and dynamics (restoring force and energetics) of simple harmonic motion, differential equation of SHM, superposition of two SHM in one dimension, charge oscillations in LC circuits	4
3	**DAMPED OSCILLATIONS:** Concept and cause of damping, differential equation of a damped oscillator and different kinds of damping, Methods of describing damping of an oscillator - logarithmic decrement, relaxation time, quality factor, band width. Series LCR	4

	circuit as a damped oscillator.	
4	**FORCED OSCILLATIONS:** States of forced oscillations, differential equation of forced oscillator – its displacement, velocity and impedance, behaviour of displacement and velocity with driver's frequency, Power, bandwidth, Quality factor and amplification of forced oscillator, resonance in forced oscillators, forced oscillations in series LCR circuit	5
5	**WAVE MOTION:** Wave equation and its solution, characteristic impedance of a string, reflection and transmission of waves on a string at a boundary, reflection and transmission of energy, the matching of impedances	3
6	**INTERFERENCE:** Division of wave front and amplitude; Fresnel's biprism, Newton's rings, Michelson interferometer and its applications for determination of λ and $d\lambda$.	4
7	**DIFFRACTION:** Fresnel and Fraunhofer diffraction, qualitative changes in diffraction pattern on moving from single slit to double slit, plane transmission grating, dispersive power & resolving power of a grating.	5
8	**POLARIZATION:** Methods of polarization, analysis of polarized light, quarter and half wave plates, double refraction.	4
9	**LASERS:** Elementary idea of LASER production, spontaneous emission, stimulated emission, Einstein's coefficients, Helium-Neon, Ruby and semiconductor lasers, applications of lasers.	4
10	**FIBRE OPTICS:** Basics of optical fibre - its numerical aperture, coherent bundle, step index and graded index fibre, material dispersion, fibre Optics sensors, applications of optical fibre in communication systems.	4
11	**HOLOGRAPHY:** Basic principle, theory and requirements.	2

List of Experiments:	
1	To find the wavelength of sodium light using Fresnel's biprism.
2	(i) To determine the wavelength of He-Ne laser using transmission grating. (ii) To determine the slit width using the diffraction pattern.
3	To determine the wave length of sodium light by Newton's rings method.
4	To determine the wave length of sodium light using a diffraction grating.
5	To find the specific rotation of sugar solution using a Bi-quartz Polarimeter.
6	To design a hollow prism and used it find the refractive index of a given liquid

Course Outcomes:	
1	Students are aware of latest developments in certain areas of Physics which have important applications for societal needs.
2	Students learn about lasers and fibre optics which have important applications for societal needs.
3	Students are expected to develop capability to tackle problems in general and in the various areas covered in the course.

Reference Books:	
Sr. No.	**Name of Book/ Authors/ Publisher**
1	Physics for Engineers (Prentice Hall India) - N.K. Verma
2	Physics of Vibrations and Waves (5th Edition, John Wiley & Sons) – H.J.Pain
3	Optics – Ajoy Ghatak

Course Name	**:**	**CONDENSED MATTER PHYSICS**
Course Code	**:**	**PYN102**
Credits	**:**	**4**
L T P	**:**	**3 1/2 2/2**

Course Objectives:

To teach the students the basic concepts of crystal structure and defects To familiarize the students with the concepts of Free electron theory of metals and its applicability To acquaint the students with the concepts of Dielectric and Magnetics materials with their applications through lectures and experiments To impart to the students the concepts of superconductivity and nanotechnology To teach the students the basic concepts of crystal structure and defects

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**CRYSTAL STRUCTURE:** Space lattices and their symmetries, crystal structures (cubic and hexagonal cells), assignment of coordinates, directions and planes in crystals, linear, planer and space densities in crystals, close packed morphology (Hexagonal and cubic close packing), single and polycrystalline structures, interstitial spaces (trigonal, tetrahedral and octahedral voids, crystal Structure analysis, X-ray diffraction and Bragg's law, crystal defects, Point, line, surface and volume imperfections	(11)
2	**THEORY OF METALS:** Free electron theory, electrical properties, thermal properties, motion in magnetic field (cyclotron resonance), Zone theory. Band theory of solids, Kronig-Penney Model (qualitative), conductors, insulators and semiconductors	(6)
3	**DIELECTRIC MATERIALS:** Review of basic formulas, dielectric constant and polarizability, sources of polarizability, classical treatment of dipolar, ionic and electronic polarizability, piezoelectricity, ferroelectrcity.	(5)
4	**MAGNETIC MATERIALS:** Review of basic formulas, magnetic susceptibility, classification of materials, Langevin diamagnetism, paramagnetism (only classical treatment), magnetism in metals, ferromagnetism in insulators, anti-ferromagnetism and ferrimagnetism, ferromagnetism in metals, ferromagnetic domains, hysteresis	(8)
5	**SUPERCONDUCTIVITY:** Zero resistance, occurrence of superconductivity, Meissner effect, critical field, thermodynamics of superconducting transitions, electrodynamics of superconductors, qualitative idea of BCS theory.	(4)
6	**SEMICONDUCTORS**: p-type and n-type semiconductors, statistics of electrons and holes, Hall effect (for single as well as both type of charge carriers)	(4)
7	**NANOTECHNOLOGY:** Introduction, Synthesis of Nanoparticles: Mechanical Method, Sputtering, Chemical Vapour Deposition, Sol-gel Technique, Applications of Nanotechnology	(4)

List of Experiments:	
1	To find the energy band gap of the given semiconductor by four probe method.
2	To study the Hall Effect of a given semiconductor.
3	To determine the dielectric constant of the given materials.
4	To study the B-H curve of the ferromagnetic materials.
5	To determine the value of e/m for electron by long solenoid (helical) method.
6	To study the variation of magnetic field with distance along the axis of a circular coil carrying current by plotting a graph.

Course Outcomes:	
1	Students learn about dielectric and magnetic materials which have important applications for societal needs.
2	Students learn about superconductivity and nanotechnology which have important applications.
3	Students are expected to develop capability to tackle problems in general and in the various areas covered in the course.

Suggested Books:	
Sr. No.	**Name of Book/ Authors/ Publisher**
1	Material science and Engineering – An Introduction by William D Callister, Jr, Sixth Edition, John Wiley and Sons.

2	Material science and Engineering – A First Course by V.Raghvan Fourth Edition, Eastern Economy Edition
3	Solid State Physics (New Age Publishers) – S.O. Pillai
4	Introduction to Solids (Tata McGraw Hill, Third Edition) - Leonid V Azaroff

Course Name	**:**	**MECHANICS**
Course Code	**:**	**PYN - 105**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
To acquaint about the engineering aspects of Mechanics
To familiarize Kinematics and Kinetics of rigid body
To inculcate the application of Mechanic concepts in engineering
To familiarize the application of relative motion analysis in the design of energy system

Total No. of Lectures – 36

Lecture wise breakup		**Number of Lectures**
1	**KINEMATICS OF A PARTICLE**: Introduction. Rectilinear Kinematics: General Curvilinear Motion. Curvilinear Motion: Rectangular Components, Normal and Tangential Components, Cylindrical Components. Absolute Dependent Motion Analysis of Two Particles. Relative-Motion Analysis of Two Particles Using Translating Axes. Motion of a Projectile.	5
2	**KINETICS OF A PARTICLE: FORCE AND ACCELERATION**: Newton's Laws of Motion. The Equation of Motion. Equation of Motion for a System of Particles. Equations of Motion: Rectangular Coordinates, Normal and Tangential Coordinates, Cylindrical Coordinates. Central-Force Motion and Space Mechanics.	4
3	**KINETICS OF A PARTICLE: WORK AND ENERGY**: The Work of a Force. Principle of Work and Energy. Principle of Work and Energy for a System of Particles. Power and Efficiency. Conservative Forces and Potential Energy. Conservation of Energy.	3
4	**KINETICS OF A PARTICLE: IMPULSE AND MOMENTUM**: Principle of Linear Impulse and Momentum. Principle of Linear Impulse and Momentum for a System of Particles. Conservation of Linear Momentum for a System of Particles. Impact. Angular Momentum. Relation Between Moment of a Force and Angular Momentum. Angular Impulse and Momentum Principles.	4
5	**PLANAR KINEMATICS OF A RIGID BODY:** Rigid-Body Motion. Translation. Rotation About a Fixed Axis. Absolute General Plane Motion Analysis. Relative-Motion Analysis: Velocity, Instantaneous Center of Zero Velocity, Acceleration. Relative-Motion Analysis using Rotating Axes.	4
6	**PLANAR KINETICS OF A RIGID BODY: FORCE AND ACCELERATION:** Moment of Inertia. Planar Kinetic Equations of Motion. Equations of Motion: Translation, Rotation About a Fixed Axis, and General Plane Motion.	4
7	**PLANAR KINETICS OF A RIGID BODY: WORK AND ENERGY:** Kinetic Energy. The Work of a Force. The Work of a Couple. Principle of Work and Energy. Conservation of Energy.	3
8	**PLANAR KINETICS OF A RIGID BODY: IMPULSE AND MOMENTUM:** Linear and Angular Momentum. Principle of Impulse and Momentum. Conservation of Momentum. Eccentric Impact.	3
9	**THREE-DIMENSIONAL KINEMATICS OF A RIGID BODY**: Rotation About a Fixed Point. The Time Derivative of a Vector Measured from a Fixed and Translating-Rotating System. General Motion. Relative-Motion Analysis using Translating and Rotating Axes.	3
10	**THREE-DIMENSIONAL KINETICS OF A RIGID BODY**: Moments and Products of Inertia. Angular Momentum. Kinetic Energy. Equations of Motion. Gyroscopic Motion.	3

	Torque-Free Motion.	

Course Outcomes:	
1	The student will be able to understand the concepts of Mechanics.
2	The students will be able to apply the concepts of Mechanics in fluid of energy.
3	The students will be able to understand various types of motion characteristic and found characteristic of rigid body.

Suggested Books:	
Sr. No.	**Name of Book/ Authors/ Publisher**
1	R.C. Hibbeler, Dynamics (11th Ed) Pearson Publishers.
2	F.P. Beer et al. Dynamics (8th Ed) Mc GrawHill Publishers.
3	Merriam and Kraige; Dynamics (5th Ed) Wiley and Sons Publications Merriam and Kraige.
4	R.C. Hibbeler, Statics (11th Ed) Pearson Publishers.

Course Name	**:**	**ELECTROMAGNETIC THEORY**
Course Code	**:**	**PYN-106**
Credits	**:**	**4**
L T P	**:**	**3 1/2 2/2**

Course Objectives:
At the end of the course, the student should be able to understand the classification of the vector fields. The student should be able to apply the concepts of electrostatics and boundary value problems. The student should be able to understand concepts of electromagnetic wave propagation.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**VECTORS AND FIELDS:** Cartesian coordinate System, Cylindrical and Spherical coordinate Systems, Constant coordinate surfaces, Del operator, Gradient, Divergence of a Vector and Divergence Theorem, Curl of a vector and Stoke's theorem, Gradient, Divergence, Curl and Laplacian in the three coordinate Systems, Laplacian of a scalar, Scalar & Vector Fields, Classification of Vector field. Sinusoidally time-varying fields, Complex Numbers and Phasor technique.	10
2	**ELECTROSTATICS:** Field intensity, Gauss's law & its applications, Maxwell's 1st eqn. (Electrostatics), Electric Energy and potential, the line integral, Potential gradient, the dipole fields, Energy density in an electrostatic field. Current and current density, Continuity of current, Metallic conductors, Conductor properties and boundary conditions, the nature of Dielectric materials and related Boundary conditions, Capacitance, Capacitance of a two-wire line, Current analogies. Electrostatic boundary-value problems, Laplace's and Poisson's equations, Uniqueness theorem, General procedure for solving Laplace's and Poisson's equation , Resistance and capacitance, Method of images.	10
3	**MAGNETOSTATICS:** Biot-Savart's law, Ampere's circuital law, Applications of Ampere's law, Magnetic flux and magnetic flux density-Maxwell's eqn., Maxwell's eqn. for static electromagnetic fields, Scalar and vector magnetic potentials. Magnetic dipole, Force due to Magnetic field on a differential current element, force between two differential current elements, Force and torque on a closed circuit, The nature of	11

	magnetic materials, Magnetization and permeability, Magnetic boundary conditions, Inductors and inductances, Magnetic energy, Magnetic circuits, Potential energy and force on magnetic materials.	
4	**MAXWELL'S EQUATIONS AND ELECTROMAGNETIC WAVE PROPAGATION:** Faraday's law, Displacement current, Maxwell's equations in point form, Maxwell's equations in integral form, Kirchoff's Voltage law and Kirchoff's Current law from Maxwell's equations, EM waves in general, EM wave propagation in Lossy Dielectrics, Wave propagation in lossless dielectrics, Plane waves in free space, Plane waves in Good conductors, Power & Poynting Vector, Reflection of a plane wave at normal incidence, Reflection of a plane wave at oblique incidence.	11

List of Experiments:		**Number of Turns**
1	To design a method to draw equipotential lines with various geometries of electrodes kept at different potentials	1
2	To study the variation of magnetic field with distance along the axis of a circular coil carrying current by plotting a graph	1
3	To find the energy band gap of the given semiconductor by four probe method	1
4	To study the Hall effect of a given semiconductor	1
5	To determine the dielectric constant of the given materials	1
6	To study the B-H curve of the ferromagnetic materials	1

Course Outcomes:	
1	By the end of the course, the student will be equipped with the tools of electromagnetic theory.
2	The student will be able to solve numerical problems based on vector fields, electrostatics, magnetostatics and electromagnetic wave propagation.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Engineering Electromagnetics, William H Hyat, Jr., and John A. Buck, Tata McGraw Hill	2013 / 5th edition
2	Elements of Engineering Electromagnetics, Matthew N.O. Sadiku, Oxford University Press	2012 / 4th edition
3	Introduction to Electrodynamics, D.J. Griffiths, Prentice Hall	2012 / 4th edition

Course Name	**:**	**APPLIED CHEMISTRY**
Course Code	**:**	**CHN101**
Credits	**:**	**4**
L T P	**:**	**3 0 3**

Course Objectives: Upon completion of this course, students will have fundamental knowledge of the following:
Concepts of water and its analysis, polymer chemistry, solid state chemistry, lubricants, coordination chemistry and substitution reactions as applied to various industries. Spectroscopic methods required for the characterization of engineering materials. Design and development of novel future engineering materials and processes. Experiments related to applications of analysis and chemical processes relevant to various Industries.

Total No. of Lectures – 42

Lecture wise breakup	**Number of Lectures**

1	**WATER TREATMENT AND ITS ANALYSIS:** Boiler feed water and its problems, Water Softening techniques, Domestic Water treatment, Chemical Analysis and related numerical problems	7
2	**POLYMER CHEMISTRY:** Classification, Mechanism and methods of polymerization, preparation, properties and uses of few engineering.	5
3	**SOLID STATE CHEMISTRY**: Introduction to structure and bonding-ionic solids, crystal defects and applications of defect structure (transistors, rectifiers, photovoltaic cells and computer chips).Introduction to ceramics.	6
4	**LUBRICANTS/ FUEL CELL TECHNOLOGY/CORROSION:** Functions mechanism, classification, properties and analysis of Lubricants and related numerical problems. Introduction to electrochemistry, types of electrodes, Reference electrodes, Ion-selective electrodes, Concentration cells, Batteries, Fuel cells/ Types of corrosion, dry and wet corrosion and their mechanisms, types of electrochemical corrosion, factors influencing corrosion, Prevention of corrosion.	6
5	**ATOMIC AND MOLECULAR SPECTROSCOPY: AAS**- Principle, instrumentation and applications of UV,IR and NMR spectroscopy and related problems.	10
6	**COORDINATION CHEMISTRY:** Crystal Field Theory, Splitting of octahedral, tetrahedral and square planner complexes, Applications of crystal field theory.	4
7	**AROMATIC ELECTROPHILIC AND NUCLEOPHILIC SUBSTITUTION:** Reaction mechanisms and applications.	4

Course Outcomes: Students who complete the course will have demonstrated the ability to do the following:	
1	Apply the knowledge for water treatment and its analysis for processing and its disposal which is relevant to all Industries for efficient utilization of water as an essential industrial resource.
2	Develop and design new materials based on knowledge of polymers, solid chemistry and substitution reactions
3	Hands on experience for carrying out experiments with precision for characterization and estimation of materials by wet analysis.
4	Will be able to carry out Instrument based spectroscopic analysis of new materials and interpretation of relevant data.

Reference Books:	
Sr. No.	**Name of Book/ Authors/ Publisher**
1	Atkin's Physical Chemistry by Peter Atkins, Julio de Paula, 7th Edition, Oxford University Press.
2	Concise Inorganic Chemistry Vth Edition J D Lee 2003 (Chapman & Hall)
3	A Textbook of Engineering Chemistry by Shashi Chawla, Dhanpat Rai& Co. Pvt. Ltd.
4	Introductory Polymer Chemistry by G.S.Mishra, John Wiley & Sons, New York, 1993.
5	Basic Inorganic Chemistry by F.A. Cotton, G. Wilkinson and P.L. Gaus, 3rd Ed., John Wiley & Sons.
6	Puri, Sharma and Pathania : Principles of Physical Chemistry, W.H. Freeman & Co, 2008.
7	Organic Chemistry by Joseph M.Hornback Brooke/Cole Publishing Company U.S.A.
8	D. S. Pavia, G.M. Lasmpman and G.S. Kriz : Introduction to Spectroscopy, 4th Edition, Thomson learning, Indian Edition 208.
9	Chemistry for environmental engineering by C. N. Sawyer, P. McCarty, G. F. Parkin, Mc Graw Hill Inc, New York.

Course Name	**:**	**PHYSICAL CHEMISTRY**
Course Code	**:**	**CHN-102**
Credits	**:**	**4**
L T P	**:**	**3 0 3**

Course Objectives:
At the end of this course the students should be able to describe and implement concepts and principles of Physical Chemistry required for indepth understanding of Physical phenomena of materials in relation to applications in Engineering .

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**CHEMICAL EQUILIBRIUM :** General characteristics of chemical equilibrium, thermodynamic derivation of the law of chemical equilibrium, Van't Hoff reaction isotherm. Relation between Kp, Kc and Kx. Temperature dependence of equilibrium constant-Van't Hoff equation, Le Chatelier's principle.)	4
2	**SOLUTIONS**: Ideal and non-ideal solutions, Raoults's law, change of free energy, enthalpy, and entropy on mixing of liquids, distillation of binary solutions. Partially miscible liquids such as Phenol- water, triethylamine- water, and Nicotine- water systems. Henry's law, Nernst distribution law, Colligative properties of dilute solutions. Abnormal molar mass, degree of dissociation and association of solutes.	8
3	**CHEMICAL KINETICS:** Rate equation of reactions of various orders, rate mechanism, kinetics of complex reactions. Concept of energy barrier and energy of activation. Theories of reaction rates, measurement of extent of reaction, zero order reactions. Rates of flow systems. Lindemann theory of unimolecular reactions.	8
4	**SURFACE PHENOMENA:** Adsorption of gases by solids. Types of adsorption, adsorption isotherms, Langmuir's adsorption equation, B.E.T. equation for determination of surface area of adsorbents, applications of adsorption, catalysis, kinetics of surface reactions. Introduction to micelles, emulsions and gels.	6
5	**PHASE EQUILIBRIA** : Phase rule and its thermodynamic derivation. One component systems-water, sulphur, Two component systems, construction and interpretation of general phase diagrams for liquid-vapour, liquid-liquid and liquid-solid systems. Eutectics, freezing mixtures, ultra purity, zone refining.	6
6.	**ELECTROCHEMISTRY:** Conductance of electrolytic solutions, transference number and its determination, Kohlrausch's law of independent migration of ions, Interionic attraction theory, activity and activity coefficients of strong electrolytes, ionic equilibria. Ionizaton of water, ionization constants of weak acids and weak bases, hydrolysis, pH, common ion effect, solubility product and salt effect.	5
7.	**ELECTROCHEMICAL CELLS:** Reversible and irreversible cells, e.m.f. and its measurement, cell reactions and e.m.f., thermodynamics of electrode potentials, half- cell potential and its determination, Nernst equation, concentration cells, liquid junction potential, determination of activity co-efficient from cell potential data, potentiometric titrations.	4

List of Experiments:		**Number of Turns**
1	Determination of Surface tension of liquids using Stalagmometer.	2
2	Distribution of Iodine between water and carbon tetrachloride.	2
3	Kinetics of the hydrolysis of methyl acetate in the presence of hydrochloric acid.	3
4	Adsorption of acetic acid on activated charcoal.	2
5	Conductometric and Potentiometric titrations and Colorimetry.	4

Course Outcomes: By the end of this course, the student will be able to-	
1	Understand the phenomenon of chemical equilibrium, phase equilibria and effect of change of process parameters such as T, P, C etc both quantitatively and qualitatively.
2	Understand physical properties of solutions like change of free energy, entropy of mixing as applies to heat and mass transfer in chemical processes.
3	Analyse the kinetics of chemical processes that are useful in the design of reactors and optimisation of material processing and its implementation.

4	Apply concepts of various surface phenomenons for material coatings, separate technology and in catalytic processes.
5	Design the sensors based on the concepts of electrochemistry.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Principles of Physical Chemistry by Maron, Samuel H. Prutton, ; Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi.	2002
2	Textbook of Physical Chemistry by Carl F. Glasstone, Samuel ; MacMillan and Co. Ltd. London	2010
3	Principles of Physical Chemistry by B.R Puri., L.R Sharma, and Pathania, S Madan,; S. Nagin &Co Jalandhar.	2013
4	Chemical Kinetics by Laidler , J Keith ;Tata McGraw-Hill Co. Ltd., New Delhi.	2002
5	A Text Book of Physical Chemistry by P.W Atkins; Oxford University Press.	2009
6	Findlay's Practical Physical Chemistry by B.P Lavitt. ; Longman Group Ltd.	1973

Course Name	**:**	**INORGANIC CHEMISTRY**
Course Code	**:**	**CHN-103**
Credits	**:**	**4**
L T P	**:**	**3 0 3**

Course Objectives: Upon completion of this course, students will have fundamental knowledge of the following:
Concepts of structure and chemical bonding essential for understanding of molecular structure. Solid state chemistry for application in electronics, ceramics and other advanced materials. Magnetic behaviour and catalytic properties of co-ordination and organometallic compounds used in various industries. Interaction and role of metals in biological systems essential for bio-engineering applications.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**QUANTUM THEORY AND ATOMIC STRUCTURE:** Introduction to wave mechanics, the Schrodinger equation, the Schrodinger equation as applied to hydrogen atom, the origin of quantum numbers and shapes of orbitals.	4
2	**CHEMICAL BONDING:** Molecular orbital and valence bond theories of bond formation and application of molecular orbital theory to the formation of homonuclear and heteronuclear diatomic molecules.	7
3	**THE SOLID STATE:** A recapitulation of close packing of spheres, structures of NaCl, CsCl, ZnS, CaF2, crystal defects and applications of defect structures (transistors, rectifiers, photovoltaic cells and computer chips).	4
4	**COORDINATION COMPOUNDS:** Part 1:Werner's theory, effective atomic number, bonding of transition metal complexes: valence bond theory, crystal field theory, crystal field splitting in tetrahedral, octahedral and distorted octahedral (square planar) crystal fields. Thermodynamic aspects of coordination compounds (crystal field stabilization energies of octahedral and tetrahedral complexes, spectrochemical series).	6
5	**COORDINATION COMPOUNDS:** Part2: Kinetic aspects of coordination compounds (substitution reactions in complexes with coordination number 4 and 6 and their mechanism - **SN^1**, SN^2). Magnetic behaviour of complexes – Para magnetism, diamagnetism, ferromagnetism and antiferromagnetism and measurement ofmagnetic susceptibility of complexes by Guoy's method.	6

6	**ORGANOMETALLIC COMPOUNDS:** Nomenclature, types of ligands and bonding in organometallic compounds, use of organometallics in industry.	5
7	**INORGANIC POLYMERS: TYPES** of inorganic polymers, polyphosphazenes, polysiloxanes –their structures and properties.	5
8	**ROLE OF METALS IN BIOLOGICAL SYSTEMS:** Bio-inorganic Chemistry of Iron – Heme proteins & Non-Heme iron proteins; bioinorganic chemistry of cobalt-vitamin B12 and metalloenzymes.	5

Course Outcomes: Students who complete the course will have demonstrated the ability to do the following:	
1	Apply the knowledge of quantum theory, chemical bonding and solid state, to know the structure and bonding required for the development of new materials.
2	Design new inorganic materials with desired physical and chemical properties.
3	Carry out experiments with precision related to synthesis and characterization of new industrially important inorganic materials.

Reference Books:	
Sr. No.	**Name of Book/ Authors/ Publisher**
1	Sharpe, A. G. : Inorganic Chemistry, 3rd Edition, Longman Publishers ELBS, 1992.
2	Lee, J. D. : Concise: Inorganic Chemistry, 5th Edition, Chapman and Hall Publishers, 1996.
3	Cotton, F. A. & Wilkinson, G. : Advanced Inorganic Chemistry, 3rd Edition,Wiley Eastern Ltd., 1982.
4	Cotton, F. A. & Wilkinson, G. : Basic Inorganic Chemistry, Wiley EasternLtd., 1987. 12
5	Mark, J., West, R. & Allcock,H. : Inorganic Polymer, Prentice Hall, New Jersey Publishers, 1982.

Course Name	**:**	**PHYSICAL CHEMISTRY**
Course Code	**:**	**CHN-104**
Credits	**:**	**4**
L T P	**:**	**3 0 3**

Course Objectives:
Concepts of chemical equilibria, solutions, chemical kinetics and electrochemistry to the physical phenomena occurring in various chemical processes. Surfaces modification of important industrial materials used in adsorption and separating technology. Phase equilibria for understanding the physical behaviour of various materials such as alloys and other biphasic and triphasic systems. Experiments related to the theoretical studies of different physical phenomena relevant to various industries.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**CHEMICAL EQUILIBRIUM:** thermodynamic derivation of the law of chemical equilibrium, Van't Hoff reaction isotherm. Relation between Kp, Kc and Kx. Temperature dependence of equilibrium constant- Le Chatelier's principle.	5
2	**SOLUTIONS:** Raoults's law, change of free energy, enthalpy, and entropy on mixing of liquids, distillation of binary solutions. Partially miscible liquids Henry's law, Nernst distribution law, Colligative properties of dilute solutions. Abnormal molar mass, degree of dissociation and association of solutes.	8
3	**CHEMICAL KINETICS**: Rate equation of various orders, rate mechanism, kinetics of complex reactions. Theories of reaction rates, measurement of extent of reaction, Rates of flow systems. Lindemann theory of unimolecular reactions.	8
4	**SURFACE PHENOMENA**: Adsorption of gases by solids., adsorption isotherms., Langmuir's adsorption equation, B.E.T. equation for determination of surface area of adsorbents, applications of adsorption, catalysis, kinetics of surface reactions. Introduction to micelles, emulsions and gels.	6

5	**PHASE EQUILIBRIA** : Phase rule and its thermodynamic derivation. One component systems-water, sulphur, Two component systems, construction and interpretation of general phase diagrams for liquid-vapour, liquid-liquid and liquid-solid systems. Eutectics, freezing mixtures, ultra purity, zone refining.	6
6	**ELECTROCHEMISTRY:** transference number and its determination, Kohlrausch's law of independent migration of ions, Interionic attraction theory, activity and activity coefficients of strong electrolytes, ionic equilibria. Ionizaton of water, ionization constants of weak acids and weak bases, common ion effect, solubility product and salt effect.	5
7	**ELECTROCHEMICAL CELLS**: Reversible and irreversible cells, e.m.f. and its measurement, cell reactions and e.m.f., thermodynamics of electrode potentials, half- cell potential and its determination, Nernst equation, concentration cells, liquid junction potential, determination of activity co-efficient from cell potential data, potentiometric titrations.	4

Course Outcomes: Students who complete the course will have demonstrated the ability to do the following:	
1	Understand the relevance of the physical phenomena occurring in various materials and processes.
2	Modify the composition of various materials required for new technological applications.
3	Hands on experience for carry out experiments with precision related to chemical equilibria, surface phenomena and reaction kinetics required for designing various processes in Industry.

Suggested Books:	
Sr. No.	**Name of Book/ Authors/ Publisher**
1	Maron, Samuel H. Prutton, Principles of Physical Chemistry, Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi.
2	Carl F. Glasstone, Samuel Textbook of Physical Chemistry, MacMillan and Co. Ltd. London.
3	Puri,B.R.,Sharma,L.R.and Pathania,Madan,S. Principles of physical chemistry, S.Nagin & co Jalandhar.
4	Laidler, Keith J. Chemical Kinetics, Tata McGraw-Hill Co. Ltd., New Delhi.
5	Atkins, P.W. A Text Book of Physical Chemistry,Oxford University Press.

HUMANITIES, SOCIAL SCIENCES AND MANAGEMENT COURSES (HSSMEC)

Course Name	**:**	**ETHICS AND SELF AWARENESS**
Course Code	**:**	**HSS 101**
Credits	**:**	**2**
L T P	**:**	**2-0-0**

Course Objectives:
To provide basic knowledge about ethics, values, norms and standards and their importance in real life. To improve the personality of students by their self-assessment

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO ETHICS** Concept of Ethics – Nature, Scope, Sources, Types, Functions and Factors influencing Ethics, Approaches to Ethics – Psychological, Philosophical and Social, Broader Ethical Issues in Society	**6**
2	**VALUES, NORMS, STANDARDS AND MORALITY** Concept and Role, Relation with Ethics, Psycho-Social Theories of Moral Development – Kohlberg and Carol Gilligan	**4**
3	**ETHICS AND BUSINESS** Concept of Business Ethics – Nature, Objectives and Factors influencing Business Ethics, 3 C's of Business Ethics, Ethics in Business Activities, Ethical Dilemmas in Business, Managing Ethics	**5**
4	**SELF-AWARENESS** Concept of Self Awareness – Need, Elements, Self Assessment – SWOT Analysis, Self Concepts – Self-Knowledge, Assertiveness and Self-Confidence, Self-Esteem	**4**
5	**SELF-DEVELOPMENT** Concept of Self-Development, Social Intelligence, Emotional Intelligence, Managing Time and Stress, Positive Human Qualities (Self-Efficacy, Empathy, Gratitude, Compassion, Forgiveness and Motivation), Personality Development Models – Johari Window, Transactional Analysis, Myers Briggs Type Indicator, Self-Awareness and Self-Development Exercises	**9**

Course Outcomes:	
1	Helps to distinguish between right and wrong in both personal and professional life
2	Students learn about their strengths, weaknesses, opportunities & threats and work enthusiastically to transform weaknesses into strengths and threats into opportunities

Reference Books:	
1	Murthy, C.S.V., "Business Ethics – Text and Cases", Himalaya Publishing House
2	Hartman, Laura P. and Chatterjee, Abha, "Business Ethics", Tata McGraw Hill
3	Rao, A.B., "Business Ethics and Professional Values", Excel Books
4	Velasquez, Manuel G., "Business Ethics – Concepts and Cases", Prentice Hall
5	Corey, G., Schneider, Corey M., and Callanan, P., "Issues and Ethics in the Helping Professions", Brooks/Cole
6	Hall, Calvin S., Lindzey, Dardner and Cambell, John B., "Theories of Personality", Hamilton Printing Company
7	Leary, M.R., "The Curse of Self: Self-awareness, Egotism and the Quality of Human Life", Oxford University Press

Course Name	**:**	**COMMUNICATION SKILLS (BASIC)**

Course Code	**:**	**HSS 102**
Credits	**:**	**2**
L T P	**:**	**1-0-2**

Course Objectives:
The main aim of the course is to build competence in English grammar and vocabulary and to enhance effective communication by developing Reading, Writing, Listening and Speaking skills of students.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**FUNDAMENTALS OF COMMUNICATION SKILLS** Scope and Significance of Communication Skills, Listening, Speaking, Reading and Writing	**3**
2	**WRITING SKILLS** Basics of Grammar – Placing of Subject and Verb, Parts of Speech, Uses of Tenses, Active-Passive, Narration	**3**
3	**VOCABULARY BUILDING AND WRITING** Word Formation & Synonyms, Antonyms, Words Often Confused, One-Word Substitutes, Idioms and Phrasal Verbs, Abbreviations of Scientific and Technical Words	**3**
4	**SPEAKING SKILLS** Introduction to Phonetic Sounds & Articulation, Word Accent, Rhythm and Intonation	**3**
5	**READING AND COMPREHENSION** Two comprehensive prose passages	**2**

List of Experiments:		**Number of Turns**
1	Introducing Oneself, Exercise on Parts of Speech & Exercise on Tense	**2**
2	Exercise on Agreement, Narration, Active Passive Voice & Dialogue Conversation	**2**
3	Exercise on Writing Skills and Listening Comprehension (Audio CD)	**2**
4	Practice of Phonemes, Word Accent, Intonation, JAM Session	**2**
5	Individual Presentation, Extempore and Picture Interpretation	**2**
6	Vocabulary Building Exercises (One Word Substitute, Synonyms, Antonyms, Words Often Confused etc.) & Group Discussion	**2**
7	Reading Comprehension & Organizational Correspondence and Debate	**2**

Course Outcomes:	
1	The students will be able to perform better in their academic and professional life.
2	The student will gain self-confidence with improved command over English.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"The Essence of Effective Communication", Ludlow R. and Panton F., Pubs: Prentice Hall.	1992
2	"A University Grammar of English", Quirk R. and Sidney G., 3rd Edition, Pubs: Pearson Education.	2008
3	"High School English Grammar", Wren and Martin, Pubs: S. Chand & Company Ltd.	2007
4	"Essentials of Business Communication", Guffrey M.E., 8th Edition, Pubs: South-Western College Publishing.	2009
5	"Technical Communication: Principles and Practice", Raman M. and Sharma S., 2nd Edition, Pubs: Oxford University Press.	2012
6	"Effective Business Communication", Rodrigues M.V., Pubs: Concept Publishing Company, Delhi.	2003
7	"English Vocabulary in Use", McCarthy M. and Felicity O' Dell, 2nd Edition, Pubs:	2010

	Cambridge University Press.	
8	"The Pronunciation of English", Jones D., Pubs: Universal Book Stall.	1992

Course Name	**:**	**COMMUNICATION SKILLS (ADVANCED)**
Course Code	**:**	**HSS 103**
Credits	**:**	**2**
L T P	**:**	**1-0-2**

Course Objectives:
The main aim of the course is to enhance communication skills of students for better performance in professional life and to improve their overall personality with the use of advanced techniques in speaking and writing and also to train them in using both verbal and non-verbal communication effectively.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO COMMUNICATION PROCESS** Scope, Significance, Types and Levels, Technical Communication, Tools of Effective Communication	**3**
2	**SPEAKING SKILLS AND PERSONALITY DEVELOPMENT** Interpersonal Communication, Oral Presentation, Body Language and Voice Modulation (Para linguistics and Non- Verbal), Negotiation and Persuasion, Group Discussion, Interview Techniques (Telephonic and Video Conferencing)	**6**
3	**ADVANCED Technical Writing** Job Application, CV Writing, Business Letters, Memos, Minutes, Notices, Report Writing & Structure, E-mail Etiquette, Blog Writing	**4**
4	**COMMUNICATION AND MEDIA** Social and Political Context of Communication, Recent Developments in Media	**1**

List of Experiments:		**Number of Turns**
1	**ORGANIZATIONAL COMMUNICATION** Verbal and Non-Verbal Communication at different levels of organization, Role Play, Case Studies	**2**
2	**SPEAKING TECHNIQUES** Mock Interviews, Participation in Group Discussions, Making and Presenting Power Point	**4**
3	**STANDARD ENGLISH & PRACTICE SESSION** Intonation and Pronunciation, Exposure to Standard English, Sounds, Stress and Rhythm, Comprehension on British and American English	**4**
4	**PRACTICE ON TECHNICAL WRITING** Writing Letters, Memos, Minutes, CV, Job Applications, Reports and e-mails	**4**

Course Outcomes:	
1	The students will gain proficiency in English language for both professional and personal life.
2	The students will learn technical aspects of communication for better performance in extra-curricular activities, recruitment process and prospective jobs.
3	The students will be able to refine their personality through a grip over advanced techniques of language.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**

1	"Effective Technical Communication", Rizvi M.A., 5th Reprint, Pubs: McGraw Hill Education (India).	2007
2	"Technical Communication: Principles and Practice", Raman M. and Sharma, S., 2nd Edition, Pubs: Oxford University Press.	2012
3	"Business Communication Today", Bovee C.L. and Thill J.V., 9th Edition, Pubs: Pearson Education Asia, New Delhi.	2009
4	"Business Correspondence and Report Writing", Sharma R.C. and Mohan K., Pubs: McGraw Hill	1994
5	"Communication for Professional Engineers", Scott B., 2nd Edition, Pubs: Thomas Teleford Ltd.	1997
6	"Handbook for Technical Writing", McMurrey D.A. and Buckley J., Pubs: Cengage Learning.	2012
7	"Student Activities for taking charge of your Career Direction and Job Search", Lock R., 3rd Edition, Pubs: Cole Publishing	1996
8	"The Definitive Book of Body Language", Pease A. and Pease B., Pubs: Manjul Publishing House Pvt. Ltd.	2005

Course Name	**:**	**ECONOMICS**
Course Code	**:**	**HSS 201**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objectives:
The main aim of this course is to make students understand how society manages its scarce resources for achieving maximum satisfaction and to make them learn about economic aspects related to a consumer, firm, market and economy.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO ECONOMICS** Nature of Economics, Economic Thoughts, Economic Activities, Relationship of Economics with other Social Sciences and Engineering	**3**
2	**THEORY OF CONSUMER BEHAVIOUR** Demand: Types, Law of Demand, Demand Supply Curve, Determinants of Demand and Change in Demand (Movement of Demand and Shift of Demand) with Case Studies Elasticity of Demand: Nature, Degrees, Types, Factors Affecting Elasticity of Demand and its Application in present scenario Laws of Consumption: Concept and Applicability of Law of Diminishing Marginal Utility and Law of Equi-Marginal Utility	**9**
3	**THEORY OF PRODUCTION AND COST** Cost: Concept and Types Production: Concept, Scale of Production, Law of Variable Proportion Returns to Factor and Returns to Scale: Causes and Implications Economies and Diseconomies of Scale: Concept and Types Relevance of Production and Cost Concept in present context	**5**
4	**THEORY OF MARKET** Market: Concept and Types (Perfect Competition, Monopoly and Monopolistic Competition), Nature and Relevance of different Markets in present scenario – Case Study	**5**
5	**BASIC CONCEPTS OF MACRO ECONOMICS** National Income: Concept and Measurement Methods, Determination of Equilibrium of Income	**6**

	Inflation: Concept, Causes and Effect of Inflation, Measures to Control Inflation, Case Study on Impact of Inflation	

Course Outcomes:	
1	The students are expected to apply engineering knowledge to maximize profit, satisfaction and welfare.
2	The students are able to identify the forces that affect the economy.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Modern Economics", Ahuja H. L., Pubs: Sultan Chand and Co. Ltd, New Delhi.	2012
2	"Economics For Engineers", Gupta M. L. and Gupta S.P., Pubs: ESS PEE Publications.	
3	"Business Economics", Ahuja H. L., Pubs: Sultan Chand and Co. Ltd, New Delhi.	2010
4	"Macro Economic Theory", Jhingan M.L., Pubs: Konark Publisher Pvt. Ltd., New Delhi.	1986
5	"Principles of Microeconomics", Stiglitz J.E. and Walsh C.E., 4th Edition, Pubs: W.W. Norton & Company.	2006
6	"Principles of Macroeconomics", Stiglitz J.E. and Walsh C.E., 4th Edition, Pubs: W.W. Norton & Company.	2006
7	"Principles of Economics", Mankiw N.G., 7th Edition, Pubs: Cengage Learning	2014
8	"Economics", Samuelson P.A. and Nordhaus W.D., 18th Edition, Pubs: McGraw Hill.	2004

Course Name	**:**	**PSYCHOLOGY**
Course Code	**:**	**HSS 202**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objectives:
The main aim of the course is to provide knowledge and understanding about important concepts in Psychology which will help the students in learning the applications of principles of psychology in personal and professional life.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO PSYCHOLOGY** Concept, Nature and Scope Methods of Studying Human Behaviour – Introspection Method, Observation Method, Experimental Method, Case History Method, Survey Method, Psychological Test Use Relevance of these Methods in present context	**4**
2	**INTELLIGENCE** Concept and Determinants of Intelligence Theories of Intelligence and its Application: Spearman, Thurston, Guilford.	**4**
3	**PERSONALITY** Personality: Concept, Determinants of Personality, Trait Paradigm (Eysenck), Psychodynamic Paradigm (Freud), Measurement of Personality – Self Report Measures (EPQ), Projective Measures (TAT), Hypothetical Measurement of Personality	**4**
4	**MENTAL HEALTH AND STRESS** Mental Health: Concept and Factors Affecting Mental Health Stress: Nature, Rections to Stress, Outcomes of Stress, Stress Management Case Study	**4**

5	**LEARNING AND MEMORY** Learning: Concept, Reinforcement Principle and Learning, Managerial Implications Memory: Concept, Long Term Memory, Short Term Memory, Episodic Memory, Methods to Improve Memory	**3**
6	**MOTIVATION** Nature and Types of Motivation: Extrinsic and Intrinsic Theories of Motivation and its Application: Humanistic and Need Theories Factors Affecting Motivation	**3**
7	**GROUP BEHAVIOUR AND DYNAMICS** Concept and Importance, Types of Groups, Group Development, Group Performance Factors, Conflict: Nature, Conflict Resolution, Case Study	**4**
8	**LEADERSHIP** Leadership: Nature and Importance, Leadership Styles: Authoritarian, Democratic, Paternalistic, Laissez faire, Transactional, Transformational, Case Study	**2**

Course Outcomes:	
1	The students will learn the causes and dynamics of human behavior.
2	The students will be able to apply psychological principles to enhance their personal and professional life.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Psychology", Ciccarelli S.K. and Meyer G.E., Pubs: Pearson India.	2007
2	"Introduction to Psychology", Morgan C.T., Weiss J.R., King R.A. and Schopler J., 7th Edition, Pubs: McGraw-Hill Education.	2004
3	"An Introduction to Psychology", Mangal S.K., 1st Edition, Pubs: Sterling Publishers Pvt. Ltd., New Delhi.	2009
4	"Fundamentals of Social Psychology", Baron R.A., Branscombe N.R., Byrne D. and Bhardwaj G., 1st Edition, Pubs: Pearson India.	2011
5	"Organizational Behaviour", Parikh M. and Gupta R., Pubs: McGraw Hill Education.	2010
6	"Organizational Behavior", Robbins S.P., Pubs: Prentice Hall of India.	2003

Course Name	**:**	**SOCIOLOGY**	
Course Code	**:**	**HSS 203**	
Credits	**:**	**3**	
L T P	**:**	**2-1-0**	

Course Objectives:
The main aim of the course is to make the students understand the role of theory in social sciences and to explain them how social problems interact and react with the larger society. This course also intends to make them learn whether the problem is evaluated on the macro or micro perspective and their cause and effect patterns.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO SOCIOLOGY** Sociology as a Science, Impact of Industrial and French Revolution on the Emergence of Sociology, Contribution of Karl Marx, Emile Durkheim, Max Weber, Alwin Toeffler to Sociology and its Application in present scenario, Relevance of Sociology for Engineering	**5**
2	**BASIC CONCEPTS** Society, Association, Institution, Culture Relativism, Social Structure, Social System,	**2**

	Socialization, Competition, Conflict, Accommodation, Social Mobility	
3	**SOCIETY AND ECONOMY** Evolution of Society: Primitive, Agrarian, Industrial and Post-Industrial, Economic Systems of Simple and Complex Societies, Sociological Dimensions of Economic Life, Market (free) Economy and Controlled (planned) Economy	**4**
4	**INDUSTRIAL SOCIOLOGY** Nature and Scope of Industrial Sociology, Pre-Conditions and Consequences of Industrialization, Impact of Automation and Industrialization on Society with Case Study	**3**
5	**SCIENCE AND TECHNOLOGY** Ethos of Science and Social Responsibility of Science	**2**
6	**SOCIAL CHANGE** Theories of Change and its Application to Sociology, Factors of Change, Directed Social Change, Social Policy and Social Development, Social Cost Benefit Analysis, Role of Engineers in Development	**4**
7	**INDIAN SOCIETY** Traditional Hindu Social Organization, Caste System, Agrarian Society in India, Social Consequences of Land Reforms and Green Revolution, Working of the Democratic Political System in a Traditional Society, Problem of Education in India, Gender Discrimination, Economic Reforms: Liberalization, Privatization and Globalization, Strategies for Development in India, Case Studies	**6**
8	**SOCIAL PROBLEMS** Concept of AIDS, Alcoholism, Drug Addiction, Corruption with Case Study	**2**

Course Outcomes:	
1	The students will be able to identify the function and application of sociology theory in social sciences.
2	The students will be able to understand how social class affects individual life chances.
3	The students will learn about social structure and how it shapes and influences social interactions.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Sociology: Themes and Perspective", Haralambos M. and Holborn M., Pubs: Collins Educational Publications.	2008
2	"Sociology of Indian Society", Rao C.N.S., 2nd Edition, Pubs: Sultan Chand and Co., New Delhi.	2004
3	"Introduction to Sociology", Bhushan V. and Sachdeva D.R., Pubs: Kitab Mahal Publications.	2002
4	"An Introduction to Sociology", Dassgupta S. and Saha P., Pubs: Dorling Kindersley (India) Pvt. Ltd.	2012
5	"Social Change in Modern India", Srinivas M.N., 1st Edition, Pubs: Orient Longman.	2010
6	"Sociology and Modern Social Problems", Ellwood C.A., Pubs: Bastian Books.	2008
7	"Industrial Sociology", Singh N., 1st Edition, Pubs: McGraw Hill Education (India).	2012
8	"Society in India: Concepts, Theories and Recent Trends", Ahuja R., 1st Edition, Pubs: Rawat Publications.	2011

Course Name	**:**	**FRENCH**
Course Code	**:**	**HSS 204**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objectives:

The main aim of this course is to introduce students with basics of a foreign language and make them learn how to communicate in a new language.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	Introductions: introduce yourself or someone else	**2**
2	Greetings	**2**
3	Alphabet / numbers	**3**
4	Communication in a class	**3**
5	Asking and answering basic questions: name – age – nationality – profession – family, friends, acquaintances	**3**
6	Giving the date / day / season / time / frequency of an event	**2**
7	Locating a place / describing a city or a locality / giving information about one's region, city or country	**4**
8	Expressing quantities	**2**
9	Expressing one's preferences / talk about one's leisure time activities	**3**
10	Describing a person / talking about his/her nature	**4**

Course Outcomes:	
1	The students will be able to express themselves in the foreign language.
2	The students will be able to make use of this language in their professional life in the globalized world.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Learn French Through English in 30 Days", Chopra B., 1st Edition, Pubs: Diamond Books.	2009
2	"Complete French", Graham G., Pubs: Hodder & Stoughton.	2012
3	"French Made Easy", Verma R., 1st Edition, Pubs: Goodwill Publishing House, New Delhi.	2012
4	"Learn French for Beginners", Schell R., Pubs: Maanu Graphics.	
5	"French Made Easy", Khan F., Pubs: Lotus Press.	2010
6	"French Course Grammar", Bertenshaw T.H., 1st Edition, Pubs: Orient Blackswan.	1998

Course Name	**:**	**PRINCIPLES OF MANAGEMENT**
Course Code	**:**	**HSM 401**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objectives:
The main aim of this course is to make students understand the management process and principles along with its application in practical life and to help them manage different jobs and situations with the help of management functions.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO MANAGEMENT** Nature of Management: Art or Science, Principles and Functions of Management	**3**
2	**EVOLUTION OF MANAGEMENT THOUGHT** Classical Theories: Bureaucratic, Scientific and Administrative Approach	**6**

	Neo-Classical Theories: Human Relations and Human Behaviour Approach Modern Theories of Management Relevance of Management Thought in present scenario – Management Cases	
3	**PLANNING** Nature of Planning, Planning Process, Application of Planning Process in a Hypothetical Situation, Types of Planning, Types of Plans, Management by Objective (MBO)	**4**
4	**ORGANIZING** Concept of Organization, Departmentation, Forms of Organization Structure Analysis of Organization Structure – Case Studies Hypothetical Formation of an Organization	**4**
5	**STAFFING** Human Resource Planning: HRP Process, Job Analysis: Job Description, Job Specifications and Used of Job Analysis Recruitment: Sources and Methods Selection: Selection Process, Role Playing and Case Study on Selection Tests and Interviews Training and Development: Techniques, Performance Appraisal: Methods Case Study on Staffing Practices	**6**
6	**DIRECTING** Concept, Leadership: Importance and Styles, Motivation: Theories and their relevance in present scenario, Communication: Process, Types and Barriers of Communication Management Game on Leadership, Motivation and Communication	**3**
7	**CONTROLLING** Nature and Process of Controlling, Requirements for Effective Controlling	**2**

Course Outcomes:	
1	The students will be able to apply management concepts and principles in daily life and thus, will be able to manage things efficiently and effectively.
2	The students will learn how to get work done easily by using management knowledge and functions.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Principles and Practices of Management", Rao V.S.P. and Narayana P.S., Pubs: Konark Publishers.	1987
2	"Principles & Practice of Management", Prasad L.M., 8th Edition, Pubs: Sultan Chand & Sons.	2012
3	"Essentials of Management: International and Leadership Perspective", Weihrich H. and Koontz H., 9th Edition, Pubs: McGraw Hill.	2012
4	"The New Era of Management", Daft R.L., 11th Edition, Pubs: Cengage Learning.	2014
5	"Management: Text and Cases", Rao V.S.P. and Krishna V.H., Pubs: Excel Books.	2008
6	"Fundamentals of Management: Essential Concepts and Applications", Robbins S.P, DeCenzo D.A., Bhattacharya S. and Agarwal M.N., 6th Edition, Pubs: Pearson India.	2009

Course Name	**:**	**BUSINESS ENVIRONMENT AND BUSINESS LAWS**
Course Code	**:**	**HSM 402**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objectives:

The main aim of this course is to make students understand different types of environment influencing business decisions and to provide knowledge about different laws that needs to be followed for initiating and managing business.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO BUSINESS** Scope and Characteristics of Business, Classification of Business Activities Forms of Ownership of Business: Sole Proprietorship, Partnership and Company	**5**
2	**BUSINESS ENVIRONMENT** Internal Environment: Concept and Elements (Value System, Vision Mission Objectives, Management Structure, Human Resources, Company Image etc.) SWOT Analysis: Concept and Case Study External Environment: Micro Environment (Suppliers, Customers, Competitors, Market Intermediaries etc.) and Macro Environment – PESTEL Analysis (Political, Economic, Social, Technological, Ecological and Legal), Case Study on Impact of Environment on Business	**7**
3	**GLOBALIZATION** Concept, Pros and Cons of Globalization, Impact of Global Environment on Business Globalization of Company – Case Study	**4**
4	**CORPORATE SOCIAL RESPONSIBILITY** Concept, Social Responsibility towards different stakeholders, Rationale for CSR CSR – Case Studies	**2**
5	**CORPORATE GOVERNANCE** Concept, Elements and Essentials of Good Governance	**3**
6	**CONTRACT LAW** Concept, Types and Essentials Elements of Contract	**3**
7	**PARTNERSHIP LAW** Nature of Partnership, Provisions of Partnership Act, Issues Related to Partnership Firm, Hypothetical Formation of a Partnership Firm	**2**
8	**COMPANY LAW** Nature of Company, Provisions of Company Act, Issues Related to Incorporation of Company, Hypothetical Formation of a Company	**2**

Course Outcomes:	
1	The students will be able to analyze the impact of environment on business and formulate appropriate business strategies to compete in the competitive world.
2	The students will learn how companies follow corporate governance and social responsibility practices along with fulfilling economic objectives.
3	The students will gain knowledge about application and implementation of various business laws in practice.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Business Environment: Text and Cases", Cherunilam F., 22nd Edition, Pubs: Himalaya Publications.	2013
2	"Legal Aspects of Business", Pathak A., 5th Edition, Pubs: McGraw Hill Education.	2013
3	"Essential of Business Environment: Text, Cases and Exercises", Aswathappa K., 11th Edition, Pubs: Himalaya Publication.	2011
4	"Business Law Including Company Law", Gulshan S.S. and Kapoor G.K., 15th Edition, Pubs: New Age International (p) Ltd.	2011

5	"Business Law and Corporate Laws", Tulsian P.C., 1st Edition, Pubs: Sultan Chand Publishing.	2011
6	"Fundamentals of Business Organization & Management", Bhushan Y.K., 19th Edition, Pubs: Sultan Chand & Sons.	2013
7	"Corporate Governance: Principles, Policies and Practices", Fernando A.C., 2nd Edition, Pubs: Pearson India.	2011

Course Name	**:**	**ENTREPRENEURSHIP AND PROJECT MANAGEMENT**
Course Code	**:**	**HSM 403**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objectives:
The main aim of this course is to make prospective engineers familiar with the concept of entrepreneurship and MSMEs and to provide knowledge about different aspects to be considered while formulating the business plan for a new entrepreneurial venture. This course also intends to create awareness among students about financial and marketing functions that is required for a new venture.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO ENTREPRENEURSHIP** Concept of Entrepreneurship, Characteristics and Functions of Entrepreneur Forms of Ownership of Business, Factors Affecting Entrepreneurship Case Studies of Entrepreneurs	**6**
2	**WOMEN ENTREPRENEURSHIP** Nature of Women Entrepreneurship, Problems of Women Entrepreneurs, Institutional Initiatives for Promotion of Women Entrepreneurs	**2**
3	**MICRO, SMALL AND MEDIUM ENTERPRISES (MSMES)** Concept of MSMEs, Schemes of MSMEs Functions of Entrepreneurial Development Programmes (EDPs)	**2**
4	**PROJECT IDENTIFICATION** Idea Generation, Project Life Cycle, Concept of SWOT Analysis SWOT Analysis of Selected Project	**2**
5	**PROJECT PLANNING AND FORMULATION** Elements of Project Formulation: Product, Technical (Location, Scale, Technology, Production Process, Layout, Manpower, Resources etc.), Market, Finance and Economic Aspects Feasibility Analysis: Financial Viability and Profitability, and Socio-Economic Desirability	**7**
6	**PROJECT REPORT** Formulation of Business Plan and Project Report, Hypothetical Example of a Real-Life Project	**2**
7	**FINANCE AND MARKETING FUNCTION** Concept of Finance, Finance Related Terminologies, Sources of Finance, Cost Estimations Marketing Mix: Product, Place, Price, Promotion, People, Process and Physical Evidence Marketing Segmentation Targeting and Positioning	**5**
8	**DISCUSSIONS ON ADDITIONAL READING** (any one of the following in the semester) - The New Age Entrepreneurs - The $100 Startup: Fire your Boss, Do what you Love and Work Better to Live More - A Guide to Entrepreneurship - Dhandha: How Gujaratis Do Business - Rokda: How Baniyas Do Business	**2**

	- Take Me Home - Business Families of Ludhiana	

Course Outcomes:	
1	The students will be able to apply engineering knowledge effectively in the field of entrepreneurship development.
2	The students can make effective use of entrepreneurial knowledge to start and manage their venture.
3	The students will learn to check the feasibility of a new project to maintain its long run sustainability.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Dynamics of Entrepreneurial Development & Management", Desai V., 5th Edition, Pubs: Himalaya Publishing House.	
2	"Projects: Planning, Analysis, Selection, Financing, Implementation and Review", Chandra P., 8th Edition, Pubs: McGraw-Hill Education (India).	2014
3	"Entrepreneur's Toolkit", Harvard Business School, Pubs: Harvard University Press.	2004
4	"Entrepreneurship", Hisrich R.D., Peters M.P. and Shepherd D.A., Pubs: McGraw Hill Education.	2006
5	"Essentials of Project Management", Ramakrishna K, Pubs: PHI Learning.	
6	"Entrepreneurship", Roy R., 2nd Edition, Pubs: Oxford University Press	2011
7	"Entrepreneurship Development in India", Gupta C.B. and Srinivasan N.P., Pubs: Sultan Chand and Sons.	2013

Course Name	**:**	**FINANCIAL MANAGEMENT**
Course Code	**:**	**HSM 404**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objectives:
The main aim of this course is to make students learn different financial decisions i.e. investing, financing and dividend, required to be taken by a company and provide knowledge about the functioning of the financial system (financial markets, financial institutions, financial services and financial instruments) of the country.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO FINANCIAL MANAGEMENT** Concept of Finance, Terminology Related to Finance, Financial Decisions, Factors Affecting Financial Decisions, Risk-Return Trade-Off	**3**
2	**FINANCIAL SYSTEM** Concept and Role of Financial System in Indian Economy	**2**
3	**FINANCIAL MARKETS AND INSTRUMENTS** Concept and Relevance of Money Market and Capital Market Money Market Instruments: Call Money, Treasury Bills, Commercial Papers, Certificate of Deposits Capital Market Instruments: Equity Shares, Preference Shares and Debentures Hypothetical Trading in Financial Markets	**5**
4	**FINANCIAL SERVICES** Nature and Functions of Financial Services: Merchant Banking, Mutual Funds, Factoring, Forfaiting, Credit Rating	**6**

	Case Study on Financial Services	
5	**FINANCIAL INSTITUTIONS** Nature and Functions of Financial Institutions: Reserve Bank of India (RBI), Securities and Exchange Board of India (SEBI), Discount and Finance House of India (DFHI)	**2**
6	**LONG TERM INVESTMENT DECISIONS** Capital Budgeting: Concept, Importance, Factors Techniques/Methods with Numerical Applications (Pay Back Period, Accounting Rate of Return, Net Present Value, Internal Rate of Return and Profitability Index), Case Study	**3**
7	**SHORT TERM INVESTMENT DECISIONS** Working Capital: Nature, Type and Factors Affecting the Requirement of Working Capital, Case Study	**2**
8	**FINANCING DECISIONS** Capital Structure: Essentials and Approaches of Capital Structure Sources of Finance (long-term and short-term), Financial Leverage: Concept and Numerical Application, Case Study	**3**
9	**DIVIDEND DECISIONS** Types of Dividend, Dividend Policy: Nature and Factors Affecting Dividend Policy, Case Study	**2**

Course Outcomes:	
1	The students will learn to make best combination of financial decisions by considering risk and return trade-off.
2	The students will identify how business can gain maximum through the financial system.
3	The students will understand how to manage funds effectively so as to maximize returns.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Financial Management", Shah P., 2nd Edition, Pubs: Dreamtech Press	2009
2	"Financial Markets and Services", Gordon E. and Natarajan K., 3rd Edition, Pubs: Himalaya Publishing House.	2006
3	"Financial Management: Theory and Practice", Chandra P., 8th Edition, Pubs: McGraw Hill Education (India).	2012
4	"Financial Management", Pandey I.M., 10th Edition, Pubs: Vikas Publishing House Pvt. Ltd., Noida.	2010
5	"Cases in Financial Management", Pandey I.M. and Bhat R., 3rd Edition, Pubs: McGraw Hill Education (India).	2012
6	"Financial Institutions and Markets: Structure, Growth and Innovations", Bhole L.M. and Mahakud J., 5th Edition, Pubs: McGraw Hill Education (India).	2009
7	"The Indian Financial System: Markets, Institutions and Services", Pathak B.V., 3rd Edition, Pubs: Pearson India.	2010
8	"Financial Management and Policy", Horne J.C.V. and Dhamija S., 12th Edition, Pubs: Pearson India.	2011

Course Name	**:**	**MARKETING MANAGEMENT**
Course Code	**:**	**HSM 405**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objectives:

The main aim of this course is to make students understand about the marketing concepts to be applied in real life and the marketing process for delivering value to customers.

Total No. of Lectures –28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO MARKETING** Concepts, Role, Scope and Types of Marketing, Case Study on Marketing Management	**3**
2	**MARKETING RESEARCH** Scope and Process of Marketing Research, Hypothetical Marketing Research Analysis	**3**
3	**CONSUMER AND BUSINESS MARKETS** Types of Markets, Building Customer Value Consumer and Business Buying Behaviour: Factors Influencing Behaviour and Buying Decision Process	**4**
4	**SELECTION OF MARKETS** Segmentation: Factors and Bases, Targeting and Positioning Preparation of STP of Selected Product	**3**
5	**MARKETING MIX** 7 P's of Marketing Mix: Product, Price, Physical Distribution, Promotion, People, Process and Physical Evidence Formulation of Marketing Mix of Selected Product	**3**
6	**PRODUCT DECISIONS** Product (Good or Service) Characteristics, Product Life-Cycle, Packaging and Branding, Product Development and Management	**3**
7	**PRICING DECISIONS** Pricing Policies and Strategies, Factors Influencing Pricing	**3**
8	**PHYSICAL DISTRIBUTION DECISIONS** Marketing Channels, Channel Players, Physical Distribution, Managing Distribution, Analysis of Supply Chain Management – Case Studies	**3**
9	**PROMOTION DECISIONS** Nature of Promotion Decisions, Managing Mass Communication and Personal Communication Analysis of Promotional Strategies – Case Studies	**3**

Course Outcomes:	
1	The students will learn how to market goods and services effectively to different segments so as to deliver value to customers.
2	The students will be able to formulate marketing mix and marketing strategies for different products and different sets of customers.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Marketing Management: Concepts, Cases, Challenges and Trends", Govindarajan M, 2nd Edition, Pubs: PHI Learning.	2009
2	"Marketing Management", Kotler P., Keller K.L., Koshy A. and Jha M., 14th Edition, Pubs: Pearson India.	2012
3	"Marketing Concepts and Strategies", Dibb S., Simkin L., Pride W.M. and Ferrell O.C., Pubs: Cengage Learning.	2012
4	"Marketing Management", Kumar A. and Meenakshi N., 2nd Edition, Pubs: Vikas Publishing House Pvt. Ltd., Noida.	2011
5	"Marketing Management", Saxena R., 4th Edition, Pubs: McGraw Hill Education (India).	2013
6	"Marketing: Managerial Introduction", Gandhi J.C., 1st Edition, Pubs: McGraw Hill	1987

	Education.	
7	"Marketing", Etzel M.J., Walker B.J., Stanton W.J. and Pandit A., 14th Edition, Pubs: McGraw Hill Education (India).	2010
8	"Super Marketwala: Secrets to Winning Consumer India", Mall D., 1st Edition, Pubs: Random House India.	2014

Course Name	**:**	**HUMAN RESOURCE MANAGEMENT**
Course Code	**:**	**HSM 406**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objectives:
The main aim of this course is to provide an overview of HRM, keeping the Indian business scenario in the background and to acquaint the students with the strategic role of HRM in managing an organization.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO HUMAN RESOURCE MANAGEMENT** HRM: Nature, Scope, Functions, HRM Practices and Problems in India with Case Studies	**4**
2	**HUMAN RESOURCE PLANNING (HRP)** Concept and Process of HRP, Factors Affecting HRP	**3**
3	**JOB ANALYSIS AND DESIGNING** Uses and Process of Job Analysis, Job Description and Job Specification: Features and Hypothetical Formulation, Job Designing: Job Enrichment, Job Enlargement	**3**
4	**RECRUITMENT AND SELECTION** Recruitment: Sources and Methods Selection: Selection Process, Selection Tests, Types and Nature of Interviews Role Playing and Case Study on Selection Process, Tests and Interview	**4**
5	**INDUCTION AND INTERNAL MOBILITY** Induction Programme, Need and Scope of Internal Mobility: Transfer, Promotion, Demotion	**3**
6	**TRAINING AND DEVELOPMENT** Training: Need and Methods, Management Development: Need, Methods and Management Development Programme HRM Games for Development of Employees	**4**
7	**PERFORMANCE APPRAISAL AND COMPENSATION** Nature and Methods of Performance Appraisal, Hypothetical Performance Appraisal Compensation: Financial and Non-Financial Benefits	**4**
8	**EMPLOYEE HEALTH AND SAFETY** Concept, Issues related to Health and Safety, Workplace Health Hazards	**3**

Course Outcomes:	
1	The students will develop the ability to solve problems in area of HRM in organizations.
2	The students will become aware of latest developments in HRM practices which are essential for effective management in organization.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Human Resource Management: Text and Cases", Rao V.S.P., Pubs: Excel Books.	2002

2	"Human Resource Management", Dessler G. and Varkkey B., 12th Edition, Pubs: Pearson India.	2011
3	"Human Resource Management: Text and Cases", Aswathappa K., 7th Edition, Pubs: McGraw Hill Education (India).	2013
4	"Human Resource Management: Text and Cases", Gupta C.B., 14th Edition, Pubs: Sultan Chand and Sons.	2012
5	"Human Resource Management: Text and Cases", Bedi S.P.S. and Ghai R.K., Pubs: Bharti Publications.	2012
6	"Human Resource Management Applications: Cases, Exercises, Incidents and Skill Builders", Fottler M.D., McAfee R.B. and Nkomo S.M., 7th Edition, Pubs: Cengage Learning.	2013

ENGINEERING SCIENCE COURSES

Course Name	**:**	**COMPUTER PROGRAMMING (BASIC)**
Course Code	**:**	**CSN104**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:
To develop logical skills so that students should be able to solve basic computing problems. To learn the syntax and usage of C programming constructs.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO PROGRAMMING** Evolution of languages: Machine languages, Assembly languages, High-level languages. Software requirements for programming: System softwares like operating system, compiler, linker, loader; Application programs like editor. Algorithm, specification of algorithm. Flowcharts.	4
2	**PROGRAMMING IN C** Data types in C, Formatted input-output for printing integer, floating point numbers, characters and strings.	2
3	**OPERATORS AND EXPRESSION** Expressions in C and their evaluation. Precedence and associativity rules. Operators: arithmetic operators, relational operators, logical operations, bitwise operators, miscellaneous operators.	6
4	**STATEMENTS** Decision making structures: if, if-else, nested if and if-else, switch. Control structures: for, while, do-while. Role of statements like break, continue, goto.	6
5	**ARRAYS** Concept and use of arrays, declaration and usage of arrays, 2-dimensional arrays.	6
6	**FUNCTIONS** Advantage of modularizing C program into functions, function definition and function invocation. Methods of passing parameters to a function: call-by-value, call-by-reference; Passing arrays to functions, Recursion, Library functions.	4
7	**POINTERS** Pointer declaration and initialization, constant pointers, pointers to constant objects, pointer arithmetic, relationship between pointer and arrays.	4
8	**SCOPE AND LIFETIMES** Scope and lifetime of a variable, storage classes: auto and typedef.	2
	USER-DEFINED DATA TYPES Structures- definition, declaration, use, accessing structure members directly or through pointer structure, structure having arrays and pointers as members, self referential structures, passing structures to functions. Unions: definition, declaration, use, accessing union members directly or through pointer structure.	6
	FILES Concepts of files and basic file operations.	2

Course Outcomes:	
1	The student will demonstrate proficiency in C programming language.

Text Books:	
1	Let Us C, Yashwant Kanetkar, BPB Publications
2	Programming in C: A practical approach, Ajay Mittal, Pearson Education

Reference Books:

1	The C programming language, Kernighan Ritchie, Pearson Education
2	Programming in ANSI C, Balaguruswamy, Tata McRaw Hill
3	Computing Fundamentals, Peter Nortan, Tata McRaw Hill

Course Name	**:**	**COMPUTER PROGRAMMING (ADVANCED)**
Course Code	**:**	**CSN105**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:
To develop logical skills so that students should be able to solve basic computing problems. To learn the syntax and usage of C programming constructs at advanced level.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO STRUCTURED PROGRAMMING** Introduction to topics: decision making, Iteration, functions: functions with variable number of arguments, multiple file programs, concept of linking.	6
2	**ARRAYS** Array declaration and use, Two-dimensional arrays and multi-dimensional arrays. Strings and Character arrays. Operations on arrays such as insertion, searching, sorting, merging.	6
3	**POINTERS** Pointer expression, pointer arithmetic, pointer to array, pointer to functions, dynamic memory allocation, dynamic allocation of arrays. Call functions through function pointers, Accessing members of arrays through pointers.	6
4	**PREPROCESSOR DIRECTIVES** Introduction, Various preprocessor directives, macros with and without arguments, conditional compilation.	6
5	**STRUCTURE, UNION, ENUMERATION AND BIT-FIELDS** Definition, declaration and initialization, structures containing arrays, array of structures, structure having structures, pointers to structures, self-referential structures, dynamic allocation of structures; Unions: Definition, declaration and initialization. Concepts of interrupts interrupt programming, enumerations and bit-fields.	8
6	**FILES** Concept of file, file operations, text mode and binary mode, command line arguments.	4
7	**INTRODUCTION TO OBJECT ORIENTED PROGRAMMING** Classes and objects, basic features of object oriented programming like encapsulation, abstraction, polymorphism, etc.	3
8	**APPLICATIONS** Projects related to the development of Terminate and Stay resident (TSRs), graphical applications, text-editors, etc.	3

Course Outcomes:	
1	The student will demonstrate proficiency in C programming language.

Text Books:	
1	Let Us C, Yashwant Kanetkar, BPB Publications
2	Programming in C: A practical approach, Ajay Mittal, Pearson Education

Reference Books:	
1	The C programming language, Kernighan Ritchie, Pearson Education
2	Programming in ANSI C, Balaguruswamy, Tata McRaw Hill

3	Computing Fundamentals, Peter Nortan, Tata McRaw Hill

Course Name	**:**	**ENGINEERING DRAWING**
Course Code	**:**	**ESC 101**
Credits	**:**	**4**
L T P	**:**	**2-0 -4**

Course Objectives:
At the end of this course, the student should be able to understand the basic concepts of Engineering Drawing. The student should be able to visualize and draw the two and three dimensional objects. The student should also be able to apply drafting softwares in various types of problems.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	Introduction to Engg. Graphics, System of Projections, Orthographic projections, Lettering, Dimensioning rules	2
2	Projections of points and lines, Projection of lines on different planes, Traces and true length of the lines	2
3	Projections of planes/laminae on reference planes, classification of Primary and secondary planes, examples	2
4	Classification of solids, Projections of solids on the basis of positions of the axis of various solids on reference planes	3
5	Sectioning of solids, True and apparent sections, sectioning on the basis of position of section planes	3
6	Developments of surfaces, Parallel line, Radial line and Triangulation methods of development of right and oblique solids	3
7	General introduction to Perspective projection, isometric views, Isometric lines & Axes, Four centre and off set method of drawing ellipse from circle, conversion of orthographic views to isometric views and vise-versa	3
8	Introduction to AutoCAD software for drawing of 2D projections, practical exercises on points, lines, planes and solids	10

List of Experiments:		**Number of Turns**
1	Exercises on projection of Points on drawing sheets	1
2	Exercises on projection of lines on drawing sheets	1
3	Exercises on projection of planes on drawing sheets	1
4	Exercises on projection of solids on drawing sheets	2
5	Exercises on sections of solids on drawing sheets	1
6	Exercises on Developments of surfaces and Isometric projections on drawing sheets	2
7	Practice of exercises on points and lines using AutoCAD software	1
8	Practice of exercises on planes using AutoCAD software	2
9	Practice of exercises on solids and developments using AutoCAD software	2
10	Practice of exercises on isometric projections using AutoCAD software	1

Course Outcomes: At the end of this course, the students will be able to:	
1	Understand the basic concepts of Engineering Graphics.
2	Visualize the actual objects and convert them in to readable drawings.
3	Understand the drawing standards, conventions and symbols that are in common usage.
4	Draw the common Engineering drawings using available drafting softwares.
5	Come up with innovative conceptual ideas by using Drafting softwares.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Engineering Drawing", P. S. Gill, S.K. Kataria & Sons	2012
2	"Engineering Drawing", D.A. Jolhe, Tata McGraw Hill	2010
3	"Engineering Graphics with Auto CAD", James Bethune, Prentice Hall, India	2003

Course Name	**:**	**FLUID MECHANICS**	
Course Code	**:**	**ESC102**	
Credits	**:**	**4**	
L T P	**:**	**3 0 2**	

Course Objectives:
To learn the basic concept of fluid mechanics. To understand the analytical method of solving fluid mechanics problem

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Fluids, Brief history of Fluid Mechanics, Properties of Fluid, Viscosity, Capillarity, Surface Tension, Compressibility, Normal and Shear Stresses in Fluid Flows, Regimes of Flow	4
2	**FLUID STATICS** Pascal's Law of measurement of pressure, Types of forces on a fluid system, manometers and gauges, forces on partially and fully submerged bodies including that on curved surfaces, Buoyancy, stability of floating bodies, centre of gravity, Metacentric height.	**6**
3	**KINEMATICS OF FLUID FLOW** Langrangian and Eulerian methods, description of properties in a moving fluid, local and convective acceleration, Streamlines, Path lines, Streak lines, Laplace equation, Stream function, velocity potential and flownets.	**4**
4	**DYNAMICS OF FLUID FLOW** Equation of conservation of mass, differential form of continuity equation. External forces, Euler's equation of motion, Bernoulli's equation, simple application to one dimensional flow, linear momentum and angular momentum, momentum theorem, moment of momentum theorem	**8**
5	**VISCOUS FLOW** Pressure gradient in steady uniform flow, flow between parallel plates, Qualitative aspects of viscous flows, Hagen-Poiseulli's flow, Transition from laminar to turbulent flow, turbulent flow in circular pipe, Navier Stokes equation (without derivation).	**5**
6	**FLOW THROUGH PIPES** Introduction, energy and hydraulics grade line, non-dimensional formulation of the pipe flow problem, head losses in pipes & pipe fittings, pipe in series & parallel, reservoir problem.	**5**
7	**DIMENSIONAL ANALYSIS AND SIMILITUDE** Buckingham's Theorem, non-dimensional groups, Geometric, Kinematic and Dynamic Similarity, Hydraulic Models.	**4**
8	**FLOW MEASUREMENT** Venturimeter, orifice meter, Pitot tube, Orifices, mouth pieces, notches, weirs, Current meter.	**6**

List of Experiments:

1	Flow Measurement by Orifice Meter
2	Flow Measurement by Venturimeter
3	Flow Measurement by V Notche
4	Computation of various coefficients involving in through orifice.
5	Determination of friction factors of pipes Minor losses in pipes
6	Determination of friction factors of pipes
7	Verification of Bernoulli's theorem
8	To determination of the metacentric height of a given vessel under unloaded condition.

Course Outcomes:	
1	To apply the learned techniques in real life problems related to fluid mechanics.

Text Books:	
1	G.L. Asawa, "Experimental Fluid Mechanics-Volume I" Nem Chand & Brothers
2	B. S. Kapoor, "Manual of Fluid Mechanics" Khanna Publishers
3	S. Singh, "Experiments in Fluid Mechanics-Second Edition" PHI Publications

Reference Books:	
1	Frank M. White, "Fluid Mechanics", McGraw Hill.
2	H. Rouse , "Elementary Mechanics of Fluids"
3	Streeter, V.L.,"Fluid Mechanics" McGraw Hill Co
4	Lewitt, E.H.,"Hydraulics and the Mechanics of Fluids" Pitman

Course Name	**:**	**INTRODUCTION TO MANUFACTURING**
Course Code	**:**	**ESC 103**
Credits	**:**	**4**
L T P	**:**	**2-0-4**

Course Objectives:
At the end of the course the students should be able to describe the properties of engineering materials and different manufacturing processes. The students should be able to select appropriate manufacturing process and manufacture a job in the different shops and areas of applications.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Classification of manufacturing processes, classification of engineering materials, comparison of material properties of metals, ceramics and plastics, crystal structures, strain hardening effects, stress-strain curves. Safety measures in workshop.	3
2	**MATERIALS AND HEAT TREATMENT** Objective of heat treatment, classification of heat treatment, annealing, normalizing, hardening & tempering, case hardening, carburizing, nitriding, flame hardening, induction hardening, applications of heat treatment.	4
3	**FOUNDRY** Pattern, properties of pattern material, types of pattern, cores. Types of sand, moulding sand ingredients. Types of moulding processes. Types of casting processes: sand casting, shell casting, investment casting and centrifugal casting. Casting defects & remedies. Case studies and applications.	4
4	**FORMING** Metal forming, types and applications, hot & cold working, forging, drawing, rolling and sheet metal operations.	3

5	**MACHINING** Metal removal processes, machines, single-point tool, cutting tool geometry, lathe - types, elements and main parts of lathe, drilling, milling and grinding machines. Applications.	3
6	**FINISHING** Surface finishing processes, principle and applications, lapping, honing, super finishing, polishing, buffing, electroplating, galvanizing.	2
7	**WELDING** Classification of welding processes, mechanism of arc formation, arc welding processes, gas welding, and resistance welding, principles and applications, welding defects, causes and remedies. Soldering and brazing. Applications and case studies in welding.	3
8	**PLASTICS MANUFACTURING** Types and properties of plastics, thermosetting and thermoplastic resins, elastomers. Fabrications of plastics, injection moulding, blow moulding, extrusion moulding etc.	2
9	**MODERN MANUFACTURING PROCESSES** Introduction, classification, electric discharge machining (EDM), electro chemical machining (ECM), laser beam machining (LBM) and Rapid Prototyping Techniques. Case studies on modern and hybrid manufacturing processes.	2
10	**CASE STUDIES** Considerations of selecting manufacturing processes for industrial products like compact disc, PCB and emerging technological applications.	2

List of Experiments:		**Number of Turns**
1	To prepare half lap T & L joint in the carpentry shop.	1
2	To prepare the pattern of half nut in carpentry shop.	1
3	To prepare cube from a piece of round bar in forging shop.	1
4	To study the lathe, milling, planer, and shaper operations.	1
5	To manufacture a multi-operational job on lathe/milling in the machining shop.	1
6	To prepare series and parallel wiring connections in the electrical shops.	1
7	To prepare the butt joint by SMAW in welding shop.	1
8	To prepare the mould of a given pattern in foundry shop.	1
9	To cast the prepared mould in foundry shop.	1
10	To prepare a square job in the fitting shop.	1
11	To prepare rectangular box in sheet-metal shops.	1
12	To prepare different joints in the sheet-metal shop.	1

Course Outcomes: By the end of this course, the students will be able to:	
1	Compare the properties of the engineering materials.
2	Select the appropriate manufacturing process for a given job/ application.
3	Identify the advantages and limitations of different manufacturing processes.
4	
5	

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Manufacturing Engineering and Technology", Serope Kalpakjian and Steven Schmid, Pearson Publications.	2009
2	"A Textbook of Production Technology: Manufacturing Processes", P. C. Sharma, S. Chand & Company Ltd.	2004
3	"Foundry, Forming and Welding", P.N. Rao, Tata M/C Graw Hill Publication.	2007
4	DeGarmo, Materials and Processes In Manufacturing, John Wiley & Sons	2011

Course Name	**:**	**THERMODYNAMICS**
Course Code	**:**	**ESC 201**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of this course, the student should be able to, Understand the basic principles of Thermodynamics and to give students a feel for how Thermodynamics is applied in Engineering practices.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**BASIC CONCEPTS :**Macroscopic and Microscopic Approach, Concept of Continuum, Thermodynamic System, Surrounding and Boundary, Thermodynamic Equilibrium, State, Path, Process, cycle, Quasi-static Process, Reversible and Irreversible Process, Working Substance. Thermodynamic Properties like Pressure, Volume and Temperature, Zeroth Law of Thermodynamics. Temperature Scales, Concept of Heat and work in Thermodynamics.	**8**
2	**FIRST LAW OF THERMODYNAMICS:** Joule's Paddle wheel Experiment; Mechanical Equivalent of Heat, First Law for a closed system undergoing a Cycle, First Law for a closed system undergoing a change of state. Different forms of stored Energy, Enthalpy, Energy of An isolated System, Perpetual Motion Machine of First kind.	**6**
3	**FIRST LAW APPLIED TO FLOW PROCESSES:** Flow Process and Control Volume, flow work, Steady and Unsteady Flow Process, Steady Flow Energy Equation, Engineering Applications of Steady Flow Energy Equation, Throttling Process, Flow Work and Non Flow work, Variable flow Processes, Limitation of First Law.	**5**
4	**SECOND and THIRD LAW OF THERMODYNAMICS:** Qualitative Difference between Heat and Work, Thermal Reservoir, Statements of 2nd Law by Max.Planck and Claussius, Equivalence between two statements, Energy Analysis of Heat Engine, Refrigerator and Heat Pump Reversibility and Irreversibility, Causes of Irreversibility Carnot Theorem, Carnot cycle, Absolute Thermodynamic Temperature, Scale, Efficiency of the Reversible Heat Engine, Equality of Ideal Gas Temperature and Kelvin Temperature.	**8**
5	**ENTROPY**: Classius Theorem, Classius Inequality and concept of Entropy, Entropy change in an Irreversible Process, Application of Entropy Principle, Entropy Transfer with Heat Flow, Entropy generation in closed and open System, Thermodynamics Equations relating properties of System, Reversible Adiabatic work in a Steady flow System. Entropy and direction, Entropy and disorder.	**5**
6	**PROPERTIES OF GASES AND GAS MIXTURE** : Equation of state of a gas, Properties of Mixture of gases, Internal Energy, Enthalpy and Specific heat of gas, mixtures, Entropy of gas Mixtures.	**3**
7	**STEAM GENERATORS:** Classification of steam generators, Boiler mountings and accessories. Principles and operations of steam accumulators. Description of Cochran, Locomotive, Lancashire, Babcock and Wilcox boiler, Modern high pressure boilers, Characteristics and advantages of high pressure boilers.	**7**
8	**BASIC CONCEPTS :**Macroscopic and Microscopic Approach, Concept of Continuum, Thermodynamic System, Surrounding and Boundary, Thermodynamic Equilibrium, State, Path, Process, cycle, Quasi-static Process, Reversible and Irreversible Process, Working Substance. Thermodynamic Properties like Pressure, Volume and Temperature, Zeroth Law of Thermodynamics. Temperature Scales, Concept of Heat and work in Thermodynamics.	**8**
9	**FIRST LAW OF THERMODYNAMICS:** Joule's Paddle wheel Experiment; Mechanical Equivalent of Heat, First Law for a closed system undergoing a Cycle, First Law for a closed system undergoing a change of state. Different forms of stored Energy, Enthalpy, Energy of An isolated System, Perpetual Motion Machine of First kind.	**6**

Course Outcomes:	
1	A fundamental understanding of various Laws of thermodynamics and their applications.
2	Understand the efficiencies of Heat Engines and other Engineering Devices.
3	Understand the working principles and applications of various types of steam generators.

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	"Engineering Thermodynamics", Gordon Rogers & Yon Machew	2006
2	"Thermodynamics", Yunus Cengel and Mike Boles	2006
3	"Thermodynamics", Arora.	2005
4	"Engineering Thermodynamics", P.K. Nag	2010
5	"Thermo dynamics", Dr. D.S. Kumar	2012

Course Name	**:**	**ESSENTIALS OF INFORMATION TECHNOLOGY**
Course Code	**:**	**ESC202**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
The students should be able to understand the concepts of networking, RBMS, Software Engineering and Web Technology.

Total No. of Lectures – 42

Lecture wise breakup		Number of Lectures
1	**NETWORKING AND COMMUNICATION** Introduction to digital communication: Signal propagation, signal types, signal parameters, Channel effect on transmission. Physical layer characterization: Types of transmission media, physical layer interfaces. Data transmission mechanisms: Communication modes, transmission modes, synchronization, introduction to packet switching, multiplexing, error control methods. Network architectures: Introduction to computer networks, Network topologies, Types of networks: LAN, WAN, MAN, layered network model. Internet Protocols: Introduction, Transport layer protocols: TCP, UDP. Application layer protocols: DNS, SMTP, POP, IMAP. Practical aspects of networking.	**12**
2	**RELATIONAL DATABASE MANAGEMENT SYSTEM** RDBMS- data processing – the database technology – data models- ER modeling concept – notations – converting ER diagram into relational schema - Logical database design - normalization (1NF, 2NF and 3NF). SQL – DDL statements – DML statements – DCL statements - Joins - Sub queries – Views - Database design Issues – SQL fine tuning.	**10**
3	**WEB TECHNOLOGIES AND INTRODUCTION TO USER INTERFACE AND WEB TECHNOLOGIES :** web fundamentals – types web content – HTML – text formatting tags in HTML – HTML form elements - and tags - text formatting using CSS : embedded CSS, inline CSS and external CSS – JavaScript and its features.	**10**
4	**SOFTWARE ENGINEERING** Software Engineering : Definition – role of software and software crisis – SDLC models : waterfall model, incremental model and spiral model – software testing – static & dynamic testing – types testing : unit testing, integration testing, system testing, performance testing and regression testing.	**10**

Course Outcomes:

1	Document artifacts using common quality standards
2	Design simple data store using RDBMS concepts

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Thomas Powell, HTML and CSS: The complete reference, 5th Edition	2010
2	Henry F Korth, Abraham Silberschatz, "Database system concepts", Second ed., McGraw-Hill International editions, Computer Science series	2006
3	A. Tanenbaum, Computer Networks, 5th Edition	2010
4	William Stallings, Data and Computer Communications, 10th Edition	2013

Course Name	**:**	**MATERIALS SCIENCE**
Course Code	**:**	**ESC 203**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:
The student will be able to know the concepts of atomic bonding, crystal structures, imperfections, diffusion, mechanical properties, electron energy, and dislocations as related to processing and performance of engineering material

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Historical perspective, Scope of Materials Science and engineering, Geometry of crystals, Structure determination by X-Ray Diffraction, Atomic structure and chemical bonding, Structure of solids	10
2	**IMPERFECTIONS IN ATOMIC AND IONIC ARRANGEMENTS** Point defects, Dislocations, Significance of Dislocations, Influence of Crystal structure, Surface defects, Importance of defects	4
3	**PHASE DIAGRAMS** Phase rule, Single component systems, Binary Phase diagrams, Microstructural changes during cooling, The lever rule, Some typical phase diagrams, Other applications of Phase diagrams	4
4	**DIFFUSION IN SOLIDS** Applications of Diffusion, Stability of atoms and ions, Mechanism for Diffusion, Activation energy for Diffusion, Rate of Diffusion (Fick's First Law), Factors affecting Diffusion, Composition Profile (Fick's Second Law), Diffusion and Materials Processing	4
5	**SOLIDIFICATION** Nucleation, Applications of Controlled Nucleation, Growth mechanisms, Solidification time and Dendrite size, Cast structure, Solidification defects, Solidification of Polymers and Inorganic glasses	4
6	**ELASTIC, ANELASTIC AND VISCOELASTIC BEHAVIOUR** Atomic model of elastic behaviour, The modulus as a parameter in design, Rubber-like elasticity, Relaxation processes, Spring-Dashpot model	4
7	**MECHANICAL BEHAVIOUR OF MATERIALS** Plastic deformations and creep in crystalline materials, Fracture	4
8	**ELECTRONIC AND MAGNETIC BEHAVIOUR OF MATERIALS** Conductivity of metals and alloys, Superconductivity, Semiconductors and their applications, Insulators and Dielectrics, Classification of magnetic materials, Magnetization,	4

	Permeability and magnetic field, Applications of magnetic materials	
9	**OVERVIEW OF MATERIALS** Metals, Ceramics, polymers and composites	4

Course Outcomes:	
1	The student will be able to develop structure-processing-properties co-relationsof materials.
2	The student will be able to describe various phenomena based on the concepts of solidification, Diffusion, mechanical behaviour of materials and compare characteristics of different types of materials such as metals, ceramics, polymers and composite

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Materials Science and Engineering-A First course/ V Raghavan/PHI	2013
2	Materials Science and Engineering, an Introduction/William D. Callister/ John Willey and Sons Inc. Singapore.	2007
3	Principles of Materials Science and Engineering/William Fortune Smith/TataMcGraw- Hill	1990
4	The Science and Engineering of Materials, Donald R Askeland&Pradeep P Phule/ Cengage Learning	2006

Course Name	**:**	**SOLID MECHANICS**
Course Code	**:**	**ESC 204**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
At the end of this course the student will be able to understand the basic concepts of behavior of the materials and analysis the basic structural elements like beams, columns, trusses and circular shafts. The student will be able to apply this knowledge for the design of various civil engineering structures.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**PROPERTIES OF MATERIALS** Introduction, uni-axial tension test, idealized stress- strain diagrams, isotropic, linear, elastic, visco-elastic and plastic materials, compression test, impact test, fatigue test, torsion and bending test.	4
2	**SIMPLE STRESSES & STRAINS** Concept of stresses and strains, relationship between elastic constants, extension of uniform bar & tapered bar under its own weight and due to load applied, stresses produced in compound bars due to axial loads, thermal stresses,	4
3	**COMPOUND STRESSES:** General state of stress, resultant stress and strain circle, prinicipal stresses and principal strains, Mohercircle for compound stresses and strais	4
4	**SHEAR FORCE AND BENDING MOMENT IN BEAMS** Shear force, bending moment, Relation between load, SF and BM, SFD , BMD and axial force diagram for determinate beams under various types of loading.	6
5	**BENDING AND SHEAR STRESSES IN BEAMS** Pure bending ,bending stresses, eccentric loading combined bending and direct stresses , Middle Third rule, composite beams, Variation of shear stresses for various cross-sections of a beam.	5

6	**ANALYSIS OF PLANE TRUSSES** Different types of trusses, Analysis of plane trusses by method of joints and method of sections.	5
7	**TORSION** Torsion equation for circular shaft , shafts under action of varying torque, torsion of composite shafts.	4
8	**COLUMNS & STRUTS** Criteria for stability of columns, Buckling of columns, Euler's theory for various end restraints, Rankine's formula, eccentrically loaded struts, struts with initial curvature, struts with lateral loading.	5
9	**DEFLECTION OF BEAMS** Slope and Deflection in beams by double integration method, Macaulay's method, Moment area method under the action of various loading conditions; slope and deflection in built in and propped beams.	5

Course Outcomes: By the end of this course the student will be able to:	
1	Analysis the simple civil engineering structures under different loading conditions.
2	Understand the behaviour of basic structural elements.
3	Apply this knowledge for the design of various civil engineering structures.
4	
5	

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"An introduction to the Mechanics of Solids", Crandall & Dahi, McGrawHill.	1978
2	"Strength of Material", G.H. Ryder, MacMillan.	2002
3	"Mechanics of Solids", E.P. Popov, Pearson Education.	1978
4	"Mechanics of Materials", E.J. Hearn, Elsevier Publications.	2001
5	"Mechanics of Materials", Punmia and Jain, Laxmi Publications (P) Ltd.	2013
6	"Mechanics of Materials", R.C.Hibbeler, Pearson Higher education.	2013
7	"Strength of Materials", S. Ramammurtham and R. Narayanan, Dhanpat Rai Publishing Comp	2014

Course Name	**:**	**INTRODUCTION TO ELECTRONICS**
Course Code	**:**	**ESC 205**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:

At the end of this course, the student should be able to

1. Identify active and passive components and to solve simple electronic circuits.
2. Explain the fundamental concepts of basic semiconductor devices & digital electronics.
3. Describe the basic principle of operational amplifier along with its applications, A/D, D/A conversion and architecture of 8085 microprocessor.
4. Define the communication system and list the various modulation techniques.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO ELECTRONICS:** Need and application of electronics in different areas, Basic elements of electronic system (Active and Passive elements, Sources,	3

	Dependent Sources), KVL and KCL	
2	**SEMICONDUCTOR DEVICES:** Concept of active and passive devices, Semiconductor Devices: Structure, principle of operation, characteristics and applications of PN-Junction (Rectifier, Clipper and Clamper), BJT, Current Components in BJT, Input & Output characteristics Common Emitter (CE), Common Base (CB), Common Collector (CC) configurations, BJT as an amplifier, Construction, working principle and characteristics of FET and MOSFET, Concept of feedback amplifier, Barkhuasen criteria, Oscillators, 555 timer as multivibrator, Four layer devices- SCR, DIAC and TRIAC (Construction, operation and characteristics)	15
3	**DIGITAL PRINCIPLES:** Digital waveforms, digital logic, moving and storing digital information, digital operations, digital integrated circuits	3
4	**OPERATIONAL AMPLIFIER AND ITS APPLICATIONS:** Block diagram, characteristics, inverting and non inverting configurations, Opamp as summing amplifier, difference amplifier, integrator, differentiator	5
5	**A/D AND D/A CONVERTERS:** Basic principle and characteristics, Weighted resistor D/A converter, Binary ladder D/A converter, counter ramp type A/D Converter	4
6	**INTRODUCTION TO MICROPROCESSOR:** Pin diagram, Architecture of 8085 Microprocessor, Concept of Microcontroller and its applications	3
7	**COMMUNICATION SYSTEMS**: Introduction to communication system, communication time line, Various frequency bands used for communication, Block diagram of Analog and Digital communication, need of modulation, Analog modulation techniques (Amplitude and frequency), Digital modulation techniques (PCM,PWM,PPM, PAM, ASK,FSK,PSK, QAM), Introduction to advanced communication systems (Optical and wireless).	9

Course Outcomes: By the end of the course the students will be able to	
1	Identify the various electronic devices and predict their behavior in an electronic system.
2	Draw the architecture of Microprocessor.
3	Differentiate between various modulation techniques in a communication system and relate them to practical systems.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Electronics Devices & Circuit Theory, RL Boylestead & L Nashelsky (PHI)	2009
2	Digital principles & applications, Malvino Leach, TMH	2011
3	Microprocessor Architecture programming and Applications with 8085 by R Gaonkar, Penram International Publishing Pvt ltd.	2002
4	Circuits and Networks: Analysis and Synthesis, Sudhakar and ShyamMohan, TMH	2009
5	Electronic Communication Systems by G. Kennedy, Mc Graw Hill, 4th Edition	2008
6	Electronic Communications, 4th Edition, Roddy & Coolen.	2009

Course Name	**:**	**BASIC ELECTRICAL SCIENCES**
Course Code	**:**	**ESC 206**
Credits	**:**	**04**
L T P	**:**	**3- 0-2**

Course Objectives:

At the end of this course, the student should be able to acquire knowledge of analytical techniques to solve electrical circuits, basic electrical machines, and electrical measuring instruments.

Total No. of Lectures – 42

Lecture wise breakup		Number of Lectures
1	**BASIC DEFINITIONS AND NETWORK THEOREMS** Basic definitions of voltage, current, power and energy. Nodes, branches, loops, mesh, Kirchhoff 's laws, nodal & mesh analysis. Circuit theorems: linearity, superposition, Norton, thevenin, max power transfer.	8
2	**AC CIRCUITS** Introduction, Generation of alternating voltage, sinusoidal waveform, phasor diagram, power relations in AC circuits, single phase AC circuits, Steady State Analysis: Nodal and Mesh analysis, Thevenin's, Norton's, Maximum Power Transfer theorems. AC Power Analysis: Instantaneous and average power, max average power transfer, RMS value, apparent power and power factor, complex power, conservation of AC power. THREE PHASE CIRCUITS**:** Phase sequence, Star and delta connection, Relation between line and phase voltages and currents in balanced systems, Analysis of balanced and Unbalanced three phase circuits, Measurement of active and reactive power.	10
3	**MAGNETICALLY COUPLED CIRCUITS** Mutual Inductance, Energy in a coupled circuit. Transformer : construction, equivalent circuit, voltage regulation, efficiency, OC and SC tests.	5
4	**DC MACHINES** Construction, emf and torque equations, circuit model, methods of excitation, characteristics of generators and motors, starting and speed control of dc motors, starters, losses, efficiency.	5
5	**AC MACHINES** Rotating magnetic field theory, three phase induction machines: General construction features, per phase equivalent circuit, approximate equivalent circuit, production of torque, slip, torque speed characteristics, no load and blocked rotor test to determine performance parameters, Starting: rotor rheostat starter, reduced voltage starting, star delta starting, centrifugal start. Synchronous motors: types, salient pole and cylindrical rotor, emf equation. Principle of operation of single phase induction motor, types and applications.	10
6	**BASIC MEASURING INSTRUMENTS** Introduction, Classification of instruments, essential features and operating principles, moving coil and moving iron instruments.	4

List of Experiments:		Number of Turns
1	Verification KCL and KVL	01
2	Verification of Ohm's Law	01
3	Verification of the principle of , superposition with ac and dc sources	01
4	Verification of Thevenin, and Nortan theorems.	01
5	Verification of maximum power transfer theorem in dc circuit.	01
6	To study resonance in series and parallel RLC circuits and plot various responses.	01
7	To verify the line voltage and phase voltage , and line current and phase current relationship in a star and delta three phase balanced circuit.	01
8	Measurement of active and reactive power in single-phase ac circuit.	01
9	To perform open and short circuit test on a 1-phase transformer and determine its equivalent circuit and efficiency	01
10	To study dc machine and determine open circuit characteristic.	02
11	To perform open circuit test and block rotor test on a 3 phase IM to draw equivalent circuit.	01
12	To perform load test on D.C. shunt motor.	01

Course Outcomes: By the end of this course, the student will be able to:	
1	Apply different techniques to solve electrical circuits.
2	Acquire the knowledge of electrical machines and electrical measuring instruments.
3	Design and conduct experiments, as well as analyze and interpret data.

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Fundamentals of Electric Circuits by Charles K Alexander and Matthew N O Sadiku, Mc Graw Hill Higher Education, 5th edition, ISBN 0073380571.	2012
2	Network Analysis & Synthesis by FF Kuo, Wiley International	1966
3	Electric Machinery and Transformers by Bhag S Guru & Huseyin R Hiziroglu, Oxford University Press, ISBN 0195138902.	1988
4	Semiconductor Physics and Devices: Basic Principles by Donald A Neamen, Irwin Professional Publishing, 3rd Revised edition, ISBN 0256242143	2006

Course Name	**:**	**MECHATRONICS**
Course Code	**:**	**ESC 207**
Credits	**:**	**04**
L T P	**:**	**3-1-0**

Course Objectives:

At the end of this course the student should be able to have basic knowledge of mechatronics and its interdisciplinary applications i.e. integration of Mechanical engineering with Electrical& Electronics Engineering and Computer Technology. He should be able to design and conduct experiments as well as to analyze and interpret data.

Total No. of Lectures – 42

Lecture wise breakup		Number of Lectures
1	**INTRODUCTION TO MECHATRONICS** Understanding Mechatronics. Key Elements of Mechatronics, Components of Mechatronics ,Human Being and Mechatronic System, Conventional and Mechatronic Approach, Advantages of Mechatronic Systems. Definition of System, Classification of System, Mechanistic System, Mechatronic System Intelligence.	04
2	**SENSOR AND TRANSDUCERS: PRINCIPLES AND APPLICATIONS** Role of Sensors and transducers in Mechatronics System , selection of sensors based on performance characteristics, static and dynamic characteristics); calibration; types of sensors , resistive transducers, inductive ,capacitive ,optical , thermal Transducer and their applications ,Measurement of : linear , angular position, displacement, rotational speed, force, pressure, strain, flow rate, temperature etc..	08
3	**SIGNAL CONDITIONING DEVICES** Role of signal conditioning **Processes** and devices in mechatronics, passive elements (RLC), semiconductors devices (PN junction diodes, AC rectification, Zener diode, Power supplies, transistors, Transistor (common emitter characteristics, emitter, follower circuit, FET); thyristor, TRIAC,DIAC, operational amplifiers (inverting, unity gain, non-inverting, C/V and V/C amplifiers, differential amplifier, instrumentation amplifier).Filters types of filters. **SIGNAL CONVERTING DEVICES**: Digital to analog converter (DAC) and Analog to Digital Converter (ADC), multiplexer.	09
4	**DIGITAL ELECTRONICS** Boolean algebra; digital electronic gates; combination logic systems (simple gates, NAND and NOR gates, latches, positive and negative logic, tri-state logic); sequential logic systems (J-K flip-flop, registers and counter, timers and pulse circuits).	05
5	**MICROPROCESSORS , MICROCONTROLLERS AND PLC'S** Fundamentals of microprocessor , the 8085, concept of interfacing memory, input /output devices , fundamentals of Microcontroller, T he 8051, PLC Hardware, PLC Memory structure, application	07

6	**ACTUATORS** Role of actuators in mechatronics, types of actuators, electrical actuators Physical principles; solenoid-type devices; DC machines; AC machines; stepper motors .Drive Technology Applications: Linear motors; voice coil motors; electro-pneumatic and electro-hydraulic actuators. Mechanical actuators :Rotary to linear motion conversion; power transmission, Electromechanical System Applications, Coupling, gearing, belts, pulleys, bearings.	07
7	**CASE STUDIES** Washing Machines, auto focusing camera, pick and place robot.	02

List of Experiments:		**Number of Turns**
1	To study various types of Resistors, Inductors, Capacitors, Diodes, Transistors, LED.	01
2	To study CRO, Function generator, Power Supply.	01
3	To study various components of Induction Machine and Synchronous Machine	01
4	To study various components of DC Machines and Transformers.	01
5	To obtain output voltage waveforms of half wave and full wave uncontrolled rectifier with and without filter capacitor.	02
6	To design a voltage regulator using Zener Diode and analyze the performance of the regulator for various loads. Also compare the performance with a linear voltage regulator.	02
7	To verify truth-tables of various flip-flops (J-K, D, Toggle etc.)	01
8	To study the characteristics of LVDT using linear displacement trainer Kit & compare with ideal characteristics.	01
9	To measure the strain of the metal strip using strain gauge trainer kit & compare with ideal characteristics.	01
10	To measure the angular displacement of resistive & capacitive transducer using angular displacement trainer kit & compare with ideal characteristics.	01
11	To obtain the characteristics of RTD, Thermistor, thermocouple with hot and cold junction thermal trainer kit & compare with ideal characteristics.	01

Course Outcomes: By the end of this course, the student will be able to:	
1	Students were able to have basic knowledge of mechatronics and its interdisciplinary applications i.e. integration of Mechanical engineering with Electronics
2	Students were able to design and conduct experiments

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Mechatronics, fourth edition, by W Bolton. ISBN 978-81-317-3253-3	2013
2	Dan Necsulescu Mechatronics published by Pearson Education (Singapore) Pvt. Ltd., Indian Branch, 482 FIE, Patparganj, Delhi India.	2001
3	Book by H M T Limited, Mechatronics Tata McGraw Hill Publishing Company Limited, New Delhi.	1988
4	Mechatronics Principles, Concepts & Applications by Nitaigour P Mahalik published by TMH	2003

Course Name	**:**	**MECHANICAL ENGINEERING DRAWING**
Course Code	**:**	**ESC**
Credits	**:**	**4**
L T P	**:**	**2-0-4**

Course Objectives:

At the end of this course, the student should be able to visualize objects and their graphical representations, understand the various engineering drawing symbols, conventions and other requirements of assembly and dis-assembly of mechanical engineering parts and materials and should be able to draw clear and understandable production drawings.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO ENGINEERING GRAPHICS:** System of Projections. Technical lettering. Drawing conventions, Orthographic projections. 3-views. Projection of oblique areas. Circular features. Dimensioning, Rules of dimensioning.	3
2	**ISOMETRIC PROJECTIONS:** General introduction to Isometric Projections. Conversion from orthographic to isometric projections and vice-versa. Freehand sketching.	3
3	Projections of Points, Lines and Planes. Geometrical Constructions.	5
4	Projection of Solids, sectioning. Auxiliary planes and views.	3
5	**REQUIREMENTS OF MECHANICAL ENGINEERING DRAWINGS:** Conventional representation, Layout of drawing sheet, symbols of standard tolerances, machining symbols. Introduction and familiarization of the code IS:296.	3
6	**FASTENERS:** Temporary and Permanent fasteners. Various types of screw threads, nuts and bolts, screws, welding joints and riveted joints.	3
7	**INTRODUCTION TO AUTOCAD:** Basic commands and features, simple exercises of points, lines, planes and solids on AutoCAD.	3
8	**ASSEMBLY AND DIS-ASSEMBLY DRAWING EXERCISES ON SOME OF THE FOLLOWING USING DRAWING SHEETS AS WELL AS AUTOCAD:** Couplings, Clutches, Knuckle and cotter joints, Pipe and pipe fittings, IC engine parts, Machine tool parts, Bearings, Screw Jack, Drill press vice.	5

List of Experiments:		**Number of Turns**
1	Drawing exercises on lettering, dimensioning, points, lines and planes	3
2	Drawing exercises on solids, sectioning and auxiliary planes	3
3	Drawing exercises on isometric and orthographic projections	2
4	Introduction to AutoCAD, familiarization with basic commands and features	2
5	Simple exercises of points, lines, planes, solids and sectioning of solids on AutoCAD	2
6	Drawing of machine parts on AutoCAD	2

Course Outcomes: By the end of this course, student will be able to	
1	Have knowledge of drawing symbols, conventions and methods of graphical representations.
2	Understand various machine components, their working and functions.
3	Able to read and understand mechanical engineering drawings.
4	Have working knowledge of the drafting package AutoCAD.
5	Able to understand and draw mechanical engineering drawings on AutoCAD.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Engineering Drawing by R. K. Dhawan	2012
2	Machine Drawing by R. K. Dhawan	2012
3	Engineering Drawing by P. S. Gill	2013
4	Machine Drawing by P. S. Gill	2013
5	Fundamentals of Engineering Drawing by Luzadder and Duff	2009
6	Engineering Graphics with AutoCAD by James D. Bethune	2011

TECHNICAL COMMUNICATION

Course Name	**:**	**TECHNICAL COMMUNICATION**
Course Code	**:**	**XXX-205**
Credits	**:**	**2**
L T P	**:**	**0-0-3**

Course Objectives:
At the end of the course the students should be able to effectively communicate as per their professional requirements.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	Need for Effective Communication, Overview of Technical and Professional communication	**3**
2	Listening Skills, Reading Skills, Writing Skills	**3**
3	Writing Letters, Official E-mails, Job Applications, Resumes, Cover Letters, Notes. Case Studies	**6**
4	Overview of Research Writing. Information Gathering; Using the Library and Internet Modes, Organizing and Presenting According to Audience and Purpose. Writing Research Proposals, Project Technical Report/ Dissertation/Theses Writing. Case Studies.	**12**
5	Presentation Skills, Interview Skills, Group Discussion skills, Case Studies.	**9**
6	Technology Based Communication- Use of Visuals and Audio to Communicate Effectively.	**3**
7	Ethics, Attitude and Team Communication	**3**
8	Social Media/ Online Communication, Public Speaking; Developing an Authorial Voice	**3**

Course Outcomes: By the end of this course the student will be able to	
1	Develop effective technical communication.
2	Write technical documents in a professional manner.
3	Present professional requirements in an effective manner

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Meenakshi Raman and Sangeeta Sharma, "Fundamentals of Technical Communication", Oxford University Press, India	2014
2	Barun K Mitra, "Effective Technical Communication- A Guide for Scientists and Engineers" ,Oxford University Press, India	2006
3	David f Beer and David McMurrey, " Guide to Writing as an Engineer" ,2nd ed., Wiley	2004
4	Diane Hacker, " Pocket Style Manual", Bedford/St martin's.	2003

Course Name	**:**	**OPERATIONS RESEARCH**
Course Code	**:**	**MAN 401**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
At the end of this course , the students should be able to describe the need of Operations Research, develop the ability to form Mathematical models of Optimization problems, identify and solve linear models of Optimization problems, apply and to describe the limitations of classical methods to solve non-linear models of Optimization problems, apply and to describe the limitations of The Transportation Model ,Decision theory, Queuing Model.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	Development of Operations Research, Definition of Operations Research, Characteristics of Operations Research, Scientific method in Operations Research, Necessity of Operations Research in industry, Scope of Operations Research	6
2	Formulation of Linear Programming problem , Graphical Solution, Simplex Method, Unrestricted variables, Artificial variables, M-Method, Dual Phase method	12
3	Introduction to the Transportation model, Assumption in the Transportation Model, Definition of the Transportation Model, Matrix terminology, Formulation and solution of Transportation Model	6
4	Decision theory, Steps in Decision theory approach, Decision making environments, Decision making under conditions of certainty, Decision making under conditions of uncertainty, Decision making under conditions of risk, Maximum likelihood criterion	6
5	Queuing Model, Introduction, Application of Queuing Model, Elements of Queuing System, Operating characteristics of Queuing System, Waiting time and idle time costs.	6
6	Non – Linear Programming, Introduction , Local and Global optimum, Concave and Convex functions, Types of non-linear programming problems.	6

Course Outcomes: By the end of this course, the students will be able to :	
1	Form Mathematical model of Optimization problems
2	Distinguish between linear and non-linear models
3	Solve simple problems of The Transportation Model
4	Solve simple problems of Decision theory
5	Solve simple problems of Queuing Model

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Operations Research" , Ravindran , Phillips , and Solberg , 2nd edition, John Wiley & sons .	2000
2	"Engineering Optimization" , S S Rao , 3nd edition, New Age .	2000
3	"Operations Research", Kantiswarup, Gupta P.K. & Sultan Chand & Sons .	2007
4	"Operations Research", Sharma S.D., Kedarnath, Ramnath & Company .	1994
5	"Operations Research", Bronson R, Shaum's Outline Series .	1997

Course Name	**:**	**OPTIMIZATION TECHNIQUES**
Course Code	**:**	**MAN 402**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of this course, the student shoule be able to describe the need of Optimization Techniques , develop the ability to form mathematical model of optimization problems , identify and solve linear models of optimization problems , apply and to describe the limitations of classical methods to solve nonlinear models for optimization problems , apply and to describe the limitations of gradient based and direct iterative methods to solve nonlinear problems.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**LINEAR PROGRAMMING** Formulation, Graphical solution, Simplex method , Relation between Graphical and Simplex method, Unrestricted variables, Artificial variables, M-Method and Dual Phase method	**(14)**
2	**OPTIMIZATION TECHNIQUES** **UNCONSTRAINED PROBLEMS -** (Single and multivariable optimization) Necessary and sufficient conditions for extreme points **CONSTRAINED PROBLEMS - (**multivariable optimization) Equality constraints , Jacobian and Lagrangean methods , Application of Jacobian method to linear problems	**(12)**
3	**NON-LINEAR PROGRAMMING PROBLEMS** Geometric Programming **UNCONSTRAINED ALGORITHMS –** Direct methods, Dichotomous and Golden search ; Univariate and Hooke and Jeeves search methods ; Gradient methods , Cauchy's steepest ascent method and Newton's method.	**(12)**
4	**PROGRAMMING TECHNIQUES** Separable programming ,Geometric Programming	**(4)**

Course Outcomes:	
1	Form mathematical model of optimization problems
2	Distinguish between linear and nonlinear models .
3	Solve simple problems using classical / iterative methods .

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Operations Research , Ravindran , Phillips , and Solberg, 2nd edition 2000 , John Wiley & sons .	2000
2	Operations Research by Hamady Taha, 8th edition	
3	Engineering Optimization , S S Rao , 3rd edition 2000 , New Age .	2000
4	Operations Research 9th Edition, Kantiswarup, Gupta P.K. & Sultan Chand & Sons .	
5	Operations Research 8th Edition, Sharma S.D., Kedarnath, Ramnath & Company .	
6	Operations Research 2nd Edition, Bronson R, Shaum's Outline Series .	
7	P. Sankara Iyer, "Operations Research", Tata McGraw-Hill, 2008.	2008
8	J K Sharma., "Operations Research Theory & Applications , 3e", Macmillan India Ltd, 2007	2007
9	P. K. Gupta and D. S. Hira, "Operations Research", S. Chand & co., 2007.	2007

Course Name	**:**	**ADVANCED PHYSICS**
Course Code	**:**	**PYN-401**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
At the end of this course the students should be able to describe and implement concepts and principles of Quantum Mechanics required for in depth understanding of Physical phenomena of materials in relation to applications in Engineering. The students should be able to solve numerical problems in Nuclear and Solid State physics.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	Quantum theory of light, X-rays - production, spectrum & diffraction(Bragg's Law), photoelectric effect, compton effect, pair production, photons & gravity, black holes, de-Broglie hypothesis, particle diffraction, uncertainty principle and applications. Postulates of quantum mechanics, Schrodinger theory, time-dependent and time-independent Schrodinger equation, wave function, Born interpretation and normalization, expectation values.	10
2	Particle in a box (infinite well potential), finite potential step and barrier problems, tunneling, linear harmonic oscillator (one-dimensional). Hydrogen atom, radiative transitions and selection rules, electron spin, Stern-Gerlach experiment, Spin-orbit coupling, exclusion principle, symmetric and anti-symmetric wave functions. Alpha decay, Zeeman Effect, Correspondence Principle, Angular Momentum in Quantum Mechanics.	10
3	Natural radioactivity, successive radioactive transformations, radioactive equilibrium, radioactive series, radiometric dating. Nuclear force and its characteristics, Elementary description of shell model, explanation of magic numbers, liquid drop model and semi-empirical binding energy formula. Nuclear fission, fission products, mass and energy distribution of fission products, neutron emission and energy distribution of neutrons emitted in fission, theory of fission process, nuclear reactors - classification, neutron cycle in thermal reactors and four-factor formula for neutron reproduction, nuclear fission - controlled thermonuclear reactions. Artificial radioactivity and its application, Beta-decay (energy spectrum & discovery of neutrino), fusion reactions in stars.	10
4	Band theory of solids, Kronig-Penney Model (qualitative), conductors, insulators and semiconductors, p-type and n-type semiconductors, statistics of electrons and holes, Hall effect (for single as well as both type of charge carriers).	6
5	Occurrence of superconductivity, destruction of superconductivity, Meissner effect, type I and type II superconductors, heat capacity, isotope effect, thermodynamical considerations, London equations & penetration depth, coherence length, BCS theory (elementary description), applications of superconductors. High temperature superconductivity, Josephson junctions.	6

Course Outcomes: By the end of this course:	
1	Students will be able to solve numerical problems in Quantum Mechanics, Nuclear and Solid State Physics.
2	Students will be aware of latest developments in certain areas of Physics like condensed matter physics, superconductivity etc. which have important applications for societal needs.
3	Students will be able to correlate the various phenomena with quantum mechanical concepts.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Concepts of Modern Physics", Arthur Beiser, McGraw Hill Education (India) Pvt. Ltd., New Delhi.	2013
2	"Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles", Robert Eisberg and Robert Resnick, Wiley India Pvt. Ltd., New Delhi	2013

3	"Introductary Nuclear Physics", Kenneth S Krane, Wiley India Pvt. Ltd., New Delhi	2014
4	"Modern Physics", J. Bernstein, P.M. Fishbane and S.G. Gasiorowicz, Pearson, Education India Pvt. Ltd., New Delhi	2009

Course Name	**:**	**CRYSTAL PHYSICS**
Course Code	**:**	**PYN-402**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
During this course students will understand basics of crystal structure and correlate the same with different material properties. They will be able to describe the concepts of lattice dynamics and crystal binding forces and correlate the same with thermal properties.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**CRYSTAL STRUCTURES** - Periodic array of atoms, Lattice, basis, primitive cell, two and three dimensional lattice types, miller indices, examples of crystal structures (NaCl, CsCl structures), Hexagonal closed packed, diamond, zinc sulfide structures, x-ray diffraction of crystal, Bragg's Law, reciprocal lattice, diffraction condition, Laue equation, structure factor, atomic form factor.	12
2	**CRYSTAL BINDING** - van der waals interaction, repulsive interaction, equilibrium lattice constant, cohesive energy, ionic crystals, covalent crystals, electrostatic energy, Madelung constant.	10
3	**PHONONS AND CRYSTAL VIBRATIONS** - monoatomic basis, first Brillouin zone, dispersion relation, two atoms per primitive basis, quantization of elastic waves, phonon momentum, inelastic scattering by phonon.	10
4	**THERMAL PROPERTIES** - phonon heat capacity, density of states, Einstein model, Debye model of heat capacity, inharmonic crystal interaction, thermal expansion. Thermal conductivity, Umklapp Processes.	10

Course Outcomes: By the end of the course	
1	Students will be able to solve the problems based on crystal structure and thermal properties of solids
2	Understand and apply the basic concepts of crystal binding and crystal vibrations in different phenomena.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Introduction to Solid State Physics", Charles Kittel, Wiley India Pvt. Ltd., New Delhi	2012
2	"Solid State Physics", S.O. Pillai, New Age International (P) Limited, New Delhi	2010
3	"Crystallography Applied to Solid State Physics", Verma and Srivastava, New Age International (P) Limited, New Delhi	2012

Course Name	**:**	**SOLID STATE PHYSICS**
Course Code	**:**	**PYN-403**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
During this course students will understand basics of free electron theory. They will study the origin of energy gaps on the basis of quantum mechanics approach. They will cover advance topics in dielectrics. Superconductivity will also be covered and student's interest will be created in possibility of high temperature superconductivity.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	Free electron theory, energy levels in one dimension, free electron gas in three dimension, heat capacity of electron gas, electrical conductivity and ohm's law, experimental electrical resistivity of metals, Hall Effect.	12
2	Energy bands, origin of energy gap, bloch functions, Kronig-Penny model, brillouin zones, metals and insulators.	10
3	Dielectric function of the electron gas, plasma optics, dispersion relation of electromagnetic wave, transverse optical modes in plasma, longitudinal plasma oscillations, polaritons, electron-phonon interaction polarons, optical processes and excitons.	12
4	Occurrence of superconductivity, destruction of superconductivity, Meissner effect, type I and type II superconductors, heat capacity, isotope effect, thermodynamical considerations, London equations & penetration depth, coherence length, BCS theory (elementary description), applications of superconductors. High temperature superconductivity, Josephson junctions.	8

Course Outcomes: By the end of the course, student will be able to	
1	Solve the problems based on free electron theory and band theory of solids.
2	Understand and apply the basic concepts of plasma optics and superconductivity in different phenomena.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Introduction to Solid State Physics", Charles Kittel, Wiley India Pvt. Ltd., New Delhi	2012
2	"Solid State Physics", S.O. Pillai, New Age International (P) Limited, New Delhi	2010
3	"Crystallography Applied to Solid State Physics", Verma and Srivastava, New Age International (P) Limited, New Delhi	2012

Course Name	**:**	**MODERN INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS**
Course Code	**:**	**CHN 401**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
At the end of this course, the student should be able to introduce the principles of chemical analysis, matrix effects, detailed instrumentation, operation and interpretation of data, error analysis and statistical methods of data handling.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**SPECTROSCOPIC TECHNIQUES:** UV – Visible, Infra red, NMR, and Mass Spectroscopy-Principles Instrumentation and Applications	10
2	**ATOMIC ABSORPTION SPECTROMETRY AND EMISSION SPECTROMETRY:** Inductively coupled plasma atomic emission spectroscopy (ICP-AES) - Principles	8

	Instrumentation and Applications	
3	**OPTICAL MICROSCOPY**: Scanning Electron Microscopy (SEM),Transmission Electron Microscopy (TEM) and Scanning Transmission Electron Microcopy (STEM) -Principles and Applications	6
4	**X-RAY TECHNIQUES**: XRD, XRF, XPS-Principles and Applications	8
5	**THERMAL ANALYSIS**: DTA, TGA- Principles Instrumentation and Applications	5
6	**CHROMATOGRAPHIC ANALYSIS**: GC, HPLC- Principles Instrumentation and Applications	5

Course Outcomes: By the end of this course, the student will be able to:	
1	Handle the analysis of mg, ppm and ppb levels of analyte by appropriate instrumental methods.
2	Carry out Chemical analysis of hazardous materials, environmental samples, inorganic, organic and biomaterials at trace and ultra trace quantities.
3	Differentiate among molecular absorption, atomic absorption and atomic emission spectrometry.
4	Carry out hands on experiments in the field related to analysis of materials required for technological developments and in advanced research in Engineering.
5	Differentiate between classical and instrumental methods of Chemical analysis.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Interpretation of Mass Spectra", McLafferty F.W., 3rd Edition, Pubs: W.A. Benzamine, New York.	1993
2	"Spectrometric Identification of Organic Compounds", Silverstein R.M. and Bassler G.S., 5th Edition, Pubs: John Wiley.	1991
3	"Instrumental Analysis", Willard H.H., Merritt L.L. and Dean J.A., 7th Edition, Pubs: Van Nostran Reinhold.	1998
4	"Instrumental Analysis", Skooq D.A. Holler F. J. and Crouch S. R., Pubs: Brooks/Cole.	2007
5	"Analytical Chemistry", Christian G.D., 5th Edition, Pubs: John Wiley.	1994
6	"X-ray structure determination a practical guide", Stout G.H. and Jeansen L.H., Pubs: John Wiley & Sons, New York.	1989
7	"Crystal structure analysis for chemists and biologists", Glusker J.P., Lewis M, Pubs: VCH Publisher inc., New York.	1994
8	"Structure Determination by X-ray crystallography", Ladd, M.F.C. and Palmer R.A., Pubs: Plenum Press, New York.	1994

Course Name	**:**	**PRINCIPLES OF MANAGEMENT**
Course Code	**:**	**HSM 401**
Credits	**:**	**4**
L T P	**:**	**2-2-0**

Course Objectives:

The main aim of this course is to make students understand the management process and principles along with its application in practical life and to help them manage different jobs and situations with the help of management functions.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO MANAGEMENT** Nature of Management: Art or Science, Principles and Functions of Management	**3**
2	**EVOLUTION OF MANAGEMENT THOUGHT** Classical Theories: Bureaucratic, Scientific and Administrative Approach	**6**

	Neo-Classical Theories: Human Relations and Human Behaviour Approach Modern Theories of Management Relevance of Management Thought in present scenario – Management Cases	
3	**PLANNING** Nature of Planning, Planning Process, Application of Planning Process in a Hypothetical Situation, Types of Planning, Types of Plans, Management by Objective (MBO)	**4**
4	**ORGANIZING** Concept of Organization, Departmentation, Forms of Organization Structure Analysis of Organization Structure – Case Studies Hypothetical Formation of an Organization	**4**
5	**STAFFING** Human Resource Planning: HRP Process, Job Analysis: Job Description, Job Specifications and Used of Job Analysis Recruitment: Sources and Methods Selection: Selection Process, Role Playing and Case Study on Selection Tests and Interviews Training and Development: Techniques, Performance Appraisal: Methods Case Study on Staffing Practices	**6**
6	**DIRECTING** Concept, Leadership: Importance and Styles, Motivation: Theories and their relevance in present scenario, Communication: Process, Types and Barriers of Communication Management Game on Leadership, Motivation and Communication	**3**
7	**CONTROLLING** Nature and Process of Controlling, Requirements for Effective Controlling	**2**

Course Outcomes:	
1	The students will be able to apply management concepts and principles in daily life and thus, will be able to manage things efficiently and effectively.
2	The students will learn how to get work done easily by using management knowledge and functions.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Principles and Practices of Management", Rao V.S.P. and Narayana P.S., Pubs: Konark Publishers.	1987
2	"Principles & Practice of Management", Prasad L.M., 8th Edition, Pubs: Sultan Chand & Sons.	2012
3	"Essentials of Management: International and Leadership Perspective", Weihrich H. and Koontz H., 9th Edition, Pubs: McGraw Hill.	2012
4	"The New Era of Management", Daft R.L., 11th Edition, Pubs: Cengage Learning.	2014
5	"Management: Text and Cases", Rao V.S.P. and Krishna V.H., Pubs: Excel Books.	2008
6	"Fundamentals of Management: Essential Concepts and Applications", Robbins S.P, DeCenzo D.A., Bhattacharya S. and Agarwal M.N., 6th Edition, Pubs: Pearson India.	2009

Course Name	**:**	**BUSINESS ENVIRONMENT AND BUSINESS LAWS**
Course Code	**:**	**HSM 402**
Credits	**:**	**4**
L T P	**:**	**2-2-0**

Course Objectives:

The main aim of this course is to make students understand different types of environment influencing business decisions and to provide knowledge about different laws that needs to be followed for initiating and managing business.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO BUSINESS** Scope and Characteristics of Business, Classification of Business Activities Forms of Ownership of Business: Sole Proprietorship, Partnership and Company	**5**
2	**BUSINESS ENVIRONMENT** Internal Environment: Concept and Elements (Value System, Vision Mission Objectives, Management Structure, Human Resources, Company Image etc.) SWOT Analysis: Concept and Case Study External Environment: Micro Environment (Suppliers, Customers, Competitors, Market Intermediaries etc.) and Macro Environment – PESTEL Analysis (Political, Economic, Social, Technological, Ecological and Legal), Case Study on Impact of Environment on Business	**7**
3	**GLOBALIZATION** Concept, Pros and Cons of Globalization, Impact of Global Environment on Business Globalization of Company – Case Study	**4**
4	**CORPORATE SOCIAL RESPONSIBILITY** Concept, Social Responsibility towards different stakeholders, Rationale for CSR CSR – Case Studies	**2**
5	**CORPORATE GOVERNANCE** Concept, Elements and Essentials of Good Governance	**3**
6	**CONTRACT LAW** Concept, Types and Essentials Elements of Contract	**3**
7	**PARTNERSHIP LAW** Nature of Partnership, Provisions of Partnership Act, Issues Related to Partnership Firm, Hypothetical Formation of a Partnership Firm	**2**
8	**COMPANY LAW** Nature of Company, Provisions of Company Act, Issues Related to Incorporation of Company, Hypothetical Formation of a Company	**2**

Course Outcomes:	
1	The students will be able to analyze the impact of environment on business and formulate appropriate business strategies to compete in the competitive world.
2	The students will learn how companies follow corporate governance and social responsibility practices along with fulfilling economic objectives.
3	The students will gain knowledge about application and implementation of various business laws in practice.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Business Environment: Text and Cases", Cherunilam F., 22nd Edition, Pubs: Himalaya Publications.	2013
2	"Legal Aspects of Business", Pathak A., 5th Edition, Pubs: McGraw Hill Education.	2013
3	"Essential of Business Environment: Text, Cases and Exercises", Aswathappa K., 11th Edition, Pubs: Himalaya Publication.	2011
4	"Business Law Including Company Law", Gulshan S.S. and Kapoor G.K., 15th Edition, Pubs: New Age International (p) Ltd.	2011

5	"Business Law and Corporate Laws", Tulsian P.C., 1st Edition, Pubs: Sultan Chand Publishing.	2011
6	"Fundamentals of Business Organization & Management", Bhushan Y.K., 19th Edition, Pubs: Sultan Chand & Sons.	2013
7	"Corporate Governance: Principles, Policies and Practices", Fernando A.C., 2nd Edition, Pubs: Pearson India.	2011

Course Name	**:**	**FINANCIAL MANAGEMENT**
Course Code	**:**	**HSM 404**
Credits	**:**	**4**
L T P	**:**	**2-2-0**

Course Objectives:
The main aim of this course is to make students learn different financial decisions i.e. investing, financing and dividend, required to be taken by a company and provide knowledge about the functioning of the financial system (financial markets, financial institutions, financial services and financial instruments) of the country.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO FINANCIAL MANAGEMENT** Concept of Finance, Terminology Related to Finance, Financial Decisions, Factors Affecting Financial Decisions, Risk-Return Trade-Off	**3**
2	**FINANCIAL SYSTEM** Concept and Role of Financial System in Indian Economy	**2**
3	**FINANCIAL MARKETS AND INSTRUMENTS** Concept and Relevance of Money Market and Capital Market Money Market Instruments: Call Money, Treasury Bills, Commercial Papers, Certificate of Deposits Capital Market Instruments: Equity Shares, Preference Shares and Debentures Hypothetical Trading in Financial Markets	**5**
4	**FINANCIAL SERVICES** Nature and Functions of Financial Services: Merchant Banking, Mutual Funds, Factoring, Forfaiting, Credit Rating Case Study on Financial Services	**6**
5	**FINANCIAL INSTITUTIONS** Nature and Functions of Financial Institutions: Reserve Bank of India (RBI), Securities and Exchange Board of India (SEBI), Discount and Finance House of India (DFHI)	**2**
6	**LONG TERM INVESTMENT DECISIONS** Capital Budgeting: Concept, Importance, Factors Techniques/Methods with Numerical Applications (Pay Back Period, Accounting Rate of Return, Net Present Value, Internal Rate of Return and Profitability Index), Case Study	**3**
7	**SHORT TERM INVESTMENT DECISIONS** Working Capital: Nature, Type and Factors Affecting the Requirement of Working Capital, Case Study	**2**
8	**FINANCING DECISIONS** Capital Structure: Essentials and Approaches of Capital Structure Sources of Finance (long-term and short-term), Financial Leverage: Concept and Numerical Application, Case Study	**3**
9	**DIVIDEND DECISIONS** Types of Dividend, Dividend Policy: Nature and Factors Affecting Dividend Policy, Case Study	**2**

Course Outcomes:	
1	The students will learn to make best combination of financial decisions by considering risk and return trade-off.
2	The students will identify how business can gain maximum through the financial system.
3	The students will understand how to manage funds effectively so as to maximize returns.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Financial Management", Shah P., 2nd Edition, Pubs: Dreamtech Press	2009
2	"Financial Markets and Services", Gordon E. and Natarajan K., 3rd Edition, Pubs: Himalaya Publishing House.	2006
3	"Financial Management: Theory and Practice", Chandra P., 8th Edition, Pubs: McGraw Hill Education (India).	2012
4	"Financial Management", Pandey I.M., 10th Edition, Pubs: Vikas Publishing House Pvt. Ltd., Noida.	2010
5	"Cases in Financial Management", Pandey I.M. and Bhat R., 3rd Edition, Pubs: McGraw Hill Education (India).	2012
6	"Financial Institutions and Markets: Structure, Growth and Innovations", Bhole L.M. and Mahakud J., 5th Edition, Pubs: McGraw Hill Education (India).	2009
7	"The Indian Financial System: Markets, Institutions and Services", Pathak B.V., 3rd Edition, Pubs: Pearson India.	2010
8	"Financial Management and Policy", Horne J.C.V. and Dhamija S., 12th Edition, Pubs: Pearson India.	2011

Course Name	**:**	**MARKETING MANAGEMENT**
Course Code	**:**	**HSM 405**
Credits	**:**	**4**
L T P	**:**	**2-2-0**

Course Objectives:
The main aim of this course is to make students understand about the marketing concepts to be applied in real life and the marketing process for delivering value to customers.

Total No. of Lectures –28

Lecture wise breakup		Number of Lectures
1	**INTRODUCTION TO MARKETING** Concepts, Role, Scope and Types of Marketing, Case Study on Marketing Management	**3**
2	**MARKETING RESEARCH** Scope and Process of Marketing Research, Hypothetical Marketing Research Analysis	**3**
3	**CONSUMER AND BUSINESS MARKETS** Types of Markets, Building Customer Value Consumer and Business Buying Behaviour: Factors Influencing Behaviour and Buying Decision Process	**4**
4	**SELECTION OF MARKETS** Segmentation: Factors and Bases, Targeting and Positioning Preparation of STP of Selected Product	**3**
5	**MARKETING MIX** 7 P's of Marketing Mix: Product, Price, Physical Distribution, Promotion, People, Process	**3**

	and Physical Evidence Formulation of Marketing Mix of Selected Product	
6	**PRODUCT DECISIONS** Product (Good or Service) Characteristics, Product Life-Cycle, Packaging and Branding, Product Development and Management	**3**
7	**PRICING DECISIONS** Pricing Policies and Strategies, Factors Influencing Pricing	**3**
8	**PHYSICAL DISTRIBUTION DECISIONS** Marketing Channels, Channel Players, Physical Distribution, Managing Distribution, Analysis of Supply Chain Management – Case Studies	**3**
9	**PROMOTION DECISIONS** Nature of Promotion Decisions, Managing Mass Communication and Personal Communication Analysis of Promotional Strategies – Case Studies	**3**

Course Outcomes:	
1	The students will learn how to market goods and services effectively to different segments so as to deliver value to customers.
2	The students will be able to formulate marketing mix and marketing strategies for different products and different sets of customers.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Marketing Management: Concepts, Cases, Challenges and Trends", Govindarajan M, 2nd Edition, Pubs: PHI Learning.	2009
2	"Marketing Management", Kotler P., Keller K.L., Koshy A. and Jha M., 14th Edition, Pubs: Pearson India.	2012
3	"Marketing Concepts and Strategies", Dibb S., Simkin L., Pride W.M. and Ferrell O.C., Pubs: Cengage Learning.	2012
4	"Marketing Management", Kumar A. and Meenakshi N., 2nd Edition, Pubs: Vikas Publishing House Pvt. Ltd., Noida.	2011
5	"Marketing Management", Saxena R., 4th Edition, Pubs: McGraw Hill Education (India).	2013
6	"Marketing: Managerial Introduction", Gandhi J.C., 1st Edition, Pubs: McGraw Hill Education.	1987
7	"Marketing", Etzel M.J., Walker B.J., Stanton W.J. and Pandit A., 14th Edition, Pubs: McGraw Hill Education (India).	2010
8	"Super Marketwala: Secrets to Winning Consumer India", Mall D., 1st Edition, Pubs: Random House India.	2014

Course Name	**:**	**HUMAN RESOURCE MANAGEMENT**
Course Code	**:**	**HSM 406**
Credits	**:**	**4**
L T P	**:**	**2-2-0**

Course Objectives:
The main aim of this course is to provide an overview of HRM, keeping the Indian business scenario in the background and to acquaint the students with the strategic role of HRM in managing an organization.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO HUMAN RESOURCE MANAGEMENT** HRM: Nature, Scope, Functions, HRM Practices and Problems in India with Case Studies	**4**

2	**HUMAN RESOURCE PLANNING (HRP)** Concept and Process of HRP, Factors Affecting HRP	**3**
3	**JOB ANALYSIS AND DESIGNING** Uses and Process of Job Analysis, Job Description and Job Specification: Features and Hypothetical Formulation, Job Designing: Job Enrichment, Job Enlargement	**3**
4	**RECRUITMENT AND SELECTION** Recruitment: Sources and Methods Selection: Selection Process, Selection Tests, Types and Nature of Interviews Role Playing and Case Study on Selection Process, Tests and Interview	**4**
5	**INDUCTION AND INTERNAL MOBILITY** Induction Programme, Need and Scope of Internal Mobility: Transfer, Promotion, Demotion	**3**
6	**TRAINING AND DEVELOPMENT** Training: Need and Methods, Management Development: Need, Methods and Management Development Programme HRM Games for Development of Employees	**4**
7	**PERFORMANCE APPRAISAL AND COMPENSATION** Nature and Methods of Performance Appraisal, Hypothetical Performance Appraisal Compensation: Financial and Non-Financial Benefits	**4**
8	**EMPLOYEE HEALTH AND SAFETY** Concept, Issues related to Health and Safety, Workplace Health Hazards	**3**

Course Outcomes:	
1	The students will develop the ability to solve problems in area of HRM in organizations.
2	The students will become aware of latest developments in HRM practices which are essential for effective management in organization.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Human Resource Management: Text and Cases", Rao V.S.P., Pubs: Excel Books.	2002
2	"Human Resource Management", Dessler G. and Varkkey B., 12th Edition, Pubs: Pearson India.	2011
3	"Human Resource Management: Text and Cases", Aswathappa K., 7th Edition, Pubs: McGraw Hill Education (India).	2013
4	"Human Resource Management: Text and Cases", Gupta C.B., 14th Edition, Pubs: Sultan Chand and Sons.	2012
5	"Human Resource Management: Text and Cases", Bedi S.P.S. and Ghai R.K., Pubs: Bharti Publications.	2012
6	"Human Resource Management Applications: Cases, Exercises, Incidents and Skill Builders", Fottler M.D., McAfee R.B. and Nkomo S.M., 7th Edition, Pubs: Cengage Learning.	2013

Course Name	**:**	**MANAGING INNOVATION AND CHANGE**
Course Code	**:**	**HSM 431**
Credits	**:**	**4**
L T P	**:**	**2-2-0**

Course Objectives:
The main aim of this course is to make students learn how to manage innovation and change in organizations and understand how innovation and change can contribute to business success.

Total No. of Lectures – 28

Lecture wise breakup		Number of Lectures
1	**INTRODUCTION TO INNOVATION AND CHANGE** Concept, Types, Sources, Components, Invention vs. Innovation	4
2	**INNOVATION IN ORGANIZATION** Innovation in Managerial Functions (Planning, Organizing, Staffing, Directing and Controlling), Innovation in Operational Functions (Marketing, Human Resource and Finance) Case Studies and Brainstorming Sessions	3
3	**INNOVATION POLICY** Innovation Cluster, National Innovation Systems	3
4	**INNOVATION MANAGEMENT** Innovation Management: Innovation Strategies, Models, Processes and Structures Case Study on Innovation Management	4
5	**REACTIONS TO CHANGE** Process of Planned Change, Responses to Change, Reasons for Resistance to Change, Change Agents, Stages in Reaction to Change	5
6	**CHANGE MANAGEMENT** Key Dimensions and Factors, Organizational Change, Approaches to Change Management Case Study on Change Management	4
7	**INTELLECTUAL PROPERTY RIGHT (IPR)** Patents, Copyrights and Trademarks	3
8	**DISCUSSIONS ON ADDITIONAL READING** (any one of the following in the semester) - 8 Steps to Innovation – Going from Jugaad to Excellence - Innovation Secrets of Indian CEOs - Jugaad Innovation: A Frugal and Flexible Approach to Innovation for the 21st Century - The Ten Faces of Innovation	2

Course Outcomes:	
1	The student will learn the technological, human, economic, organizational, social and other dimensions of innovation.
2	The students will understand how to encourage, manage and implement innovation and change in organization and how to take a new idea to the stage where it can be implemented.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Managing Change and Transition", Harvard Business School, Pubs: Harvard University Press.	2003
2	"Managing Creativity and Innovation", Harvard Business School, Pubs: Harvard University Press.	2003
3	"Managing Change, Creativity and Innovation", Dawson P. and Andriopoulos C., Pubs: Sage Publications.	2014
4	"Managing Strategic Innovation and Change", Tushman M.L. and Anderson P., 2nd Edition, Pubs: Oxford University Press.	2004
5	"The International Handbook of Innovation", Larisa V.S., Pubs: Elsevier Science.	2003
6	"Managing Innovation and Change", Mayle D., 3rd Edition, Pubs: Sage Publications.	2006
7	"Managing Technology and Innovation for Competitive Advantage", Narayanan V.K., Pubs: Pearson India.	2002
8	"Managing Technological Innovation, Competitive Advantage from Change", Betz F., Pubs: Wiley.	2011

Course Name	**:**	**BUSINESS RESEARCH**
Course Code	**:**	**HSM 432**
Credits	**:**	**4**
L T P	**:**	**2-2-0**

Course Objectives:
The main aim of this course is to make students understand the concepts of business research and learn the methods to formulate, analyze and interpret the business problems.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO BUSINESS RESEARCH** Concept and Types of Business Research	3
2	**PROBLEM IDENTIFICATION** Defining Problem, Literature Review: Essentials of Literature Review and Writing of Review, Research Objectives: Essentials of Research Objectives and its Formulation	3
3	**FRAMEWORK FOR BUSINESS RESEARCH** Research Questions, Hypothesis: Essentials of Hypothesis and its Formulation, Types of Variables	2
4	**INTRODUCTION TO RESEARCH DESIGN** Purpose and Scope of Research Design, Research Proposal: Elements and Framing a Research Proposal	2
5	**MEASUREMENT SCALES** Rating Scales, Ranking Scales, Reliability, Validity, Questionnaire: Essentials of Questionnaire, Developing a Questionnaire on a Hypothetical Research Problem	4
6	**SAMPLING DESIGN** Concept, Process and Techniques of Sampling, Framing of Sampling Design	3
7	**DATA COLLECTION** Sources and Methods of Data Collection	3
8	**PRESENTATION AND ANALYSIS OF DATA** Tabular, Graphic and Diagrammatic Presentation of Data, Statistical Data Analysis, Presentations and Analysis of Data using MS Excel	5
9	**RESEARCH REPORT** Contents and Characteristics of Project Report, Formulation of Project Report	3

Course Outcomes:	
1	The students will develop ability to tackle problems in business by following research techniques.
2	The students will learn to collect the right data and to analyze and present the data in the right way.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Research Methods for Business: A Skill Building Approach", Sekaran U. and Bougie R., 5th Edition, Pubs: Wiley India Pvt. Ltd., New Delhi.	2011
2	"Research Methodology: Methods and Techniques", Kothari C.R. and Garg G., 3rd Edition, Pubs: New Age International.	2014
3	"Business Research Methods", Bryman A. and Bell E., 2nd Edition, Pubs: Oxford University Press.	2010
4	"Business Statistics", Beri G.C., 3rd Edition, Pubs: McGraw Hill Education (India).	2009
5	"Statistics for Management", Levin R.I., Rubin D.S., Rastogi S. and Siddiqui M.H., 7th Edition, Pubs: Pearson India.	2012

6	"Business Research Methods and Statistics using SPSS", Burns R.P. and Burns R., 1st Edition, Pubs: Sage Publications.	2008
7	"Statistics for Management", Srivastava T.N. and Rego S., 2nd Edition, Pubs: McGraw Hill Education (India).	2012

Course Name	**:**	**ALGEBRA - I**
Course Code	**:**	**MAN 431**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of this course, the students should be able to describe the basic results of Group Theory. They should be able to recognise examples of groups. They should know the definitions of basic terms and should be able to write elements of the symmetric group as cycles or products of transpositions, should know simple uses of Lagrange's Theorem, quotients and products of groups. They should know difference between finding a proof from the axioms that works for all groups, and finding a counter example.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	Definition of a group, examples, some preliminary lemmas, Subgroups, examples, Cosets, Order of a group, Lagrange's Theorem,Euler's Theorem, A counting principle.	10
2	Normal subgroups and quotient groups, Homomorphism, Cauchy's Theorem, Sylows Theorem, Automorphism, Cayley's Theorem, Permutation groups, Conjugacy classes, Sylow subgroups and Sylow's Theorem,	16
3	Direct products, Finite abelian groups.	6
4	Vector Spaces: Elementary basic concepts, Linear independence and bases, Dual Spaces.	10

Course Outcomes:	
1	By the end of the course, the students will be able to describe the basic results of Group Theory, recognise examples of groups, know the definitions of basic terms, such as: order of a group, order of an element, subgroup, cyclic group and isomorphism. They will also be able to prove simple consequences, write elements of the symmetric group as cycles or products of transpositions, describe quotients and products of groups.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Topics in Algebra", Herstein, I.N., Wiley Eastern Limited, New Delhi.	1981
2	"Modern Algebra", Singh, S and Zameeruddin, Q ,Vikas Publishing House, New Delhi	2015
3	"Rings and Modules", Musili, C, Narosa Publishing House, (Second Revised Edition),New Delhi.	1994.
4	"Algebra", Artin, M. Prentice Hall of India, New Delhi.	1994
5	"The Theory of Groups of Finite Order", Burnside, W. (2nd Ed.), Dover, New York.	1955

Course Name	**:**	**NUMBER THEORY**
Course Code	**:**	**MAN 432**

Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of this course, the students should be able to describe the fundamental properties of integers and to prove basic theorems. They should be able to solve congruences and Diophantine equations. They should also be able to approximate reals by rationals.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	Introduction, Divisibility, Greatest common divisor, The Euclidean algorithm, primes, Fundamental theorem of Arithmetic,	8
2	Congruences, Residue classes and reduced residue classes, Fermat's theorem, Euler's theorem, Wilson Theorem, Solution of congruences , congruences of degree1, Chinese Remainder theorem with applications. Euler's φ-function,	12
3	Congruences of higher degree, prime power modulii, prime modulus, Primitive roots, Indices and their applications, power residues, Quadratic residues, Quadratic reciprocity, Legendre Symbol, Euler's criterion, Gauss's Lemma, Quadratic reciprocity law, Jacobi symbol,	10
4	Greatest integer function, arithmetic function, Mobius inversion formula, Diophantine equations Farey sequences,Continued fractions, approximations of reals by rationals.	12

Course Outcomes: By the end of the course, the students will be able to	
1	Describe the fundamental properties of integers.
2	Prove basic theorems.
3	Solve congruences.
4	Sove Diophantine equations
5	Approximate reals by rationals

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"An introduction to theory of numbers", Niven I., Zuckerman S. H. and Montgomary L. H.John Wiley and Sons .	1991
2	"Theory of Numbers", Hardy and Wright W. H.Oxford University Press	1979
3	"Higher arithmetic", Davenport H.Cambridge University Press .	1999.
4	"Elementary Number Theory", David M. Burton, Wm.C.brown Publishers, Dubuque, Ivova .	1989

Course Name	**:**	**FOURIER SERIES AND INTEGRAL TRANSFORMS**
Course Code	**:**	**MAN 433**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of this course, the students should be able to expand functions in Fourier series, Fourier Integrals and learn Fourier sine and cosine Transforms, Harmonic analysis and their applications. The students should be able to evaluate Laplace transforms and Inverse Laplace transform. The students should be able to apply Laplace transforms to solve ordinary differential equations.

Total No. of Lectures – 42

Lecture wise breakup		Number of Lectures
1	Periodic functions, Trigonometric series, Fourier Series, Euler's formulae, Conditions for existence of Fourier series, Functions of any period p = 2L, Even and odd functions, Half range expansions, Complex Fourier series, Applications of Fourier series, Parseval's identity, Harmonic analysis. Approximation by Trigonometric Polynomials	12
2	Fourier Integral, Fourier Sine and Cosine Integrals ,Evaluation of Integrals, Fourier Transforms, Fourier Cosine Transform, Fourier Sine Transform, Properties of Fourier Transform, Linearity ,Symmetry, change of Time Scale, Time Shifting , Frequency Shifting , Fourier Transform of derivatives, integrals, convolution , Properties of Fourier cosine and sine Transforms, Parseval Identity for Fourier Transform , Finite Fourier Cosine and Sine Transform	18
3	Laplace transform, Inverse transform, properties, Transforms of derivatives and integrals, s-Shifting ,t-Shifting, Unit step function, Dirac's delta function, Differentiation and integration of transforms, Applications to differential equations. Convolution Theorem ,Integral Equations	12

Course Outcomes:	
1	By the end of this course the students will be able to expand a function in terms of its Fourier Series ,Fourier Integrals, Fourier Transforms and apply harmonic analysis to numerical data.
2	The students will be able to evaluate Laplace transforms and inverse Laplace transforms.
3	The students will be able to use Laplace transform to solve ordinary differential equations arising in engineering problems.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Higher Engineering Mathematics", B V Ramana, Tata McGraw -Hill	2006
2	"Advanced Engineering Mathematics", E. Kreyszig, John Wiley.	2006
3	"Advanced Engineering Mathematics", Wylie and Barrett, McGraw Hill.	2003

Course Name	**:**	**CALCULUS OF VARIATIONS**
Course Code	**:**	**MAN 434**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of the course the students should be able to understand the concept of functional, extremum, Euler's equations, the concepts of transversality conditions, Weirstress-Endmann corner condition and canonical form of Euler equations, canonical transformations and Rayleigh Ritz method,They should be able to apply direct methods in calculus of variations Euler's finite difference methods, use Rayleigh Ritz method and Sturm-Liouville to solve differential equations.

Total No. of Lectures – 42

Lecture wise breakup		Number of Lectures
1	Variation of a functional. A necessary condition for an extremum, Euler's equation. Some classical problems. Fixed end point problems for unknown functions. Variational problems	10

	with subsidary conditions.	
2	General variation of a functional. Variable end point problems, transversality conditions. Transversal theorem. Weirstress-Endmann corner condition. Canonical form of Euler equations and their first integrals. Canonical transformations. Weather's theorem. The principle of the least action. Censervation laws. Hamilton-Jacobi equations. Jacobi's theorem.	14
3	The second variation of a functional and the formula for second variation. Legendre's necessary condition. Iaoobi's necessary condition. Conjugate points, Sufficient condition for a weak extremum. General definition of a field and field of a functional. Hilberts invariant integral. The weierstrass E-functional. Sufficient conditions for a strong minimum. Direct methods in calculus of variations Euler's finite difference methods and the Rayleigh Ritz method. Applications to sturm-Liouville problem.	18

Course Outcomes:	
1	At the end of the course the students will be able to understand the concept of functional, extremum, Euler's equations.
2	They will be able to learn the concepts of transversality conditions, Weirstress-Endmann corner condition and to evaluate canonical form of Euler equations, canonical transformations and Rayleigh Ritz method.
3	They will be able to apply direct methods in calculus of variations Euler's finite difference methods, use Rayleigh Ritz method and Sturm-Liouville to solve differential equations.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Calculus of variations", I M. Gelfand and S. V. Fomin	1963
2	"Calculus of variations", L.E. Elsgolc.	1962

Course Name	**:**	**ALGEBRAIC CODING THEORY**
Course Code	**:**	**MAN 435**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of this course, the students should be able to translate fundamental problems of coding theory into mathematical problems and then solve them by using the theory of finite fields, polynomial rings and finite groups.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO CODING THEORY** Source and Channel coding, Error detecting and error correcting codes	2
2	**ERROR DETECTION, ERROR CORRECTION AND DECODING** Communication Channels, maximum likelihood decoding, Hamming distance, Nearest neighbour/ minimum distance decoding, distance of a code	6
3	**FINITE FIELDS** Fields, Polynomial rings, Structure of finite fields, Minimal polynomials	10
4	**LINEAR CODES** Vector spaces over finite fields, Linear Codes, Hamming weight, Bases for linear codes Generator matrix and parity check matrix, Equivalence of linear codes, Encoding with a linear code, Decoding of linear codes, Cosets, Nearest neighbor decoding for linear codes, Syndrome Decoding, Weight Enumerator of a Code, Macwilliam's Identity,	16

5	**CYCLIC CODES** Definition, Generator polynomials, Generator matrix and parity check matrix, Decoding of linear codes.	8

Course Outcomes: By the end of the course, the students will be able to	
1	Translate fundamental problems of coding theory into mathematical problems and then solve them by using the theory of finite fields, polynomial rings and finite groups.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Coding Theory", San Ling & Chaoping Xing , Cambridge University Press	2004
2	"Introduction to the 'Theory of Error Correcting Codes", Vera Pless, Cambridge University Press	2003
3	"Introduction to Error Correcting Codes", Raymond Hill, Clarendon Press, Oxford	1986
4	"Theory of Error Correcting Codes Part I & II", F.J.Macwilliams & NJA Sloane	1977

Course Name	**:**	**QUANTUM MECHANICS**
Course Code	**:**	**PYN-431**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
At the end of this course the students should be able to describe and implement concepts and principles of Quantum Mechanics required for in depth understanding of Physical phenomena of materials in relation to applications in Engineering. The students should be able to solve numerical problems related to hydrogen atom.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	Blackbody radiation, photoelectric effect, X-rays, X-ray diffraction, Compton effect, Pair production	7
2	Inadequacy of classical physics, Bohr-Sommerfield quantization rules, Quantum-Mechanical viewpoint.	4
3	De Broglie waves, phase and group velocities, particle diffraction, Uncertainty Principle, limitations on experiment, wave packets.	7
4	One-dimensional Schrodinger wave equation, extension to three dimensional statistical interpretation of wave function, Normalization, expectation value.	6
5	Separation of wave equation, one-dimensional square well potential, perfectly rigid wall, finite potential step, tunnel effect.	8
6	Linear harmonic oscillator, three-dimensional square well potential, the hydrogen atom, separation of variables, quantum numbers, principal quantum number, orbital quantum number, magnetic quantum number, Zeeman effect.	10

Course Outcomes: By the end of the course, student will be able to	
1	Solve the problems based on Quantum Mechanics.
2	Apply the concepts of Quantum Mechanics in different phenomena.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/**

		Reprint
1	"Concepts of Modern Physics", Arthur Beiser, McGraw Hill Education (India) Pvt. Ltd., New Delhi.	2013
2	"Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles", Robert Eisberg and Robert Resnick, Wiley India Pvt. Ltd., New Delhi	2013
3	"Modern Physics", J. Bernstein, P.M. Fishbane and S.G. Gasiorowicz, Pearson, Education India Pvt. Ltd., New Delhi	2009

Course Name	**:**	**STATISTICAL PHYSICS**
Course Code	**:**	**PYN-432**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
The students will be able to describe and implement concepts and principles of Statistical Mechanics required for in depth understanding of Physical phenomena in solid state, nuclear physics.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	Laws of Thermodynamics - First Law of Thermodynamics, Second Law of Thermodynamics, Entropy, Third Law of Thermodynamics.	6
	Phase Transitions, Kinetic Theory, Vander waal equation of state, Boltzmann transport equation, Maxwell-Boltzman Distribution, the method of most probable distribution.	8
2	Classical Statistical Mechanics, Microcanonical ensemble, Cnonical ensemble, Grand Canonical ensemble, Chemical Potential.	7
	Distribution function, Ideal Fermi Gas, Degenerate and non-degenerate states, Theory of white dwarf stars, Landau Diamagnetism.	7
3	Equation of state for ideal Fermi gas, quantized Hall effect, Pauli paramagnetism, Ideal Bose gas, Bose-Einstein distribution, Derivation of Planck's Law.	7
	Phonons, Specific heat, superfluids, Landau's theory, superfuid flow, superfluid velocity, Bose-Einstein Condensation.	7

Course Outcomes:	
1	Solve the problems based on Statistical Mechanics.
2	Understand the importance of statistical physics in describing various natural phenomena.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Statistical Mechanics" , K. Huang, Wiley India Private Ltd., New Delhi	2013
2	"Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles", Robert Eisberg and Robert Resnick, Wiley India Pvt. Ltd., New Delhi	2013
3	"Concepts of Modern Physics", Arthur Beiser, McGraw Hill Education (India) Pvt. Ltd., New Delhi.	2013

Course Name	**:**	**NUCLEAR PHYSICS**
Course Code	**:**	**PYN-433**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
The students should be able to describe and implement concepts and principles of Quantum Mechanics required for in depth understanding of Physical phenomena of materials in relation to applications in Engineering. The students should be able to solve numerical problems related to hydrogen atom.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	Mass, charge and constituents of nucleus, Nuclear size and distribution of nucleons, Energies of Nucleons, Nucleus as a quantum system, nuclear force, properties of nucleus.	10
2	Particle in a one-dimensional square well, particle in a three-dimensional square well, vector model for addition of angular momentum.	10
3	Bound states of two nucleons - Deuteron nucleus, Meson theory of nuclear forces. Shell theory of nucleus, shell theory potential, allowed orbits, filling of allowed orbits, non-spherical nucleus.	10
4	Natural radioactivity, successive radioactive transformations, radioactive equilibrium, radioactive series, radiometric dating. Nuclear force and its characteristics, Elementary description of shell model, explanation of magic numbers, liquid drop model and semi-empirical binding energy formula. Nuclear fission, fission products, mass and energy distribution of fission products, neutron emission and energy distribution of neutrons emitted in fission, theory of fission process, nuclear reactors - classification, neutron cycle in thermal reactors and four-factor formula for neutron reproduction, nuclear fission - controlled thermonuclear reactions.	12

Course Outcomes: By the end of the course, student will be able to	
1	Solve the problems based on Nuclear Physics.
2	Understand and apply the basic concepts of nuclear physics in different nuclear phenomena.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Concepts of Nuclear Physics" , B.L. Cohen, Tata Mcgraw Hill, New Delhi	2013
2	"Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles", Robert Eisberg and Robert Resnick, Wiley India Pvt. Ltd., New Delhi	2013
3	"Introductary Nuclear Physics", Kenneth S Krane, Wiley India Pvt. Ltd., New Delhi	2014

Course Name	**:**	**EXPERIMENTAL NUCLEAR PHYSICS**
Course Code	**:**	**PYN-434**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
At the end of this course the students should be able to describe and implement concepts and principles of Quantum Mechanics required for in depth understanding of Physical phenomena of materials in relation to applications in Engineering. The students should be able to solve numerical problems related to hydrogen atom.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**Experimental Nuclear Physics** Binding energies of nuclei, semi-empirical mass formula, magnetic dipole moment, electric quadrupole moment, Beta decay, nucleon emission, decay laws.	10
2	Experimental method in nuclear physics, interaction of charged particle with matter, detectors for energetic charged particles, detectors which make tracks visually observable, scintillation detectors, charge collection detectors, mass spectrometer.	10
3	Accelerators, linear accelerator, cyclic accelerator, synchrocyclotron.	10
4	Natural radioactivity, successive radioactive transformations, radioactive equilibrium, radioactive series, radiometric dating. Nuclear force and its characteristics, Elementary description of shell model, explanation of magic numbers, liquid drop model and semi-empirical binding energy formula. Nuclear fission, fission products, mass and energy distribution of fission products, neutron emission and energy distribution of neutrons emitted in fission, theory of fission process, nuclear reactors - classification, neutron cycle in thermal reactors and four-factor formula for neutron reproduction, nuclear fission - controlled thermonuclear reactions.	12

Course Outcomes: By the end of the course, student will be able to	
1	Solve the problems based on experimental Nuclear Physics.
2	Predict that which type of detector or accelerator is suitable for particular application.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Concepts of Nuclear Physics" , B.L. Cohen, Tata Mcgraw Hill, New Delhi	2013
2	"Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles", Robert Eisberg and Robert Resnick, Wiley India Pvt. Ltd., New Delhi	2013
3	"Introductary Nuclear Physics", Kenneth S Krane, Wiley India Pvt. Ltd., New Delhi	2014

Course Name	**:**	**X-Ray Crystallography**
Course Code	**:**	**PYN-435**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
At the end of the course, student will become familiar with the applications of X-ray crystallography in the determination of molecular structure. On the basis of structure, student will be able to explain the experimental observed properties.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	Bonding in Solids, Ionic bonding, Covalent, metallic bonding, intermolecular bond, dispersion bond, hydrogen bond. General features of crystals, basis and crystal structure, unit cell and lattice parameters, external symmetry of crystals, seven crystal systems, thirty two crystal classes, Miller indices, space lattice, symmetry elements, space group.	12
2	General description of scattering process, Thomson scattering, Compton scattering, scattering of X-rays by atoms.	10

3	Diffraction from one-dimensional and three-dimensional array of atoms, reciprocal lattice, Ewald sphere, Laue equation, structure factor, Diffraction by periodic distribution, electron-density equation, Patterson method. Powder camera, oscillation camera, Weissenberg camera.	10
4	Relevance of crystallography in the studies of theory of solids, influence of translational periodicity on the physical behavior of solids, tight binding approximation, density of states,	10

Course Outcomes:	
1	Solve the problems based on crystal systems.
2	Apply X-ray crystallography in the determination of molecular structure.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"An introduction to X-Ray Crystallography" by M.M. Woolfson Vikas Publishing House, Cambridge University Press, New Delhi	2012
2	"Solid State Physics", S.O. Pillai, New Age International (P) Limited, New Delhi	2010
3	"Crystallography Applied to Solid State Physics", Verma and Srivastava, New Age International (P) Limited, New Delhi	2012

Course Name	**:**	**INORGANIC CHEMISTRY**
Course Code	**:**	**CHN-431**
Credits	**:**	**4**
L T P	**:**	**3 0 3**

Course Objectives:
At the end of this course, the students should be able to describe concepts of Inorganic chemistry related to structure, properties & applications of inorganic and organometallic compounds.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**QUANTUM THEORY AND ATOMIC STRUCTURE:** Introduction to wave mechanics, the Schrodinger equation, the Schrodinger equation as applied to hydrogen atom, the origin of quantum numbers and shapes of orbitals.	4
2	**CHEMICAL BONDING:** Molecular orbital and valence bond theories of bond formation and application of molecular orbital theory to the formation of homonuclear and heteronuclear diatomic molecules.	7
3	**THE SOLID STATE:** A recapitulation of close packing of spheres, structures of NaCl, CsCl, ZnS, CaF2, crystal defects and applications of defect structures (transistors, rectifiers, photovoltaic cells and computer chips).	4
4	**COORDINATION COMPOUNDS:** Part 1: Werner's theory, effective atomic number, bonding of transition metal complexes: valence bond theory, crystal field theory, crystal field splitting in tetrahedral, octahedral and distorted octahedral (square planar) crystal fields. Thermodynamic aspects of coordination compounds (crystal field stabilization energies of octahedral and tetrahedral complexes, spectrochemical series).	6
5	**COORDINATION COMPOUNDS:** Part2: Kinetic aspects of coordination compounds (substitution reactions in complexes with coordination number 4 and 6 and their mechanism - SN^1, SN^2). Magnetic behaviour of	6

	complexes – Para magnetism, diamagnetism, ferromagnetism and antiferromagnetism	
6	**ORGANOMETALLIC COMPOUNDS:** Nomenclature, types of ligands and bonding in organometallic compounds, use of organometallics in industry.	5
7	**INORGANIC POLYMERS:** Types of inorganic polymers, polyphosphazenes, polysiloxanes –their structures and properties.	5
8	**ROLE OF METALS IN BIOLOGICAL SYSTEMS:** Bio-inorganic Chemistry of Iron – Heme proteins & Non-Heme iron proteins; bioinorganic chemistry of cobalt-vitamin B12 and metalloenzymes.	5

List of Experiments:		**Number of Turns**
1	Estimation of oxalate using potassium permagnate.	1
2	Estimation of Fe^{2+} and Fe^{3+} using potassium dichromate.	1
3	Estimation of Cu^{2+} and AsO_3^{3-} iodimetrically.	2
4	Determination of Zn by EDTA titration.	1
5	Estimation of Ba^{2+}/SO_4^{2-} by as $BaSO_4$ gravimetrically.	1
6	Estimation of Fe^{2+} and Fe^{3+} as Fe_2O_3 gravimetrically.	2
7	Preparation and characterization of inorganic complexes (2 nos.).	2
8	Preparation and characterization of organometallic compound.	1
9	Crystallization techniques for purification of inorganic complexes.	1
10	Melting point determination of few inorganic compounds.	1

Course Outcomes: By the end of this course, the student will be able to:	
1	Understand the structure of atom based on quantum theory, concept of chemical bonding in homo- and hetro-atomic molecules & structure of advanced materials along with their applications in electronic fields.
2	Apply the thermodynamic, kinetic, magnetic and mechanistic aspects to coordination compounds.
3	Develope organometallic compounds to study the interaction and role of metals in biological systems essential for bio-engineering applications.
4	Design new inorganic materials with in-depth understanding of their structures and properties.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Inorganic Chemistry", A. G. Sharpe., 3rd Edition, Longman Publishers ELBS.	1992
2	"Inorganic Chemistry", J. D. Lee, 5th Edition, Chapman and Hall Publishers.	1996
3	"Advanced Inorganic Chemistry", F. A. Cotton & G. Wilkinson,3rd Edition, Wiley Eastern Ltd.	1982
4	"Basic Inorganic Chemistry", F. A. Cotton & G. Wilkinson; Wiley Eastern Ltd.	1987
5	"Inorganic Polymer", J. Mark, R. West & H. Allcock, Prentice Hall, New Jersey Publishers.	1982
6	"Vogel's Qualitative Inorganic Analysis", G. Svehla, 7th Edition Pearson Education.	2002

Course Name	**:**	
Course Code	**:**	
Credits	**:**	
L T P	**:**	

Course Objectives:

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**Ultrasonics** Production, detection and uses of ultrasonics, reverberation, sabine's formula (no derivation)	(3)
2		
3		
4		

List of Experiments:		**Number of Turns**
1		
2		
3		
4		
5		

Course Outcomes:	
1	
2	
3	
4	
5	

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	" Computer Graphics", Donald Hearn and M. Pauline Baker, Pearson Education	2012
2		
3		
4		
5		

Course Name	**:**	**ANALYTICAL CHEMISTRY**
Course Code	**:**	**CHN-433**
Credits	**:**	**4**
L T P	**:**	**310**

Course Objectives:
At the end of this course, the student should be able to develop sufficient knowledge about the major instrumental methods of chemical analysis so that they can determine what technique should be used for study of structural aspects of all kinds of materials. The student will be able to analyze the advances in instrumentation which have been made, especially those made as a result of problems encountered with the method. Students will gain practical knowledge of experimental methods and analytical instrumentation for carrying out analytical separations using gas and liquid chromatography.

Total No. of Lectures – 42

Lecture wise breakup		Number of Lectures
1	**COMPLEXOMETRIC TITRATIONS :** Complexes-formation constants; chelates – EDTA, Chelon Effect, EDTA equilibria, effect of pH on EDTA equilibria, EDTA titration curves, endpoint – detection and indicators; Importance of complexometric titrations.	4
2	**SOLVENT EXTRACTION :** Distribution law, extraction process, factors effecting extraction, technique for extraction, quantitative treatment of solvent extraction equilibria, and classification of solvent extraction systems. Advantages and applications of solvent extraction.	6
3	**CHROMATOGRAPHY:** Introduction to chromatography, principles, classification of chromatographic techniques, thin layer and paper chromatography – principle and technique. Column Chromatography – Factors affecting column efficiency and applications. Gas – liquid chromatography – theory, instrumentation and applications. HPLC – instrumentation, method, column efficiency and applications.	8
4	**THERMOANALYTICAL METHODS :** Principle, classification of methods. TGA –Instrumentation, factors affecting results and analysis of data. Applications. DTG – Instrumentation, analysis of data and applications. DTA – Principle, Instrumentation and applications.	8
5	**SPECTROSCOPIC TECHNIQUES:** UV Introduction to spectroscopy, Lambert Beer s law, instrumentation and applications ,IR Introduction, basic principles, factors affecting IR group frequencies , Instrumentation and Applications ,NMR Basic principles, elementary ideas and instrumentation chemical shifts, spin-spin coupling.	10
6	**ELECTRON MICROSCOPY:** Scanning electron microscopy (SEM), Transmission Electron Microscopy (TEM) and Scanning Transmission Electron Microcopy (STEM) Principles and Applications	6

Course Outcomes: By the end of this course, the student will be able to:	
1	Address the problems of analyzing complex samples. This would include defining the problem, determining any constraints, choosing the best methodology, and determining how to test the methodology to prove its merits. Where there are alternatives the student should be able to define the advantages and disadvantages of each.
2	Interpret data from analytical separation methods and will understand approaches for the validation of these analytical.
3	Carry out hands on experiments in the field related to analysis of materials required for technological developments and in advanced research in Engineering.
4	Apply various analytical techniques for analysis of organic and inorganic materials.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Principles of Instrumental Analysis", by Skoog, D. A. & West D. M., 5th Edition, Saunders College Publishers, USA.	1998
2	"Fundamentals of Analytical Chemistry", Skoog, D. A. & West D. M., 7th Edition, Saunders College Publishers, USA.	2000
3	"Industrial Methods of Analysis", Willard, Merritt, Dean &Settle, 7th Edition.	1989
4	"Industrial Methods of Chemical Analysis", Galen W. Ewing, 5th Edition.	1985
5	"Spectrometric identification of Organic Compounds", Silverstein R. M. &Webster F.X., 6th Edition, John Wiley and Sons, Inc., USA	2005
6	"Quantitative Inorganic Analysis", A.I, Vogel, 5th Edition.	1989

Course Name	**:**	**ENVIRONMENTAL CHEMISTRY**	
Course Code	**:**	**CHN-434**	
Credits	**:**	**4**	
L T P	**:**	**3 1 0**	

Course Objectives:
At the end of this course, the student should be able to understand the basic knowledge of environmental chemistry, such as chemistry of atmosphere, hydrosphere, pedosphere and biosphere. The student will be able to apply basic theories and methods of chemistry to study the environmental issues caused by chemical substances (pollutants).

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	CHEMICAL COMPOSITION OF AIR : Classification of elements, chemical speciation. Particles, ions, and radicals in the atmosphere. Chemical processes for formation of inorganic and organic particulate matter. Sources of trace gases in the atmosphere; Thermo-chemical and photochemical reactions in the atmosphere. Tropospheric oxidation chemistry; Oxygen and ozone chemistry. Chemistry of air pollutants. Role of hydrocarbons; Sulphur chemistry; Halogen Chemistry in the atmosphere.	8
2	WATER CHEMISTRY: Chemistry of water, dissolution / precipitation reactions; complexation reactions; concept of DO, BOD, COD; concept of salinity; composition of sea water and physic-chemical speciation in oceans; Suspended particles; concept of sedimentation, coagulation, filtration,	8
3	SOIL POLLUTION : Pollutants in soil, Agricultural Pollution, Role of Micro nutrients in soil, Ion exchange reaction in soil, Pesticide (Classifications & Degradation), Path of Pesticides in Environment, Monitoring techniques.	8
4	ENVIRONMENTAL TOXICOLOGY AND ITS EVALUATION: Emergence as a science; concepts and definitions; Factors affecting toxicity, Evaluation of LC50, LD50, LCIC and IT.	5
5	TOXIC CHEMICAL IN THE ENVIRONMENT : Metals and other inorganic contaminants; Organic contaminants; Fate of organic contaminants; Pesticides; Biochemical aspects of arsenic, cadmium, lead, mercury, carbon monoxide, ozone and PAN Pesticides; Insecticides, MIC, carcinogens in the air. Photochemistry of Brominated Flame Retardants (BFR) Gene toxicity of toxic chemicals.	8
6	GREEN CHEMISTRY FOR SUSTAINABLE FUTURE : Reagents, Media, Special Importance of Solvents, Water the Greenest Solvents, Synthetic and Processing Pathways, Role of Catalyst, Biological Alternatives, Biopolymers, Principles and Application of Green Chemistry.	5

Course Outcomes: By the end of this course, the student will be able to:	
1	Describe the chemical composition (and the main elements' occurrence forms) of the geosphere, the atmosphere, the hydrosphere, and the biosphere and to explain how interactions between these spheres and the techno sphere affect the environment.
2	Know the basic chemical features of some environmental concerns of today and their societal origin, with specific focus on acidification, eutrophication, ozone, nuclear wastes, heavy metals, organic pollutants, and climate change issues.
3	Develop integrated technologies to support the recycling of carbon and plant nutrients from agricultural crops, bio-based industries and municipal water treatment plants.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Environmental Chemistry", Banerji, S.K, 2nd Edition, Prentice-Hall, New Delhi, India.	1999
2	"Environmental Chemistry", A. K. De, 4th Edition, New Age International (P) Ltd., New Delhi, India.	2000
3	"Introductory Chemistry for the Environment Science", Harrison, R. M. and de Mora, S. J. 2nd Edition, Cambridge University Press, New Delhi.	1996
4	"Introduction to Atmospheric Chemistry", Hobbes, P.B. Cambridge University Press, UK.	2000
5	"Principles of Environmental Chemistry", Kothandaaman, H. and Swaminathan, G. B.I. Publications, Chennai, India.	1997
6	"Fundamentals of Environmental Chemistry", Manahan, S. E. 2nd Edition, CRC Press, Inc., USA.	2001

Course Name	**:**	**RECENT ADVANCES IN CHEMICAL SCIENCES**
Course Code	**:**	**CHN-435**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
At the end of this course, the student should be able to use molecular building blocks to design functional supramolecular constructs and nano-structured materials by using the principles of Supramolecular Chemistry. The student will be able to understand chemical and physical phenomena particular to surfaces and interfaces and reduce chemical pollutants flowing to the environment by using principles of Green Chemistry.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**SUPRAMOLECULES:** Concepts of supramolecular chemistry- Thermodymanics of molecular recognition, solvation, multivalency, Molecular Recognition: Cations,Anions and Neutral guests, Self processes - Self-assembly, Supramolecular -devices and Sensors, Molecular logic, photo switching materials, Supramolecular -material Chemistry Crystal engineering, MOFs and coordination polymers, templates for biomineralisation	8
2	**CHEMISTRY OF NANOMATERIALS:** Synthesis of nanoparticles by chemical routes and characterization techniques: Thermodynamics and kinetics of nucleation; Growth of polyhedral particles by surface reaction, Ostwald ripening, size distribution; Properties of nanostructured materials : Optical properties; magnetic properties;	9
3	**HOMOGENEOUS CATALYSIS :** Stoichiometric reaction for catalysis, homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, catalytic reations involving carbon monoxide such as hydrocarbonylation of olefins (oxo reaction) oxopalladation reactions, activation of C-H bond.	8
4	**SURFACTANT AGGREGATION:** Micelles, Surface active agents, Classification of surface active agents, Micellization, Hydrophobic interaction, Critical micellar concentration (cmc), Factors affecting the concentration of surfactants, Counter-ion binding of micelle, Thermodynamics of micellization, Phase separation and Mass action models, Solubilization Emulsions, Mechanism of formation of microemulsion and their stability, Phase maps, Physical techniques, Applications..	9

5	**GREEN CHEMICAL PROCESSES:** An introduction to the tools of green chemistry and its fundamental principles. Use of Renewable Raw Materials. Evaluating feedstock and starting materials -commodity chemicals from glucose Greener Solvents: The use of supercritical fluids, and aqueous systems Greener reagents and products. Methods of designing safer chemicals Examples of greener reagents replacement of phosgene, methylations using dimethylcarbonate,	8

Course Outcomes: By the end of this course, the student will be able to:	
1	Exploit supramolecular engineering to design structures with adapted morphologies and properties.
2	Initiate self-assembly processes in bimolecular systems and the basis of bio-inspired chemistry.
3	Understand the interactions between surfaces and gases, liquids or solutions, and how interfaces are important in many technological a biological processes..
4	Identify the new advancements and approaches of chemical sciences for technological leads in various fields of sciences and Engineering.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"The Organometallic Chemistry of the Transition Metals", Crabtree, R.G. 4th Edition, John Wiley.	2005
2	"Wilkinson Advanced Inorganic Chemistry", Cotton, F.A.; 6th Edition, John Wiley.	1999
3	"Supramolecular Chemistry",Steed J. W. and Atwood J. L., John Wiley and Sons, Ltd.	2000
4	"Green Chemistry and Catalysis",Roger Arthur Sheldon, Dr. Isabel W. C. E. Arends, Dr. Ulf Hanefeld, Wiley-VCH Verlag GmbH & Co. KGaA.	2007
5	"Physical Chemistry of Surfaces", Adamson A.W., Pubs: John Willey, New York.	1982
6	"Surfactant Science and Technology", Myers D., Pubs: VCH Publishers.	1988