First Semester								
	Theory					Practical		
Code	**Course Name**	**Hours/ Week L/T**	**Credit Theory**	**University Marks**	**Internal Evaluation**	**Hours/ Week L/T**	**Credit Practical**	**Marks**
BS	Mathematics-I	3-1	4	100	50	-	-	-
BS	Chemistry/ Physics	3-0	3	100	50	2	1	50
ES	Basics of Electronics / Basic Electrical Engineering	3-0	3	100	50	2	1	50
ES	Mechanics/ Thermodynamics	3-0	3	100	50			
ES	Programming in 'c"	3-0	3	100	50	2	2	50
HS	English Communication Skill	3-0	2	100	50	2	1	50
ES	Engineering Workshop/ Engineering Drawing					4	2	100
Total		16	18	600	300	18	7	300
Total Marks: 1200								
Total Credits: 25								

Second Semester								
	Theory					Practical		
Code	**Course Name**	**Hours/ Week L/T**	**Credit Theory**	**University Marks**	**Internal Evaluation**	**Hours/ Week L/T**	**Credit Practical**	**Marks**
BS	Mathematics-II	3-1	4	100	50	-	-	-
BS	Chemistry/ Physics	3-0	3	100	50	2	1	50
ES	Basics of Electronics / Basic Electrical Engineering	3-0	3	100	50	2	1	50
ES	Mechanics/ Thermodynamics	3-1	3	100	50			
ES	Data Structure Using 'C"	3-0	3	100	50	2	2	50
HS	Business communication	3-0	2	100	50	2	1	50
ES	Engineering Workshop/ Engineering Drawing					4	2	100
MC	NSS/NCC	-	-	-	-			
Total		17	18	600	300	14	7	300
Total Marks: 1200								
Total Credits: 25								

Second Year Engineering

Third Semester

		Theory				Practical		
Code	**Course Name**	**Hours/ Week L/T**	**Credit Theory**	**University Marks**	**Internal Evaluation**	**Hours/ Week L/T**	**Credit Practical**	**Marks**
PC	Science &Engg. Of Materials	3-0	3	100	50	2	1	50
PC	Metallurgical Thermodynamics & Kinetics	3-0	3	100	50	2	1	50
PC	Transport Phenomena	3-0	3	100	50	2	1	50
PC	Materials Processing	3-0	3	100	50	2	1	50
PC	Principle OF Extractive Metallurgy	3-1	4	100	50			
HS	Engineering Economics/ Organizational Behavior	2-1	3	100	50			
Total		19	19	600	300	8	4	200
Total Marks: 1100								
Total Credits: 23								
Honours	Physical materials	4	4	100	50			
Minor Specialization								

Fourth Semester

		Theory				Practical		
Code	**Course Name**	**Hours/ Week L/T**	**Credit Theory**	**University Marks**	**Internal Evaluation**	**Hours/ Week L/T**	**Credit Practical**	**Marks**
HS	Purely Applied Mathematics for Specific Branch of Engineering	3-0	3	100	50			
PC	Phase Transformation & Heat Treatment	3-0	3	100	50	2	1	50
PC	Mineral Processing	3-0	3	100	50	2	1	50
PC	Composite Material	3-0	3	100	50	2	1	50
PC	Deformation Behavior of Materials	3-0	3	100	50	2	1	50
HS	Engineering Economics/ Organizational Behavior	2-1	3	100	50			
	*Skill Project and Hands on					6	3	100
Total		18	18	600	300	14	7	300
Total Marks: 1200								
Total Credits: 25								
Honours	Diffusion materials	4	4	100	50			

- *College should conduct at least one NSDC program under this categor

Fifth Semester(Third Year Engineering)								
		Theory				Practical		
Code	**Course Name**	**Hours/ Week L/T**	**Credit Theory**	**University Marks**	**Internal Evaluation**	**Hours/ week L/T**	**Credit Practical**	**Marks**
PC	Mechanical Working & Testing of Materials	3-0	3	100	50	2	1	50
PC	Solidification & Casting Processes	3-0	3	100	50	2	1	50
PC	Ferrous Metallurgy-I	3-0	3	100	50	2	1	50
PE	Fuel Furnaces & Refractories/Nanomaterials/Characterization	3-1	4	100	50			
OE	Advance Numerical Methods/Non-Conventional energy Sources/Operating system/Industrial Process Control & Dynamics	3-1	4	100	50			
PC	Advance Lab-I(Advanced Materials Processing)					8	4	200
Total		17	17	500	250	14	7	350
Total Marks: 1100								
Total Credits: 24								
Honours	Material Failure & Analysis	4	4	100	50			
Minor Specialization								

Sixth Semester								
		Theory				Practical		
Code	**Course Name**	**Hours/ Week L/T**	**Credit Theory**	**University Marks**	**Internal Evaluation**	**Hours/ week L/T**	**Credit Practical**	**Marks**
PC	X-ray & electron Microscopy	3-0	3	100	50	2	1	50
PC	Ferrous Metallurgy-II	3-0	3	100	50	2	1	50
PE	Corrosion & Degradation of Materials/Joining of Materials/Advances Casting Processes	3-1	4	100	50			
PE	Non-Ferrous Extractive Metallurgy/	3-1	4	100	50			
MC &GS	Environmental Science & Engineering	3-0	3	100	50			
OE	Industrial Lecture #					3	1	50
HS	Presentation Skill & Skill for Interview # #	2-0	1		50	4	2	100
MC	Yoga					2	1	50
Total		19	18	500	300	13	6	300
Total Marks: 1100								
Total Credits: 24								
Honours	Secondary Steel Making	4	4	100	50			
Minor Specialization								

To be conducted by the Training & Placement department by inviting experts from the industry. No academician to be called. Record may be asked by the University for verification. Evaluation to be done by the TPO.

To be conducted by the Training & Placement department of the College.

Final Year Engineering

Seventh Semester								
	Theory					Practical		
Code	**Course Name**	**Hours/ Week L/T**	**Credit Theory**	**University Marks**	**Internal Evaluation**	**Hours/ Week L/T**	**Credit Practical**	**Marks**
GS	Nano Science & Bio Technology	3-1	4	100	50			
PE	Materials for Advanced Applications/Engg. Polymers/Surface Engg.	3-1	4	100	50			
PE	Alternative Routes of Iron Making/Ferroalloys Technology/Electrometallurgy	3-1	4	100	50			
OE	Soft Computing */ Other subjects	3-1	4	100	50			
PC	Advance Lab-II/ Project					8	4	200
	Projects on Internet of Things					8	4	200
Total		16	16	400	200	16	8	400
Total Marks: 1000								
Total Credits: 24								
Honours	Tribology of Materials / Computer Application in Metallurgical Engineering	4	4	100	50			
Minor Specialization								

*Student can choose from any department but subject must be running in that semester.

Eighth Semester						
	Training cum Project				Evaluation Scheme	
Code	**Course Name**	**Hours/ Week L/T**	**Credit Theory**	**Total Marks**		**Marks**
	Industrial Training cum Project/ Entrepreneurship Training cum Project / Stratup Training cum Project	30	20	1000	Evaluation by the Industry / Training Organisation	500
					Evaluation by the Institute (Report & Institute Viva)	500
Total		30	20	1000		1000
Total Marks:1000						
Total Credits:20						

Note- Minimum Pass Mark from Industry Evaluation is 300 (i.e. 60%)

Distribution of Credit Semester wise:

Semester	Credit
First	25
Second	25
Third	23
Fourth	25
Fifth	24
Sixth	24
Seventh	24
Eighth	20
Total	190

Internal Evaluation Scheme

Attendance & Class Interaction	05
Assignment	05
Surprise Test	05
Quiz	05
Class Test I & II	30
Total	50
Class Test Time(Hrs.): 1	

Pass Mark in Internal is 50% of total marks i.e. 25

External Evaluation Scheme

University Semester Examination of 3 Hours duration.

Pass mark will be 35% which means students have to score 35 out of 100.

Practical/Sessional Evaluation Scheme

Pass mark will be 50% which means students have to score 25 out of 50.

Evaluation Scheme

Attendance & Daily Performance	-10
Lab Record	- 10
Lab Quiz	- 05
Final Experiments & Viva	– 25
Total	=50

All Lab examinations are to be completed one week before the end semester examination and marks are to be displayed on the college notice board.

DETAIL SYLLABUS
FROM
III - VIII SEMESTER OF B.TECH. DEGREE PROGRAMME

for

ADMISSION BATCH 2015-16

BRANCH-METALLURGICAL AND MATERIALS ENGINEERING

Second Year Engineering									
Third Semester									
	Theory						Practical		
Code	**Course Name**		**Hours/ Week L/T**	**Credit Theory**	**University Marks**	**Internal Evaluation**	**Hours/ Week L/T**	**Credit Practical**	**Marks**
PC	Science &Engg. Of Materials		3-0	3	100	50	2	1	50
PC	Metallurgical Thermodynamics & Kinetics		3-0	3	100	50	2	1	50
PC	Transport Phenomena		3-0	3	100	50	2	1	50
PC	Materials Processing		3-0	3	100	50	2	1	50
PC	Principle OF Extractive Metallurgy		3-1	4	100	50			
HS	Engineering Economics/ Organizational Behavior		2-1	3	100	50			
Total			19	19	600	300	8	4	200
Total Marks: 1100									
Total Credits: 23									
Honours		Physical materials	4	4	100	50			
Minor Specialization									

3rd Semester

SCIENCE AND ENGINEERING OF MATERIALS

Module-I

Bonding in Solids: Ionic, Covalent, and Metallic bonding, bonding forces and energy, secondary bonding.

Crystal Structure: Space lattices and Bravais lattices, Miller Indices of planes and directions, slip planes and slip directions, stereographic projections.

Selected crystal structures: Pure metals, Diamond and Graphite, coordination in ionic crystals, AB type compounds, Silica, Alumina, Complex Oxides, Silicates. Inorganic glass: Network structure in glasses. Polymeric structures: Thermo plastics, Elastomers, Thermosets, crystalinity in polymers.

Module-II

Principles of Alloy theory: Primary substitutional solid solution, Interstitial solid solution, types of intermediate phases, Ordered-Disordered phenomena. Hume Rothery Rules, Intermetallic compounds, Normal valency compounds, Electron compounds, Interstitial compounds.

Imperfections: Point defects, Vacancies, Interstialcies, Dislocations; Edge & Screw dislocations; Burgers vector. Crystallization from the melt:

Freezing of a pure metal, plane front and dendritic solidification at a cooled surface, formation of cast structure, gas porosity and segregation, directional solidification.

Module-III

Binary Phase Diagrams: Isomorphous, Eutectic, Peritectic, Eutectoid, Monotectic and Syntectic systems, Phase rule and Lever rule. Iron-Cementite Equilibrium diagrams and its applications, Plain carbon and alloy steel, Industrial applications of steels.

Diffusion: Fick's First and Second law of diffusion, Atomic model of diffusion, Grain boundary, surface and thermal diffusion, Kirkendall Effect, Interstitial diffusion.

Nucleation: Homogeneous and Heterogeneous nucleation, Kinetics of nucleation, Growth and overall transformation kinetics.

Books for reference:

1. V. Raghavan, Materials Science and Engineering, Prentice-Hall of India Private Limited,2003.
2. W. F. Smith, Mc Graw Hill, Principles of Materials Science and Engineering, New York,1994.
3. R. E Reid Hill, Physical Metallurgy Principles, PWS-Kent Publishing,2004.
4. Vijendra Singh, Physical Metallurgy, Standard Publisher,2008.
5. C.Daniel Yesudian and D.G.Harris Samuel, Scitech Publication,India-2010
6. W. D. Callister, Materials Science & Engineering, An Introduction, John Wiley & Sons,2007.
7. L. H. Van Vlack, Addison Wisley, Elements of Materials Science and Engineering, New York, 1985.
8. M.S.Vijaya and G.Rangarajan Mc Graw Hill Education(India)-2014

(Practical)

Suggested experiments:

1. *Preparation of metallurgical sample for microscopic observation.*
2. *Study of Metallurgical Microscope and familiarity with its components.*
3. *Determination of cooling curves of pure metals like Pb, Zn and Sn. Also acquaintance to differential cooling curves.*
4. *Microstructure of pure metals.*
5. *Microstructure of isomorphous alloys belonging to Cu-Zn, Cu-Sn and Cu-Ni systems.*
6. *Effect of cold working on hardness and microstructures of metals like Cu.*
7. *Recrystallisation and grain growth in cold worked and annealed Cu.*
8. *Microstructure of plain carbon annealed steels with variation in carbon content (Hypoeutectic, eutectic, Hypereutectic)*

3rd Semester

METALLURGICAL THERMODYNAMICS & KINETICS

Module I (15 Hours)

Importance of Thermodynamics, definition of thermodynamic terms; concept of states, simple equilibrium. Equation of states, extensive and intensive properties, homogeneous and heterogeneous systems. Phase diagram of a single component system. Internal energy, heat capacity, enthalpy, isothermal, and adiabatic processes.
Second law of thermodynamics, entropy, degree of reversibility and irreversibility, criteria of equilibrium, auxiliary functions, combined statements, Maxwell's relations, transformation formula, Gibbs-Helmoltz equation.
Concept of Third law of thermodynamics, temperature dependence of entropy, statistical interpretation of entropy, Debye and Einstein concept of heat capacity, relation between C_p and C_v, consequences of third law.

Module II (13 Hours)

Fugacity, activity, equilibrium constant, use of S-functions, controlled atmospheres, homogeneous and heterogeneous equilibrium.
Ellingham – Richardson diagrams, phase stability diagrams.
Solutions: partial molal quantities, ideal and non-ideal solutions, Henry's law, Gibbs – Duhem equation, regular solution, quasi-chemical approach to solution, statistical treatment. One weight percentage standard state, chemical potential, phase relations and phase rule – its applications.

Module III (15 Hours)

Free energy – composition diagrams for binary alloy systems, determination of liquidus, solidus and solvus lines. Effect of pressure on phase transformation and phase equilibria.
Thermodynamics of electrochemical cells, solid electrolytes. Thermodynamics of point defects in solids.
Introduction to metallurgical kinetics: heterogeneous reaction kinetics: gas-solid, solid – liquid, liquid – liquid and solid-solid systems. Empirical and semi-empirical kinetics, concept of Johnson – Mehl equation, Thermal analysis.

References

1. *Introduction to the Thermodynamics of Materials by D.R.Gaskell; Taylor and Francis.*
2. *Physical Chemistry of Metals by L.S.Darken & R.W. Gurry; McGraw Hill Book Company Inc.*
3. *Problems in Applied Thermodynamics by C. Bodsworth & A.S. Appleton; Longmans, Green and Co. Ltd.*
4. *Principles of Metallurgical Thermodynamics by S.K.Bose and S.K.Roy;University Press-IIM*
5. *Introduction to Metallurgical Thermodynamics by R.H.Tupkary; tu publishers, Nagpur.*
6. *Problems in Metallurgical Thermodynamics & Kinetics by G.S. Upadhyay & R.K.Dube; Pergamon Press.*
7. *Chemical and Metallurgical Thermodynamics – Part I & II by M.L.Kapoor.*
8. *Kinetics of Metallurgical Reactions by H.S.Ray; Oxford and IBH Publishing Co.*
9. *Textbook of Materials and Metallurgical Thermodynamics by A. Ghosh; Prentice Hall of India Pvt. Ltd.*

(Practical)

Suggested experiments:

1. *Isothermal Kinetic study of limestone decomposition.*
2. *Devolatilization kinetics of Coal.*
3. *Oxidation of Copper.*
4. *To study the decomposition of calcium carbonate and determination of equilibrium constant and free energy change.*
5. *To determine the partial molal volume of each component in a solution of water and ethanol.*
6. *To study the effect of temperature on % reduction of iron ore pellet.*
7. *To study the effect of time on % reduction of iron ore pellet*
8. *Pelletization of iron ore fines, firing of pellets and measurement of their crushing strengths.*
9. *Dilatometric study of given Al plate sample*
10. *Thermal analysis of 0. 2% C steel using DSC – TG technique to study Microstructural changes with temperature*

3rd Semester

TRANSPORT PHENOMENA

Module I (14 hours)

Classification of fluids, ideal & real, Newtonian & Non-Newtonian, Newton's law of viscosity. Types of fluid flow – streamline & turbulent, continuity equation for incompressible and compressible fluid and its application. Concept of velocity bounds layer.; Bernoulli's equation and its application for flow measurement by venturimeter, orifice meter, pilot tube and rotameter. Dimensional analysis by Rayleigh's method of indices and Buckingham's π theorem. Example of analysis of pressure gradient, mass transfer co-efficient & convective heat transfer co-efficient, concept of similarly and dimensionless criteria. Dimensionless groups & their significance. Pressure drop & friction factor in various configurations, flow in packed bed & fluidized bed. Free and partially restricted jets, high velocity fluid jets.

Module II (14 hours)

Heat Transfer: Internal & External modes of heat transfer, steady state heat conduction in monolayer and composite flat walls & cylinders. Unsteady state heat conduction, thin & massive body heating & cooling. Finite difference method in solving unsteady state heat conduction. Natural and forced convection, concept of heat transfer co-efficient, thermal boundary layers, some examples of connective co-relations. Law of radiation – Steffan-Boltzmann's law, Kirchoff's law & Lambarth's law, Black & grey body concepts, view factor, Radiation from flames & gases. Radiation between simple surfaces with & without absorbing gas media. Radiation shields. Overall Heat transfer co-efficient.

Module III (12 hours)

Mass transfer: Mass Transfer: Law of diffusion and their application, concept of mass transfer co-efficient & concentration boundary layer, Interfacial mass transfer, overall mass balance.

Books for Reference:-

1. *Transport Phenomena by R. B. Bird, W. E. Stewart and E. N. Lightfoot, Wiley, 1960*
2. *Transport Phenomena in Metallurgy by G. H. Geiger and D. R. Poirier, Addison-Wesley,*
1. *1973.*
2. *Rate Phenomena in Process Metallurgy by J. Szekely and N. J. Themelis*
3. *Rate Processes in Metallurgy by A. K. Mohanty, PHI*
4. *J. R. Welty, R. E. Wilson and C. E. Wicks, Fundamentals of Momentum Heat and Mass Transfer, Wiley, 1976.*

(Practical)

Suggested experiments:

1. *To find thermal conductivity of composite wall.*
2. *To find overall heat transfer coefficient in counter flow heat exchanger/parallel flow heat exchanger.*
3. *To determine the mass transfer coefficient for the given system using experimental set up.*
4. *To verify the flow whether it is laminar or turbulent.*
5. *To find out the pressure drop (flow through pipes).*
6. *To determine minimum fluidisation velocity and pressure drop.*
7. *To find out the pressure drop when a fluid is flowing through a packed bed.*
8. *To find out the flow rate of fluid flowing inside a pipe by using venturi meter.*
9. *To find out the flow rate of fluid flowing inside a pipe by using orifice meter*
10. *To verify the Bernoulli's equation by using Bernoulli's apparatus.*

3rd Semester

Materials Processing

Module I (16 hours)

Introduction to metal casting, Moulding methods, materials and processes, with special reference to patterns, sand and binders. Solidification of short & long freezing range alloy castings, Gating and Risering of castings. Melting practices for ferrous and non-ferrous alloys-Cupola, rotary furnace, induction furnace, crucible furnace melting. Casting defects and remedy. Special casting processes.

Module II (13 hours)

Introduction to metal joining processes. Theory and classification of welding processes. Metallurgical principles involved in welding of carbon and alloy steels and important nonferrous alloys. Welding defects and their remedies.

Module III (13 hours)

Basic processes in Powder Metallurgy, Characteristics of powders. Compaction in rigid dies. Sintering of metal powders. Application of powder metallurgy products-their relative advantages.

Books for reference:

1. *Casting by J. Campbell , Butterworth - Haneman, London, 1993*
2. *Solidification Processing by M.C. Flemings, McGraw Hills, 1974.*
3. *Principles of Metal Casting by Heine, Loper, Rosenthal,.*
4. *Welding by Little, TMH.*
5. *Welding by A.C. Davies, Cambridge University Press.*
6. *Metallurgy of Welding, Brazing and Soldering by J.F.Lancaster.*
7. *Metallurgy of Welding by Sefarin, John Wiley.*
8. *Welding Hand Book, Vol-I &II.*
9. *Introduction to Powder Metallurgy by F.V.Lenel*
10. *Powder Metallurgy Science by R.M.German*
11. *Treaties on Powder Metallurgy by Goetzel, Vol-I&II*
12. *Powder Metallurgy by R.Lsande & C.R.S.Shakespere*
13. *Powder Metallurgy by A.K.Sinha, Dhanpat Rai*
14. *Powder Metallurgy, ASM Metals Handbook Vol-7*

(Practical)

Suggested experiments:

1. *Examination of the various zones of the arc in arc welding process.*
2. *Effect of increasing amperage on the quality of weld bead.*
3. *Microstructural investigation of the welded and heat affected zones.*
4. *Brazing of steel/ cast iron and observation of the relevant joined microstructures.*
5. *Preparation of standard samples for common sand testing.*
6. *Measurement of green compression strength, permeability and moisture content in the moulding sand.*
7. *Determination of compressive strength in sodium silicate/C02 mould as a function of gassing time and pressure.*
8. *Determination of the tensile strength of oil/resin bonded core sand.*
9. *Experiments on mechanical working processes like rolling, forging, extrusion, wire drawing, forming.*

3rd Semester

Principles of Extractive Metallurgy

Module I (14 hours)

Unit processes in Pyrometallurgy:Calcination and roasting, sintering, smelting, converting, reduction, smelting-reduction, metallothermic and hydrogen reduction; distillation and other physical and chemical refining methods: Fire refining, Zone refining, Liquation and Cupellation.Small problems related to pyro metallurgy.

Module II (14 hours)

Unit processes in Hydrometallurgy:Leachingpractice: In situ leaching, Dump and heap leaching, Percolation leaching, Agitation leaching,Purification of leach liquor,Kinetics of Leaching; Bio-leaching: Recovery of metals from Leach liquor by Solvent Extraction, Ion-exchange , Precipitation and Cementationprocess. Importance of potential-pH diagram. Some process flow sheet: recovery of Au from leach liquors, recovery of Nickel and Cobalt
Small problems relate to hydrometallurgy

Module III (12 hours)

Unit Process in Electrometallurgy:Faraday's Laws of Electrolysis, concept of overvoltage, limiting current density, total cell voltage, series and parallel electrical circuits in refining, aqueous and fused salt electrolysis, electro refining of common metals like Cu, Zn, Au, Ni, Al, Mg etc.Electroplating
Small related problems to Electrometallurgy

Books for Reference:

1. *Principles of Extractive Metallurgy by T. Rosenqvist.*
2. *Principles of Extractive Metallurgy by Ahindra Ghosh and H. S. Ray.*
3. *Unit Processes of Extractive Metallurgy by R. D. Pehlke.*
4. *Fundamentals of Metallurgical Processes by L. Coudurier, D. W. Hopkins and I. Wilkomirsky.*
5. *Metallurgical Problems by A. Butts.*
6. *Electrochemical Engineering by C. L. Mantell.*
7. *Principles of Mineral Dressing by A. M. Gaudin.*
8. *Text Book of Ore Dressing by R. H. Richards and C. E. Locks.*
9. *Element of Ore Dressing by A.E. Taggart.*
10. *Handbook of Mineral Dressing- Ores and Industrial Minerals by A.E. Taggart.*
11. *Textbook of Ore Dressing by S.J. Trusscott.*
12. *Ore Dressing by S.K. Jain.*
13. *Mineral Processing Technology by Berry A Willis.*

3rd Semester

Engineering Economics & Costing

Module-I: (12 hours)

Engineering Economics – Nature and scope, General concepts on micro & macro economics. The Theory of demand, Demand function, Law of demand and its exceptions, Elasticity of demand, Law of supply and elasticity of supply. Determination of equilibrium price under perfect competition (Simple numerical problems to be solved). Theory of production, Law of variable proportion, Law of returns to scale.

Module-II: (12 hours)

Time value of money – Simple and compound interest, Cash flow diagram, Principle of economic equivalence. Evaluation of engineering projects – Present worth method, Future worth method, Annual worth method, internal rate of return method, Cost-benefit analysis in public projects. Depreciation policy, Depreciation of capital assets, Causes of depreciation, Straight line method and declining balance method.

Module-III: (12 hours)

Cost concepts, Elements of costs, Preparation of cost sheet, Segregation of costs into fixed and variable costs. Break-even analysis-Linear approach. (Simple numerical problems to be solved)
Banking: Meaning and functions of commercial banks; functions of Reserve Bank of India. Overview of Indian Financial system.

Text Books:

1. *Riggs, Bedworth and Randhwa, "Engineering Economics", McGraw Hill Education India.*
2. *M.D. Mithani, Principles of Economics.*

Reference Books :

1. *Sasmita Mishra, "Engineering Economics & Costing ", PHI*
2. *Sullivan and Wicks, " Engineering Economy", Pearson*
3. *R.Paneer Seelvan, " Engineering Economics", PHI*
4. *Gupta, " Managerial Economics", TMH*
5. *Lal and Srivastav, " Cost Accounting", TMH*

3rd Semester

Organizational Behaviour

Module I : (14 hours)

The study of Organizational Behaviour : Defination and Meaning, Why Study OB
Learning – Nature of Learning, How Learning occurs, Learning and OB.
Foundations of Individual Behaviour : Personality – Meaning and Defination, Determinants of Personality, Personality Traits, Personality and OB.
Perception – Meaning and Definition, Perceptual Process, Importance of Perception in OB.
Motivation – Nature and Importance, Herzberg's Two Factor Theory, Maslow's Need Hierarchy Theory, Alderfer's ERG Theory, Evaluations.

Module II : (14 Hours)

Organizational Behaviour Process : Communication – Importance, Types, Gateways and Barriers to Communication, Communication as a tool for improving Interpersonal Effectiveness, Groups in Organizations – Nature, Types, Why do people join groups, Group Cohesiveness and Group Decision-making Managerial Implications, Effective Team Building. Leadership-Leadership & Management, Theories of Leadership-Trait theory, Leader Behaviour theory, Contingency Theory, Leadership and Followership, How to be an effective Leader, Confict-Nature of Conflict and Conflict Resolution. An Introduction to Transactional Analysis (TA).

Module-III : (14 Hours)

Organization : Organizational Culture – Meaning and Definition, Culture and Organizational Effectiveness. Introduction to Human Resource Management-Selection, Orientation, Training and Development, Performance Appraisal, Incentives Organizational Change – Importance of Change, Planned Change and OB techniques. International Organisational Behaviour – Trends in International Business, Cultural Differences and Similarities, Individual and Interpersonal Behaviour in Global Perspective.

Books for Reference:

1. *Keith Davis, Organisational Behaviour, McGraw-Hill.*
2. *2 Fred Luthans, Mc Graw Hill Educaation,India-Twelfth Edition-2013*
3. *K.Aswathappa, Organisational Behaviour, Himalaya Publishing House.*
4. *Reference Books :*
5. *Stephen P. Robbins, Organisational Behaviour, Prentice Hall of India*
6. *Pradip N. Khandelwal, Organizational Behaviour, McGraw-Hill, New Delhi.*
7. *Uma Sekaran, "Organizational Behaviour", TATA McGraw-Hill, New Delhi.*
8. *Steven L McShane, Mary Ann Von Glinow, Radha R Sharma" Organizational*
9. *Behaviour" , TATA McGraw- Hill.*
10. *D.K. Bhattachayya, "Organizational Behaviour", Oxford University Press*
11. *K.B.L.Srivastava & A.K.Samantaray, "Organizational Behaviour" India Tech*

3rd Semester

PHYSICS OF MATERIALS (HONOURS)

Module I (13Hours)
Crystallography: Crystalline and amorphous structures, Elements of crystal symmetry, symmetry elementsand axes, two, three, four and six fold symmetry, review of atomic bonding. Order-disorder transformations:Ordering, Degrees of long range and short range ordering, Anti phase domain, super lattice, Elements of superlattice theories, properties and applications.

Module II (13 Hours)
Electron theory of Metals: Heisenberg's uncertainty principle, Schrodinger's equation, free electron theory,Zone theory, Density of states, Fermi energy level, Application of zone theory to alloy phases; Conductorsand insulators, semi conductors, P- and N- type semi conductors. Optical properties, Refraction, Absorption,Absorption in dielectrics, photographic images, Luminescence, Lasers.

Module III (14 Hours)
Magnetic Properties: Dia, Para and Ferro- magnetism, Domain theory of Ferro magnetism, Antiferromagnetism and Ferrites, Hysteresis loop, soft magnetic materials, Hard magnetic Materials, Superconductivity, BCS theory, Type- I and Type- II super conductors. Thermoelectric properties of metals andsemiconductors, ionic and superionic conductivity in solids. Different types of dielectric materials, ferro,antiferro and ferri-electric materials. Piezo electric materials.

Books for Reference:

1. *Reed Hill R.E., Physical Metallurgy Principles, Affiliated East West.*
2. *Kakani S.L. and Kakani A., Materials Science, New Age International.*
3. *Higgins R.A., Engineering Metallurgy, Standard Publishers.*
4. *Raghavan V., Materials Science and Engineering, PHI.*
5. *Mauraka S.P. and Peckrar M.C., Electronic Materials Science and Technology, Academic Press.*
6. *Rose-innes A.C. and Rhoderick E.H., Introduction to Superconductivity, Pergamon press, Oxford.*
7. *Srivastava C.M. and Srinivasan C., Science of Engineering Materials, New Age Pub., New Delhi.*
8. *Kittel C., Introduction to Solid State Physics, John Wiley.*
9. *Streetman B.G., Solid State Electronic Devices, Prentice Hall, New Delhi.*
10. *Goldman A., Van Nostrand, Modern Ferrite Technology, New York.*

Fourth Semester								
	Theory					Practical		
Code	**Course Name**	**Hours/ Week L/T**	**Credit Theory**	**University Marks**	**Internal Evaluation**	**Hours/ Week L/T**	**Credit Practical**	**Marks**
HS	Purely Applied Mathematics for Specific Branch of Engineering	3-0	3	100	50			
PC	Phase Transformation & Heat Treatment	3-0	3	100	50	2	1	50
PC	Mineral Processing	3-0	3	100	50	2	1	50
PC	Composite Material	3-0	3	100	50	2	1	50
PC	Deformation Behavior of Materials	3-0	3	100	50	2	1	50
HS	Engineering Economics/ Organizational Behavior	2-1	3	100	50			
	*Skill Project and Hands on					6	3	100
Total		18	18	600	300	14	7	300
Total Marks: 1200								
Total Credits: 25								
Honours	Diffusion materials	4	4	100	50			

4th Semester

APPLIED MATHEMATICS-II
"Will be updated soon"

4th Semester

PHASE TRANSFORMATIONS AND HEAT TREATMENT

Module I (14 Hours)

Introduction: Thermodynamics of phase equilibrium and phase changes; Definition, utility, order and classification of phase transformations.
Diffusion: Definition of Fick's law on steady and non-steady state diffusion and their solutions; Mechanism of diffusion in solids; Chemical diffusion and Darken's equation; Kirkendall effect; Effect of pressure and temperature on diffusivity.
Nucleation and growth: Formation of nucleus; Homogeneous and Heterogeneous nucleation; Mechanism and kinetics of thermally activated growth; Interface and diffusion control growth regimes.
Phase equilibrium and phase diagrams: Important phase changes in unary and binary systems; Types and interpretation of phase diagram; Utility of phase diagrams, Lever rule; Important phase diagrams in metallic and ceramic systems; Free energy Composition diagrams; Ternary phase diagrams; Isomorphous and eutectic Systems.

Module II (12 Hours)

Liquid-solid transformation: Solidification, nucleation and growth mechanisms and kinetics; Alloy solidification – cellular and dendritic morphology; Eutectic and peritectic solidification. Application of solidification.
Solid state diffusive transformation: Classification of solid-solid transformations; Nucleation in solids; Precipitate growth; Age hardening; Spinodal decomposition; Precipitate coarsening. Order-disorder change, polymorphic change. Recrystallization, grain growth. Eutectoid transformation. Application of solid state precipitation. Pearlitic and bainitic transformations in steel; Martensite and martensitic changes in ferrous materials.

Module III (12 Hours)

Review of Iron-carbon alloy system: Iron-cementite and iron-graphite phase diagrams, cooling of hypo-eutectoid, eutectoid and hyper-eutectoid steels, hypo-eutectic, eutectic and hyper-eutectic cast irons, nucleation and growth of pearlite.
Heat treatment of steels: TTT and CCT diagrams, conventional heat treatment processes – annealing, normalizing, hardening and tempering. Hardenability, role of alloying elements in steels. Surface hardening and chemical treatment in steels. Thermo-mechanical treatment of steels; High temperature and low temperature Thermo-Mechanical treatment. Heat treatment of some Cu, Al and Ti based alloys.

Books for reference

1. *Phase Transformations in Metals and Alloys by D. A. Porter and K. E. Easterling, CRC Press.*
2. *Phase Transformations in Materials by R. C. Sharma*
3. *Solid State Phase Transformations by Raghavan, PHI.*
4. *Steel and its Heat treatment by K E Thelning, Butterworth.*
5. *Heat Treatment by Rajan and Sharma, PHI.*
6. *Principles of Heat Treatment of Steels, ASM*
7. *Physical Metallurgy Principles by R. E. Reed-Hill, East West Press.*
8. *Theory of Transformations in Metals and Alloys by J.W.Christian, Pergamon Press.*
9. *W C Leslie, The Physical Metallurgy of Steels , MeGraw-Hill International.*

(Practical)

Suggested experiments:

1. *Annealing treatment of a cold worked steel and comparison of the annealed microstructure with the cold worked structure.*
2. *Normalizing treatment of steel and comparison of the microstructure with annealed structure.*
3. *To study the quenched structures of steel – quenched in oil, water and brine solution.*
4. *To study the quenched and tempered structures of steel –*
1. *(i) low temperature tempering.*
2. *(ii) medium temperature tempering.*
3. *(iii) high temperature tempering.*
4. *To study the recrystallisation behaviour of pure metal (iron / copper).*
5. *To study the effect of time and temperature on grain size of a metal (grain growth) (iron/ copper).*
6. *To study the nucleation rate and growth rate of pearlite in eutectoid steel.*
7. *To study the susceptibility of a steel to harden by quenching (hardenability) by Jominy test.*
8. *Pack carburizing of 0.2% carbon steel and to measure the diffusion coefficient of carbon in steel.*
9. *To study the microstructure of tool steels, stainless steels and other high alloy steels.*
10. *Austempering of steels and S G cast irons.*
11. *To carry out age hardening of non ferrous alloys.*
12. *Determination of hardenability of steels.*

4th Semester

MINERAL PROCESSING

Module I (14 Hours)

Introduction to mineral beneficiation, sampling, liberation studies and its importance.
Comminution: Fundamentals of comminution, crushing -- construction and operational features of jaw, gyratory, cone and roll crushers.
Grinding: Theory of ball mill, rod mill, critical speed of the mill, open circuit and closed circuit, circulating load.
Size separation: Sieving and screening, laboratory sizing and its importance, representation and interpretation of size analysis data, industrial screening.
Classification: Movement of solids in fluids, free setting and hindered settling of particles, different types of classifiers, e.g. sizing and sorting classifiers used in mineral industry.

Module II (12 Hours)

Concentration: Gravity separation, concentration criteria, jigging, flowing film concentration and tabling, dense media separation.
Froth flotation: Theory, reagents used in floatation processes, machines and practice.
Magnetic and electrostatic separation: Theory and application of magnetic and electrostatic separation techniques in mineral industry.
Dewatering and drying: Theory and practice of thickening; filtration and drying.

Module III (12 Hours)

Flow sheets: Typical flow sheets for beneficiation of iron, gold, copper, lead-zinc sulphide ores, rock phosphate, beach sand, uranium and other industrial minerals.
Agglomeration techniques: Sintering, palletizing, briquetting and their applications in ferrous and non-ferrous metal industries, testing of agglomerates. Important mineral deposits in India.

Books for reference

1. *Principle of Mineral Dressing by A. M. Gaudin.*
2. *Text Book of Ore Dressing by R. H. Richards and C. E. Locks.*
3. *Element of Ore Dressing by A.E. Taggart.*
4. *Handbook of Mineral Dressing- Ores and Industrial Minerals by A.E. Taggart.*
5. *Textbook of Ore Dressing by S.J. Trusscott.*
6. *Ore Dressing by S.K. Jain.*
7. *Mineral Processing Technology by Berry A Willis.*

(Practical)

Suggested list of experiments:

1. *Physical examination and identification of minerals.*
2. *Crushing of ore/ coal in a jaw crusher and to study the size analysis of the product.*
3. *To study the jaw crusher and determine the actual capacity and reduction ratio.*
4. *Verification of Rittinger's Law of crushing in a jaw crusher.*
5. *Crushing of ore/ coal in a roll crusher and to study the size analysis of the product.*
6. *Crushing of ore/ coal in a gyratory crusher / pulveriser and to study the size analysis of the product.*
7. *Crushing of ore/ coal in a cone crusher and to study the size analysis of the product.*
8. *To study the effect of grinding with grinding time in cylindrical ball mill and rod mill.*
9. *To separate coal from a mixture of coal and stones or quarts by zigging and determine the weight fractions of the products.*
10. *To separate a mixture of two minerals of different densities by gravity concentration using Wilfley Table and determine the weight and density of each fraction of the products.*
11. *Beneficiation of ore pulp mix using flotation cell.*
12. *To separate a mixture of iron and sand using magnetic separator and determine its efficiency.*
13. *Screening of ore/ coal using vibrating screen and determine its effectiveness.*

COMPOSITE MATERIALS

Module I (14 Hours)

Introduction: definitions and classifications; natural composites; role of matrix and reinforcement; factors which determine properties; the benefits of composites.
Reinforcements and the reinforcement matrix interface: natural fibers; synthetic organic fibers – aramid, polyethylene; and synthetic inorganic fibers – glass, alumina, boron, carbon, silicon based fibers; particulate and whisker reinforcements, reinforcement-matrix interface – wettability, interfacial bonding, methods for measuring bond strength.
Metal matrix composites: Introduction, important metallic matrices; metal matrix composite processing: solid state processing – diffusion bonding, powder metallurgy; liquid state processing – melt stirring, compocasting (rheocasting), squeeze casting, liquid infiltration under gas pressure; deposition – spray co-deposition and other deposition techniques like CVD and PVD; in situ processes. Interface reactions. Properties of MMCs – physical properties; mechanical properties like elastic properties, room temperature strength and ductility, properties at elevated temperatures, fatigue resistance. Processing, structure of multifilamentary superconductors, properties of aluminium reinforced with silicon carbide particles.

Module II (12 Hours)

Ceramic matrix composites: Introduction; processing and structure of monolithic materials – technical ceramics, glass-ceramics. Processing of ceramics: conventional mixing and pressing – cold pressing and sintering, hot pressing, reaction bonding processes, techniques involving slurries, liquid state processing – matrix transfer moulding, liquid infiltration, sol-gel processing, vapour deposition techniques like CVD, CVI, liquid phase sintering, lanxide process and in situ processes. Processing, properties and applications of alumina matrix composites - SiC whisker reinforced, zirconia toughened alumina; Glass-ceramic matrix composites; Carbon-carbon composites - porous carbon-carbon composites, dense carbon-carbon composites.
Polymer matrix composites: Introduction; polymer matrices – thermosetting, thermoplastic, rubbers. Processing of PMCs: Hand methods – hand lay-up, spray-up methods; Moulding methods – matched die moulding, bag moulding processes (autoclave moulding), resin transfer moulding, pultrusion; Filament winding; Injection moulding. Processing, properties and applications of fibre-reinforced epoxies, PEEK matrix composites, rubber matrix composites. Damping characteristics. Environmental effects in polymer matrix composites. Recycling of PMCs.

Module III (12 Hours)

Sandwich structures, foam core type arrangements; Honey comb structures.
Micromechanics of unidirectional composites: micromechanics models for stiffness – longitudinal stiffness, transverse stiffness, shear modulus, poisson's ratio. Micromechanics models for strength – longitudinal tensile strength, longitudinal compressive strength, transverse tensile strength, transverse compressive strength, inplane shear failure, thermal and moisture effects.
Short fibre composites: reasons for using short fibre composites, fibre length, fibre orientation, stress and strain distribution at fibres, critical fibre length and average fibre stress, stiffness and strength: stiffness of aligned systems, non-aligned systems and variable fibre orientation, strength of aligned systems, 2-D composites, variable fibre orientation.
Toughening mechanisms in composite materials: crack bowing, crack deflection, debonding, pull-out, wake toughening, microcrack toughening, transformation toughening.

Books for reference:

1. *Composite Materials: Engineering and Science, by Matthews and Rawlings, CRC Press.*
2. *Composite Materials Science and Engineering, K.K.Chawla, Springer.*
3. *An Introduction to composite material, by D.Hull and T.W. Clyne, Cambridge University press.*
4. *Metal Matrix Composites, Thermomechanical Behaviour by M.Taya, and R.J.Arsenault, Pergamon Press, Oxford.*
5. *Fundamentals of Metal Matrix Composites by S.Suresh, A.Martensen, and A.Needleman, Butterworth, Heinemann*

(Practical)

Suggested list of experiments:

1. *Fabrication of Al-Ceramic particulate composite by stir casting method.*
2. *Fabrication of Ceramic matrix particulate composite by powder metallurgy route.*
3. *Comparison of mechanical properties (Strength, Hardness, Wear) of MMC with monolith metals.*
4. *Fabrication of CMCs by Sol-Gel technique.*
5. *Fabrication of composites by insitu method.*

4th Semester

DEFORMATION BEHAVIOUR OF MATERIALS

Module-I (14 Hours)

Introduction: Elastic, plastic and visco-elastic deformation.
Continuum mechanics:Concepts of stress and strain in 3D stress and strain tensor, principal stresses and strains and principal axes, mean stress, stress deviator, maximum shear, equilibrium of stresses, equations of compatibility, Octahedral shear stress and shear strain, Plastic stress-strain relationship.
Elastic behaviour of materials:Constitutive equations in elasticity for isotropic and anisotropic materials, strain energy, elastic stiffness and compliance tensor, effect of crystal structure on elastic constants.
Plastic response of materials:a continuum approach: classification of stress-strain curves, yield criteria.
***Plastic deformation of single crystals*:** Concepts of crystal geometry, lattice defects, deformation by slip, slip in a perfect lattice, slip by dislocation movement, critical resolved shear stress, deformation by twinning, stacking faults, deformation band and kink band, strain hardening of single crystal; stress-strain curves of fcc, bcc and hcp materials.

Module- II (12 Hours)

Dislocation Theory*:* Elements of dislocation theory, movement of dislocation, elastic properties of dislocation, intersection of dislocation, dislocation reactions in different crystal structures, origin and multiplication of dislocations, dislocation pile-ups.

Plastic deformation of polycrystalline materials: Role of grain boundaries in deformation, strengthening by grain boundaries, yield point phenomenon, strain ageing, strengthening by solutes, precipitates, dispersoids and fibres.

Module- III (12 Hours)

Fracture:Types of fracture in metals, theoretical cohesive strength of metals, Griffth theory of brittle fracture, fracture of single crystals, metallographic aspects of fracture, dislocation theories of brittle fracture, ductile fracture.
Tension test:Engineering & true stress-strain curves, evaluation of tensile properties, Tensile instability, Effect of strain-rate & temperature on flow properties.
Deformation in non-metallic materials:structure and deformation of polymers, concept Super-lattice dislocations in intermetallics, concept of charge associated with dislocations in ceramics.

Books for reference:

1. *Mechanical Metallurgy by G. E. Dieter, McGraw-Hill.*
2. *Deformation and Fracture Mechanics of Engineering Materials by R.W.*
1. *Hertzberg, John Wiley.*
2. *Mechanical Behaviour of Materials by M. A. Meyers and K. K. Chawla*

(Practical)

Suggested list of experiments:

1. *Determination of stress-strain curve of FCC & BCC materials.*
2. *Determination of stress-strain curve of polymeric materials.*
3. *Determination of stress-strain curve of ceramic materials.*
4. *Comparison of stress-strain behaviour of metallic, polymeric & ceramic materials.*
5. *Study of fracture surface of FCC & BCC metals and ceramics.*
6. *Determination of the effect of cold working on hardness of metals.*
7. *Determination of the effect of cold working on stress-strain behaviour of metals.*
8. *Determination of the effect of strain rate on UTS.*

4th Semester

SKILL PROJECT & HANDS ON

(College should conduct at least one NSDC program under this category)

"will be uploaded soon"

4th Semester

DIFFUSION IN MATERIALS (HONOURS)

Module-I (14 Hours)

Diffusion Equations: Flux Equation, Diffusion Equation, Diffusion Equation (Constant D, Kinetics of Precipitation, Stress-Assisted Diffusion, Solution for Variable D, Two phase Binary Systems.
Atomic Theory of Diffusion: Random Movement and the Diffusion Coefficient, Mechanism of Diffusion, Random Walk Problem, Calculation of D, Calculation of H and S from First Principles, Experimental Determination of Hv, Hm and Sv , Effect of Hydrostatic Pressure on Diffusion, Empirical Rules for Obtaining Q and D0, Divacancy Formation, Self Diffusion Anomalies.

Module-II (13 hours)

Diffusion in Dilute Alloys: Interstitials and Anelasticity, Impurity Diffusion in Pure Metals, Correlation Effects, Interstitial Diffusion in Substitutional Alloys.
Diffusion in a Concentration Gradient: The Kirkendal Effect, Darken Analysis, Phenomenological Equations, Relationship between Chemical D1 and Tracer D*1 , Test for Darken's Assumptions, Ternary Alloys.

Module-III(14 hours)

Diffusion in non Metals: Defects in Ionic Solids, Diffusion and Ionic Conduction, Experimental Check of Relation between σ and DT, Effect of Impurities on DT and σ, Effect of Impurities on Conductivity (Frenknel Disorder).
High Diffusivity Paths: Analysis of Grain Boundary Diffusion, Experimental Observations on Grain Boundary Diffusion, Dislocation & Grain Size Effects, Diffusion along Moving Boundaries, Surface Diffusion and Shape Change.

Books for Reference:

1. *Showmon P.,Diffusion in Solids, John Wiley & Sons, 2nd Edition, 2010*

Fifth Semester(Third Year Engineering)								
	Theory					Practical		
Code	**Course Name**	**Hours/ Week L/T**	**Credit Theory**	**University Marks**	**Internal Evaluation**	**Hours/ week L/T**	**Credit Practical**	**Marks**
PC	Mechanical Working & Testing of Materials	3-0	3	100	50	2	1	50
PC	Solidification & Casting Processes	3-0	3	100	50	2	1	50
PC	Ferrous Metallurgy-I	3-0	3	100	50	2	1	50
PE	Fuel Furnaces & Refractories/Nanomaterials/Characterization	3-1	4	100	50			
OE	Advance Numerical Methods/Non-Conventional energy Sources/Operating system/Industrial Process Control & Dynamics	3-1	4	100	50			
PC	Advance Lab-I(Advanced Materials Processing)					8	4	200
Total		17	17	500	250	14	7	350
Total Marks: 1100								
Total Credits: 24								
Honours	Material Failure & Analysis	4	4	100	50			
Minor Specialization								

5th Semester

MECHANICAL WORKING AND TESTING OF MATERIALS

Module I (14 Hours)

Classification of forming processes.
Fundamentals of metal working – Effect of temperature, strain rate, metallurgical structure, friction & lubrication, workability and residual stress.
Rolling - Classification & processes, load, torque, power, variables controlling process, forward slip. Fundamentals of roll pass design, mill type. Rolling defects and their control.
Forging - Classification & processes, load for circular & rectangular plate.
Extrusion - Classification & processes, force & variables affecting it.

Module II (12 Hours)

Drawing of Wires and Tubes- Processes, drawing stress.
Sheet Metal Forming- Forming methods, Forming limit criterion, Special Forming techniques and defects in formed products
National and International Standards for Mechanical tests
Hardness Tests- Brinell, Rockwell, Vickers, Meyer, Knoop, etc., relationship with flow curve.
Compression Test- Comparison with tension, phenomenon of buckling & barreling.
Torsion Test- Stresses for elastic & plastic strain, Torsion vs. Tension.
Bend Test- Pure bending & flexure formula.
Impact Test- Notched bar impact tests, transition temperature & metallurgical factors affecting it.

Module III (14 Hours)

Fracture- Energy based criterion, Strain energy release rate, stress intensity factor, fracture toughness estimation and design of engineering component.
Fatigue – Stress cycles & S-N curve, effect of mean stress, stress concentration, surface, size, metallurgical factors etc. on endurance limit, Cyclic stress-strain curve, Low cycle fatigue, High cycle Fatigue, Paris law.
Creep- Creep & Stress rupture tests, Mechanism of creep deformation, Deformation mechanism Maps, Development of creep resistant alloys, Prediction of long time properties, Creep-Fatigue interaction.
Non Destructive Testing: Scope and significance of non destructive testing. Principles, equipment, specifications and limitations of liquid penetrant, Magnetic particle, Eddy current, Ultrasonic and Acoustic emissions, and Radiography (X-Ray and Gamma Ray).

Books for reference:

1. *Mechanical Metallurgy by G. E. Dieter, McGraw-Hill.*
2. *Roll Pass Design, The United Steel Companies Ltd., U.K.*
3. *Testing of Metallic materials by C. Suryanarayana.*
4. *Principles of Industrial Metal Working Processes by C. Russak, G. W. Rowe.*
5. *Practical Non Destructive Testing by Baldev Raj.*

(Practical)

Suggested list of experiments:

1. *To determine the Vickers Hardness Number of the given Samples.*
2. *To determine the Brinell Hardness Number of the given Samples.*
3. *To determine the Rockwell Hardness of the given samples.*
4. *To determine the impact strength of the given samples by Charpy and Izod Impact Tests.*
5. *To determine the tensile properties of the given materials using Universal Testing Machine (UTM) – yield strength, tensile strength, % elongation, % reduction of area.*
6. *To determine the compression strength of the given sample.*
7. *To determine the fatigue strength of the given sample.*
8. *To determine the drawability of aluminium / steel sheet by Erichsen cup test.*
9. *Three– point bend test of non – metallic materials*
10. *Impact testing of steels / non – ferrous alloys / non – metallic materials*
11. *To determine the cracks in a sample using the magnetic crack detector.*
12. *Wear studies of different carbon steels.*

5th Semester

SOLIDIFICATION AND CASTING PROCESSES

Module I (14 Hours)

1. ***Introduction:*** Casting as a process of Manufacturing. Advantages of casting over other forming processes. A brief mention about mould and its components etc. with special reference to mould factors in metal flow and moulding factors in casting design.
2. ***Special Casting Methods:*** Investment casting, Die casting, Centrifugal casting, Full mould casting, Vacuum sealed casting etc.
3. ***Melting Practices for Casting Purposes:*** Role of Ellingham diagram in melting of Metals for casting purposes; melting and post-melting treatments; Industrial melting practices as adopted for a few metals and alloys such as; Cast-iron; Steel; Copper; Aluminium, etc.

Module II (12 Hours)

4. ***Solidification of Metals and Alloys:*** Crystallisation, Liberation of energy and solute redistribution. Nucleation and growth processes; planar growth and factors hindering planar growth; Dendritic growth; Cellular growth; Independent nucleation; Eutectic freezing, Peritectic reactions.
5. ***Structure of Casting:*** Additional influences on structure.
6. ***Practical Control of Cast Structure:*** Grain shape and orientation; grain size consideration. Brief discussions on refinement and modification of cast structure.

Module III (10)

7. ***Principles of Gating and Risering*****:** Types of gates and Risers; Chowrinov rule; Gating ratio, Wlodawer system of determining feeder head requirements.
8. ***Casting Yield:*** Various considerations for improving casting yield.
9. ***Casting Defects and Their Remedies:*** Various casting Defects; Their causes and remedial measures.

Books for reference:

1. *Solidification Processing by M.C. Flemings, McGraw Hill.*
2. *Physical Metallurgy edited by R.W.Cahn and P.Hassen, North Holland.*
3. *Casting by J. Campbell, Butterworth - Haneman, London.*
4. *Principles of Metal Casting by Hein R.W., Loper C. R. & Rosenthal P.C, T.M.H.*
5. *Foundry Engineering by Taylor H.F., Flemming M.C. & Wulff, Wiley Eastern.*
6. *Foundry Technology by Beeley P.R., Butterworth, London.*

(Practical)

Suggested list of experiments:

1. *To determine the cooling curve of pure metals/ alloys.*
2. *To study the microstructure of ingot.*
3. *To compare the microstructure, hardness of Al casted in metal and sand mold.*
4. *To determine the contact angle of molten metal.*
5. *To study the casting defects by visual inspection and NDT methods.*
6. *To study the effects of grain refiners on the cast structure of Al alloys.*
7. *To study the front of solidification under different heat transfer conditions.*
8. *To study the effect of superheat temperature and pouring temperature on the microstructure of casting.*

FERROUS METALLURGY-I

Module I (14 Hours)

Raw materials and their properties: Iron ores, Limestones, Agglomerates and Coke. Preparation of ores: sintering and palletizing, blast furnace burdening and distribution, testing of raw materials for blast furnace, material balance.
Design: Blast furnace profile, stove and gas cleaning units; instrumentation, refractory used in blast furnace and stove.

Module II (14 Hours)

Reactions: Fe-C-O, Fe-O-H phase equilibria, Reactions in stack, bosh and hearth; formation of primary slag, bosh slag and hearth slag. Slag composition and its control, Metal-slag reactions, Control of hot metal composition.
Process Control: Factors affecting fuel consumption and productivity, Recent developments in Blast furnace operations like, Bell-less top charging system, High top pressure, Humidified & Oxygen enriched blast and Auxiliary fuel injection through tuyers.

Module III (12 Hours)

Irregularities in blast furnace operation and their remedies.
Alternative routes of iron making: Introduction, Processes of Sponge Iron production; SL/RN, MIDREX, HyL processes. Smelting Reduction Processes; COREX, ROMELT, Hismelt.

Books for reference:

1. *K. Biswas, Principles of Blast Furnace Iron Making, SBA publication, Calcutta, 1999*
2. *Ahindra Ghosh and Amit Chatterjee: Ironmaking and Steelmaking Theory and Practice, Prentice-Hall of India Private Limited, 2008*
3. *G. R. Bashforth, The Manufacture of Iron and Steel, vol.I, Chapman, London, 1962.*
4. *David H. Wakelin (ed.): The Making, Shaping and Treating of Steel (Ironmaking Volume), The AISE Steel Foundation, 2004.*
5. *Dipak Mazumdar, A First Course in Iron and Steel Making, University Press-IIM-2015*

(Practical)

Suggested list of experiments:

1. *Proximate analysis of coal and coke.*
2. *To determine calorific value of coal and coke using bomb calorimeter.*
3. *To determine bulk and true density of coal sample.*
4. *To determine shatter and abrasion indices of coal and coke.*
5. *To determine Reactivity of coke*
6. *To determine Reactivity of coke Reducibility of iron ore.*
7. *Evaluation of swelling index of pellet.*
8. *Pelletisation of Iron ore.*
9. *Preparation of fluxed, super fluxed and acid sinter*

5th Semester

FUEL FURNACES AND REFRACTORIES

Module I(12 Hours)

Fuels:

Classification of fuels: Solid, Liquid and Gaseous fuels. Primary and Secondary fuels.

Coal: Rank of coal, Caking, Coking and Non-coking Coals.

Characterisation of Coal: Proximate Analysis, Ultimate Analysis, Calorific value, Caking and Swelling index .Coal washing: Principle of coal washing, Washability curve, Washing efficiency (Yancey and Geer formula and Fraser and Yancey formula) and recovery of clean coal.

Coal blending and its importance in metallurgical industries.

Carbonisation of coal: Metallurgical coke preparation, Testing and properties of coke. Formed coke, Dry quenching of coke

Use of gaseous fuels: Coke oven gas, Blast furnace gas, Producer gas

Some coal combustion problems

Module II (14 Hours)

Furnaces:

Classification of Furnaces: based on the purpose, based on the type of fuel used, based on the use of waste heat saving appliance, based on draft control system and based on mode of operation of furnace.

Fuel economy of Industrial furnace: factors effecting fuel economy in the furnace.

Waste heat recovery: Recuperators; types(counter flow, parallel flow and heat flow) and availability. Temperature distribution in different types of recuperators, Sankey diagram for non-recuperative and recuperative batch reheating furnace. AMTD and LMTD.Heat transfer and principle of design.

Regenerators: Temperature distribution heat transfer and principles of design.

Module III (14 Hours)

Refractories:

Classification of refractories, Manufacturing, Testing and Properties of heavy and special refractories: Silica, Silicides, Sialon, high alumina, Magnesite, Chrome-magnesite, carbon and insulating refractories. Castables and Ramming masses.

Refractory selection for coke oven, iron Blast furnace, Copper convertor, soaking reheating furnaces, heat treatment and Electric arc furnace.

Books for reference:

1. *Fuels, Furnaces and Refractories by J.D. Gilchrist.*
2. *Refractories manufacture properties and uses by M.L.Mishra*
3. *Refractories manufacture properties and application by A.R.Chesti*
4. *Steel Plant Refractories by Chester*
5. *Refractories by Norton*
6. *Industrial Furnace, Vol –I & II, by Trinks&Mawhinney*

5th Semester

NANO MATERIALS

Module-I (12 Hours)

Introduction: Emergence and challenges of nanotechnology, Types of nonmaterial.
Synthesis and Characterization: Bottom-up and top-down approaches, Solid, Liquid, Gas phase synthesis, Hybrid Phase synthesis.

Module – II (12 Hours)

Structural characterization by XRD, SAXS, SEM, TEM, SPM, gas adsorption; Chemical characterization by spectroscopy techniques.

Module – III (16 Hours)

Properties and application of nanomaterials: Stability of nanomaterials, Mechanical properties, Optical, Electrical and Magnetic properties, Diffusion. Application of nanomaterials: Electronics and optoelectronics applications, Nanobots, Biological applications, Catalytic applications, Quantum devices, Application of carbon nanotubes, Nanofluids.

Books for reference:

1. *Nanostructures and Nanomaterials: Synthesis, Properties and Applications by G. Cao, Imperial College Press.*
2. *Textbook of Nanoscience and Technology , B.S.Murthy, P.Shankar, Baldev Raj, B.B.Rath and James Murday, University press-IIM-2012*
3. *Nanomaterails Handbook, (Ed.) by Y. Gagotsi, Taylor and Francis.*
4. *Introduction to Nanotechnology by C. P Poole and F. T. Owee, Willey Press.*
5. *Nano Materials Synthesis, Properties and Applications, by Edlstein and Cammarate.*
6. *Nano Materials, by A.K. Bandyopadyay, New age Publications.*
7. *Nano - The Essentials, by T. Pradeep, TMH.*
8. *Nanostructured Materials: Processing, Properties and applications, by C. Koch, William Andrew Publishing.*

5th Semester

CHARACTERIZATION OF MATERIALS

Module I (12 Hours)

Introduction:

Scope of subject, classification of techniques for characterization, macro and micro-characterization structure of solids. Bulk averaging techniques:

Thermal analysis: DTA, DSC, TGA, dilatometry, resistivity/ conductivity.

Optical & X-ray spectroscopy: Atomic absorption spectroscopy, X-ray spectrometry, infrared spectroscopy and Raman spectroscopy.

Mass spectroscopy: Principles and brief account.

Metallographic techniques: Optical metallography, image analysis, quantitative phase estimation.

Module II (14 Hours)

Diffraction methods:

X-ray diffraction, X-ray topography, residual stress measurement techniques, small angle X-ray and neutron scattering.

Electron optical methods:Scanning electron microscopy and X-ray microanalysis including electron probe microanalysis, electron optics, electron beam specimen interaction, image formation in the SEM. X-ray spectral measurements: WDS and EDS, quantitative X-ray analysis; application of SEM and EPMA to solid samples and biological materials; type of data base required to process the results.

Module III (14 Hours)

Analytical transmission electron microscopy: Electron diffraction, reciprocal lattice, analysis of SAD patterns; different electron diffraction techniques, atomic resolution microscopy, analytical devices with TEM, field ion microscopy, scanning tunneling microscopy, advanced techniques.

Methods based on sputtering or scattering phenomena: Field ion microscopy, atom probe microanalysis, low energy ion scattering spectroscopy, Rutherford back scattering spectroscopy, ion channeling and secondary ion mass spectroscopy.

Chromatography: Principles of gas chromatography, mass spectrometry, liquid and ion chromatography.

Books for reference:

1. *Materials Characterization, Metals Handbook, Vol 10, ASM*
2. *Characterization of Materials, by E N Kaufman, Wiley Publishers*
3. *Structure of Metals, by Barett, C.S. and Massalski, T.B., Pergamon Press, Oxford.*
4. *Elements of X-ray Diffraction, by Cullity B.D., Addison-Wesley, 1978*
5. *Transmission Electron Microscopy by Williams, D.B. and Barry Carter C., Plenum Press.*
6. *Scanning Electron Microscopy and X-Ray Microanalysis, by J.I. Goldstein, C. E. Lyman*
7. *Differential Thermal Analysis by R.C.Machenzie 8. Modern Metallographic Techniques and their application by Victor A.Phillips*

5th Semester

ADVANCED NUMERICAL METHODS

Module-I : **(10 Hours)**

Interpolation: Piecewise Linear Interpolation, Piecewise Quadratic Interpolation, Piecewise Cubic Hermite Interpolation, Piecewise Spline Interpolation.
Numerical Differentiation: First Derivative, Higher Derivatives, Partial Derivative, Richardson's Extrapolation. Romberg algorithm for numerical integration.

Module-II (10 Hours)

Eigen values and Eigen Vectors: Basic power method, Rayleigh Quotient, Shifted power method, Accelerating convergence, Inverse power method, Basic QR method, Better QR method, Finding Eigen vectors, Accelerating convergence
Fourier methods: Discrete Fourier Transforms, Fast Fourier Transforms, Matrix form of FFT, Algebraic form of FFT, Mixed-Radix FFT

Module-III (10 Hours)

Ordinary Differential Equations: Adams-Bashforth Methods, Adams-Moulton Methods, Adams Predictor-Corrector methods, Other Predictor-Corrector methods (Simpson's method and Milne's method)
Parabolic Partial Differential Equation: Explicit Method, Implicit method, Crank-Nicolson method
Hyperbolic Partial Differential Equation: Explicit Method, Implicit method. Elliptic Partial Differential Equation: Finite-Element method.

Text Book:

1. *L.V. Fausett," Applied Numerical Analysis Using MATLAB", Pearson Education*

Reference Books:

2. *1.W.Cheney and D. Kincaid,"Numerical Mathematics and Computing", Fifth Edition, Thomson/CENGAGE Learning*
3. *S.C.Chapra,"Applied numerical methods with MATLAB", second edition, Tata McGraw Hills*
4. *R.J. Schilling and S.L.Harris,"Applied Numerical Methods for Engineering", CENGAGE learning*

5th Semester

NON CONVENTIONAL ENERGY SOURCES

Module I (10 Classes)

***Energy, Ecology and environment*:** Introduction, Classification of Energy Resources, Common Forms of Energy, Energy Chain, Advantages and Disadvantages of Conventional Energy Sources, Importance and Salient Features of Non-Conventional Energy Sources, Environmental and ecological Aspects of Energy use, Environment-Economy-Energy and Sustainable Development, World Energy Status, Energy Scenario in India.
Energy Conservation and Energy Storage:Salient Features of "Energy Conservation Act, 2001", Various Aspects of Energy Conservation, Principles of Energy Conservation, General Electrical ECO's (Energy Conservation Opportunities),
Solar Energy:Basics, The Sun as a Source of Energy, Sun, Earth Radiation Spectrums, Extraterrestrial and Terrestrial Radiations, Spectral Energy Distribution of Solar Radiation, Depletion of Solar Radiation, Measurements of Solar Radiation, Solar Time (Local Apparent Time), Solar Radiation Geometry, Solar Day Length, Empirical Equations for Estimating Solar Radiation(Hourly Global, Diffuse and Beam Radiations) on Horizontal Surface Under Cloudless and Cloudy Skies, Solar Radiation on Inclined Plane Surface only (empirical relations for numerical)

Module II (15 Classes)

Solar Thermal Systems:Solar Collectors: Flat plate and concentric collectors, Solar Water Heater, Solar Passive Space - Heating and Cooling Systems, Solar Refrigeration and Air-Conditioning Systems, Solar Cookers, Solar Furnaces, Solar Green House, Solar Dryer, Solar Distillation (or Desalination of Water),
Solar Photovoltaic Systems:Solar Cell Fundamentals, Solar Cell Characteristics, Solar Cell Classification, Solar Cell, Module, Panel and Array Construction, Solar PV Systems, Solar PV Applications.
Wind Energy:Origin of Winds, Nature of Winds, Wind Turbine Siting, Major Applications of Wind Power, Wind Turbine Types and Their Construction, Wind Energy Conversion Systems (WECS), Effects of Wind Speed and Grid Condition (System Integration),

Module III (15 Classes)

Biomass Energy:Photosynthesis Process, Usable Forms of Biomass, their Composition and Fuel Properties, Biomass Resources , Biomass Conversion Technologies, Urban Waste to Energy Conversion, Biomass Gasification ,Biomass Liquefaction, Biomass to Ethanol Production, Biogas Production from Waste Biomass, Energy Farming.
Miscellaneous Non-conventional Technologies
Geothermal Energy:Applications, Origin and Distribution of Geothermal Energy, Types of Geothermal Resource. ***Ocean Energy:***Tidal Energy, Wave Energy, Ocean Thermal Energy
Fuel Cell Technology:Types, Principle of operation, Advantages and disadvantages.

Text Book:

1. *Non Conventional Energy Sources: B.H. Khan, TMH Publications*
2. *Renewable Energy Sources and Emerging Technology: D.P.Kothari and etal., PHI*
3. *Renewable Energy Sources & Conversion Technology: N.K.Bansal, Manfred Kleenman & MichaelMeliss, TMH Publication.*

Reference:

1. *Renewable Energy Sources:Fundamentals & Applications:G.N.Tiwari & M.K.Ghosal, Narosa Pub*
2. *Non Conventional Energy Resources: D.S. Chauhan and S.K.Srivastava, New Age International*
3. *Non Conventional Energy Sources: H.P.Garg*
4. *Non-Conventional Energy Systems: G.D.Rai, Khanna publications*
5. *Solar Energy Technology: Sukhatme and Nayak, TMH*
6. *Renewable Energy, Godfrey Boyle, Oxford University Press*

5th Semester

OPERATING SYSTEMS

Module-I (12 Hours)

INTRODUCTION TO OPERATING SYSTEM:
What is an Operating System? Simple Batch Systems, Multiprogramming and Time Sharing systems. Personal Computer Systems, Parallel Systems, Distributed Systems and Real time Systems.
Operating System Structures: Operating System Services, System components, Protection system, Operating System Services, system calls
PROCESS MANAGEMENT:
Process Concept, Process Scheduling, Operation on Processes, Interprocess communication, Examples of IPC Systems, Multithreading Models, Threading Issues, Process Scheduling Basic concepts, scheduling criteria, scheduling algorithms, Thread Scheduling.

MODULE-II (14 Hours)

PROCESS COORDINATION: Synchronization: The Critical section problem, Peterson's solution, Synchronization hardware, Semaphores, Classical problems of synchronization, Monitors.
Deadlocks: System model, Deadlock Characterization Methods for Handling Deadlocks, Deadlock Prevention, Deadlock avoidance, Deadlock Detection, recovery from Deadlock.
MEMORY MANAGEMENT: Memory Management strategies, Logical versus Physical Address space, swapping, contiguous Allocation, Paging, Segmentation.
Virtual Memory: Background, Demand paging, performance of Demand paging, Page Replacement, Page Replacement Algorithms. Allocation of frames, Thrashing, Demand Segmentation.

MODULE-III (11 Hours)

STORAGE MANAGEMENT:
File System Concept, Access Methods, File System Structure, File System Structure, File System Implementation, Directory implementation, Efficiency and Performance, Recovery, Overview of Mass Storage Structure, Disk Structure, Disk Scheduling, Disk Management, Swap-Space Management, I/O System Overview, I/O Hardware, Application I/O Interface, Kernel I/O Subsystem, Transforming I/O Request to Hardware Operation.
CASE STUDIES: The LINUX System, Windows XP, Windows Vista

TEXT BOOK:

1. ***Operating System Concepts –*** *Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, 8th edition, Wiley-India, 2009.*
2. ***Mordern Operating Systems –*** *Andrew S. Tanenbaum, 3rd Edition, PHI*
3. ***Operating Systems:*** *A Spiral Approach – Elmasri, Carrick, Levine, TMH Edition*

REFERENCE BOOK:

1. *Operating Systems – Flynn, McHoes, Cengage Learning*
2. *Operating Systems – Pabitra Pal Choudhury, PHI*
3. *Operating Systems – William Stallings, Prentice Hall*
4. *Operating Systems – H.M. Deitel, P. J. Deitel, D. R. Choffnes, 3rd Edition, Pearson.*

5th Semester

INDUSTRIAL PROCESS CONTROL & DYNAMICS

Module-I (10 Hours)

Analog Signal Conditioning
Introduction, Principles of Analog Signal Conditioning, Signal-Level Changes, Linearization, Conversions, Zero adjustment, Span adjustment, Level changing, AC/DC Power supply, Filtering and Impedance Matching, Passive Circuits, Divider Circuit, Bridge Circuits, RC Filters, Operational Amplifiers, Op Amp Characteristics, Op Amp Specifications, Op Amp Circuits in Instrumentation, Voltage Follower, inverting Amplifier, Non- inverting Amplifier, Differential Amplifier, Active Filters, Protection Voltage-to –Current Converter, Current-to-Voltage Converter, Integrator, Linearization. Book-1-Ch-2.2,2.3,2.4,2.5,2.6.
Digital Signal Conditioning
Introduction, Review of Digital Fundamentals, Digital Information, Fractional Binary Numbers, Boolean Algebra, Digital Electronics, Programmable Logic Controllers, Busses and Tri-State Buffers, Converters, Comparators, Digital-to-Analog Converters (DCA), Analog-to-Digital Converters (ADCs), Sample and Hold, Multiplexer and De-multiplexer, decoder and encoder, Pulse modulations, Digital recorder. Book-1-Ch-3.1,3.2,3.3,3.4,3.5.

Module-2 (20 Hours)

Thermal Sensors
Definition of Temperature, Metal Resistance versus Temperature Device, Thermistors, Thermocouples, Other Thermal Sensors, Design Consideration.
Book-1-Ch-4.1,4.2,4.3,4.4,4.5,4.6,4.7.
Mechanical Sensors: Displacement, Position Sensors, Strain Sensors, Motion Sensors, Pressure Sensors, Flow Sensors. Book-1-Ch-5.2,5.3,5.4,5.5,5.6
Optical Sensors: Photodetectors, Pyrometry, Leser Principles,Applications.
Book-1-6.2,6.3,6.4,6.5,6.6.
Final Control: Final Control Operation, Signal Conversions, Switching and Control Devices, Actuators, control Elements. Book-1-Ch-7.2,7.3,7.4,7.5,7.6.
Discrete-State Process Control: Characteristics of the System, Relay Controllers and Ladder diagrams, PLCs. Book-1-Ch-8.2,8.3,8.4,8.4,8.5.

Module-3 (10 Hrs)

Controller Principles:Process Characteristics, Control System Parameters, Discontinuous and Continuous Controller Modes, Composite Control Modes. Book-1-Ch-9.2,9.3,9.4,9.5,9.6.
Analog Controllers:Electronic controllers, pneumatic controllers, design consideration.
Book-1-10.2,10.3,10.4,10.5.
Casecade,Feedforward, and Ratio Control:Casecade Control,Feedfrrward Control,Feedforward-feedback Control Configuration,Ratio Control. Book-2, Ch-!0.1,!0.2,!0.3,!0.4,!0.5.
Selective and Adaptive Control Systems:Selective Control, Adaptive Control,Adaptive Control Configuration. Book-2. Ch-11.1,11.2,11.3,11.4.

TEXT BOOK

1. *1.-PROCESS CONTROL INSTRUMENTATION TECHNOLOGY BY-Curtis D.Johnson.PHI Pub.*
2. *2-PROCESS CONTROL PRINCIPLES AND APPLICATIONS BY-Surekha Bhanot. Oxford Pub.*

Reference:-

1. *Process control Systems and Instrumentation By-Terry Bartelt , Cengage Learning Publication*

5th Semester

ADVANCE LAB-I

"Will be uploaded soon'

5th Semester

MATERIAL FAILURE & ANALYSIS (HONOURS)

Module-I (14 Hours)

Aims of failure analysis, Methodology of Failure Analysis, Tree analysis.Prime factors in the premature failure of metallic components and structures, Tools and techniques in failure analysis, Sources of Failures, Steps in Failure Analysis, preservation and preparation of samples for failure analysis.

Module-II (12 Hours)

Types of failures: ductile, brittle, fatigue, creep, corrosion, wear etc., fractography, mixed mode and fatigue failures, Failure mechanisms, Embrittlement phenomena, environmental effects, Failures due to faulty heat treatments, Failures in metal forming and weldments.

Module-III (12 Hours)

Case studies in failure analysis: Case histories of component failures. Typical case studies of failure of important components such as gears, shafts, pressure vessels etc. Prevention of failures.

Books for reference:

1. *Failure Analysis & Prevention (Vol. - X), Metal Hand Book, ASM Publication.*
2. *Colangelo V. J. and Heiser F. A., Analysis of Metallurgical Failures, (Wiley).*
3. *Mobley R.K., Root cause failure analysis.*
4. *Dieter G.E., Mechanical Metallurgy, McGraw-Hill Company.*
5. *Courtney T.H., Mechanical Behaviour of Materials.*
6. *Rolfe S.T. and Barsom J.M., Fracture and Fatigue Control in Structures, Prentice.*

Sixth Semester								
	Theory					Practical		
Code	**Course Name**	**Hours/ Week L/T**	**Credit Theory**	**University Marks**	**Internal Evaluation**	**Hours/ week L/T**	**Credit Practical**	**Marks**
PC	X-ray & electron Microscopy	3-0	3	100	50	2	1	50
PC	Ferrous Metallurgy-II	3-0	3	100	50	2	1	50
PE	Corrosion & Degradation of Materials/Joining of Materials/Advances Casting Processes	3-1	4	100	50			
PE	Non-Ferrous Extractive Metallurgy/	3-1	4	100	50			
MC &GS	Environmental Science & Engineering	3-0	3	100	50			
OE	Industrial Lecture #					3	1	50
HS	Presentation Skill & Skill for Interview # #	2-0	1		50	4	2	100
MC	Yoga					2	1	50
Total		19	18	500	300	13	6	300
Total Marks: 1100								
Total Credits: 24								
Honours	Secondary Steel Making	4	4	100	50			
Minor Specialization								

6th Semester

X-RAY AND ELECTRON MICROSCOPY

Module I (12 Hours)

Introduction to x-ray and properties of x-ray: Continuous characteristics x-ray, absorption, filter, production and detection of x-rays. Diffraction of x-rays; special topics on crystallography, directions and intensities of diffracted beams.

Module II (14 Hours)

Experimental methods in x-ray analysis: Laue methods, powder photographs diffractometer and spectrometer measurements. Applications: orientation of single crystal, crystal structures of polycrystalline materials, precise lattice parameter measurements. Calculation of integrated intensity, structure factor calculation.
Application: Phase diagram, order-disorder transformation, chemical analysis, residual stress, texture.

Module III (12 Hours)

Electron optical methods:
(a) Scanning electron microscopy and X-ray microanalysis including electron probe microanalysis, electron optics, electron beam specimen interaction, image formation in the SEM. X-ray spectral measurements: WDS and EDS, quantitative X-ray analysis.
(b) Analytical transmission electron microscopy: Electron diffraction, reciprocal lattice, analysis of SAD patterns; different electron diffraction techniques, atomic resolution microscopy, analytical devices with TEM, field ion microscopy, scanning tunneling microscopy, advanced techniques.

Books for reference:

1. *Elements of X-Ray Diffraction by B. D. Cullity, Adison-Wesley.*
2. *Scanning Electron Microscopy and X-Ray Microanalysis, by J.I. Goldstein, C. E. Lyman*
3. *Structure of Metals by C. Barret and T. B. Massalski, Pergamon.*
4. *X-ray Diffraction – its Theory and Applications by S. K. Chatterjee, Prentice Hall of India.*
5. *Physical Metallurgy Principles by R. E. Reed-Hill.*
6. *Transmission Electron Microscopy by Williams, D.B. and Barry Carter C., Plenum Press.*
7. *Materials Characterization, Metals Handbook, Vol. 10, ASM*
8. *Characterization of Materials, by E N Kaufman, Wiley Publishers*

(Practical)

Suggested list of experiments:

1. *Study of the X-Ray diffraction equipment.*
2. *Sample preparation for XRD analysis.*
3. *Study of FCC metal using XRD and identifying various phases present.*
4. *Determination of crystallite size in a given sample using Scherer formula.*
5. *Texture analysis of given rolled aluminium sample.*
6. *Sample preparation for SEM analysis*
7. *Micro structural characterization using SEM.*
8. *Sample preparation for TEM analysis.*
9. *Micro structural characterization using TEM.*
10. *Elemental analysis of given sample using EDAX and EPMA*.

6th Semester

FERROUS METALLURGY-II

Module I

Introduction: History of steel making, principles of steel making reactions viz decarburization, desulphurization, dephosphorisation, silicon and manganese reactions.
Slag theories: Molecular and io nic theories; interpretation of the above reactions in terms of ionic theory of slags. Open Hearth steel making practices.
L.D. Process: Design of converter and lance; quality of raw materials charged, operation, control of bath and slag composition, chemical reactions involved, temperature and residual bath oxygen control, use of oxygen sensor; some characteristics of L.D blow vi z. emulsion formation, slopping, maneuvering lance height for dephosphorisation and decarburization. Catch Carbon technique. Recovery of waste heat.

Module II

OBM/Q-BOP process: Concept and operation of the process. Mixed / Combined blowing processes: Oxygen top blowing with inert gas purging at bottom; oxygen top blowing with inert and ox idizing gases at bottom, oxygen top and bottom: status in India.
Electric arc furnace: Advantages, charging, melting and refining practices for plain carbon and alloy steel; uses of DRI in arc furnace and its effect on performance. UHP electric arc furnace with D.C supply, single graphite electrode, oxygen lancing, oxyfuel burner, water cooled panel and computer control. Combination of blast furnace: EAF. Duplex processes of stainless steel making using VOD, AOD and CLU.
Induction Furnace: Special feat ures, advantages and limitation.

Module III

Deoxidation of liquid steel: Requirements of deoxidizers, deoxidation practice, stoke'slaw, use of complex deoxidizers. Inclusions and their influence on quality of steel. Killed, semi-killed and rimming steel. Secondary refining of steel: Objectives; principles of degassing different industrial process such as DH, RH, VAD, SD, LF, and ESR; limitations and specific applications.
Continuous Casting of steel: Advantages; types of machines; mould lubrication and reciprocation. Develo pment in C.C. Techno logy with respect to productivity, quality and energy conservation; Near Net Shape Casting.
Pollutant emissions from steel making processes and their control. Management of wastes from
steelmaking operations.

Books for reference:

1. *Ironmaking and Steelmaking Theory an d Practice by A. Ghosh and A. Chatterjee, PHI.*
2. *Steel Making by A.K.Chakravorty, PHI*
3. *Physical Chemistry of Iron and Steel Manufacture by C. Bodsworth, Longman Green & Co.*
4. *Physical Chemistry of Iron and Steel Making by R.G.Ward, ELBS and Edward Arnold 1962.*
5. *The Making Shaping and Treating of Steel (Steelmaking Volume), R.J.FruehN (ed.), The AISE Steel foundation.*
6. *Electric Furnace Steel Making: Design, Operation & Practice, Vol. I &II, by C.E.Sims (ed), Interscience.*
7. *Theoretical Principles of Electric Steel Making by V.Atanseyev, Mir Publishers, Moscow*
8. *Introduction to Modern Steel Making by R.H.Tupkary, Khanna Publishers, New Delhi1977.*
9. *Principles of Secondary Processing and Casting of Liquid Steel by A.Ghosh, Oxford &IBP 1990.*
10. *Electrometallurgy of Steel and Ferro-Alloys , Vol I, by F.P.Edneral, Mir Publishers.*
11. *Proceeds of International Works hop on Environmental and Waste Management in Iron and Steel Industries, De c 2 – 3, 1999, NML Jamshedpur.*

(Practical)

Suggested list of experiments:

1. *Flow sheets for different steel making processes*
2. *Charge calculation in steel making*
3. *LD Slag characterization using XRD.*
4. *Oxidation of sponge iron.*
5. *Decomposition kinetics of Dolomite.*
6. *Study of different parameters of EAF*

6th Semester

CORROSION AND DEGRADATION OF MATERIALS

Module I (12 Hours)

Technological importance of corrosion study, corrosion as non equilibrium process, corrosion rate expressions, electrochemical principles of corrosion-cell analogy, concept of single electrode potential, reference electrodes, e.m.f. and galvanic series-their uses in corrosion studies, polarization, passivity.

Module II (12 Hours)

Different forms of corrosion-uniform attack, galvanic, crevice, pitting, intergranular, selective leaching, erosion, stress corrosion cracking-their characteristic features, causes and remedial measures. Principles of corrosion prevention-material selection control of environment including inhibitors, cathodic and anodic protection, coatings and design considerations. Corrosion testing methods.

Module III (14 Hours)

Introduction to high temperature corrosion, Pilling-Bedworth ratio, oxidation kinetics, oxide defect structures, Wagner-Hauffe valence approach in alloy oxidation, catastrophic oxidation, internal oxidation.
Considerations in high temperature alloy design, prevention of high temperature corrosion -use of coatings.
Liquid metal attack - liquid metal embrittlement, preventive measures. Chemical degradation of non-metallic materials like rubbers, plastics, ceramics etc. Hydrogen damage - types, characteristics, mechanism and preventive measures.

Books for reference:

1. *Corrosion Engineering by Fontana, M.G., McGraw-Hill.*
2. *Corrosion & Corrosion Control by H.H. Uhlig, John Wiley & Sons.*
3. *Introduction to Metallic Corrosion by Evans.*
4. *Introduction to Electrochemistry by S.Glasstone.*
5. *An Introduction to Science of Corrosion & its Inhibition by S.N. Banerjee, Oxonian*
1. *Press Pvt. Ltd.*

6th Semester

JOINING OF MATERIALS

Module I

Theory and classification of welding processes Gas, arc, resistance, pressure, submerged arc, TIG, MIG, plasma arc and electron beam welding including spot welding laser welding and diffusion welding.
Mass and heat flow in fusion welding. Metallurgical effects of the weld thermal cycles.

Module II

Metallurgy of welding of structural steels, HAZ. Metallurgy of fusion welding of ferritic and austenitic steels, cast iron etc. welding pool solidification.
Metallurgical principles of welding nonferrous alloys, Cu alloys, Al alloys etc., welding pool solidification, structure of welds, heat treatment and transformation.

Module III

Welding stresses and stress relieving treatments.
Design of welded joints, welding defects an d their remedies. Inspection and testing of weldments.
Brazing and soldering. Joining of ceramics and plastics.

Books for reference:

1. *Metallurgy of Welding, by J.F.Lancaster, Allen and Unwin.*
2. *Welding and Welding Tec hnology by R.L.Little, TMH.*
3. *Welding by A.C. Davies, Cambridge University Press.*
4. *Metallurgy of Welding by Sefarin, John Wiley.*
5. *Welding Processes Hadbook, K. Weman, Woodhead.*

6th Semester

ADVANCED CASTING PROCESSES

Module I

Molding materials for special casting processes and special castings. Automation and mechanization of molding, Mold and die coatings, Testing of binders and base sand.
Modes of solidification, Casting properties: fluidity, shrinkage and stresses in castings, Mechanism of grain refinement and modification/ inoculation of aluminum alloys, magnesium alloys and cast iron. Degassing and inclusion control in castings.

Module II

Semi-solid casting processes, compo-cast ing, directional solidification, solute redistribution, zone refining and zone meltin g, counter pressure casting, squeeze casting, casting of single crystal turbine blades, Near net shape casting: strip casting.
Casting design, planning and selection of casting technology, Optimum pouring time and gating system design, riser design, feeding resistance, methods for improving riser efficiency, use of chills.

Module III (12 Hours)

Melting and casting of special metals and alloys, alloy cast irons and cast steels, heat and acid resistant aluminum alloys, cast magnesium alloys, zinc and lead alloys.
Casting defect analysis and remedies.

Books for reference:

1. *Science and Engineering of Casting So lidification by Doru Michael Stefanescu.*
2. *Solidification in cast House by H. Fredrickson.*
3. *Metals Handbook, volume 15.*
4. *Casting Handbook by J. Campbell, Butterworth - Haneman, London, 1993.*
5. *Solidification Processing by M.C. Flemings, , McGraw Hills, 1974.*
6. *Principles of Metal Casting by Hein R.W., Loper C. R. & Rosenthal P.C, T.M.H.*

6th Semester

NON FERROUS EXTRACTIVE METALLURGY

Module-I

Fundamentals of Unit processes involved in Metal Extraction. Thermodynamic considerations and process selection in Pyro-metallurgical extraction of metals.
Kinetics of leaching of ores; effect of various operating variables on leaching process; bio leaching. Principles involved in Electro-metallurgical extraction of metals.

Module-II

Extraction of metals from oxide ores (Sn, Mg), Extraction of metals from Sul phide ores (Cu, Ni, Pb and Zn), Extraction of metals through halide route (Ti and Zr)
Refining involving oxidation, chemical transport reactions, zone refining, distillation, etc. Ion exchange and solvent extraction processe s and their applicati on in extraction processes (Zr, V, Th, Nb, etc)

Module-III

Electro winning and Electro refining of metals:
a) From aqueous salts (Cu, Ni, Au, Ag)
b) From fused salts (Al and Mg)
Environmental pollution and its address related to various metal extraction processes in general.

Books for reference :

1. *Extraction of Non Ferrous Metals by H. S.Ray, R.Sridhar & K.P.Abraham, Affiliated*
1. *East –West Press, New Delhi*
2. *Extraction and Refining of Metals, by C. Bodsworth, CRC Press.*
3. *Metallurgy of Non Ferrous Metals by W.H.Dennis, Pitman.*
4. *Principles of Extractive Metallurgy, by T. Rosenquist, McGraw hill, 1974*
5. *Non Ferrous Production Metallurgy by J.I.Bray, John Wiley, N.Y.*
6. *General Metallurgy by N.Severykov et al, Mir Publishers, Moscow.*
7. *Rare Metal Extraction by Chemical E ngg. Tech. by W.D.Jamrack, Pergamon Press, Oxford.*

6th Semester

BIOMATERIALS

Module I

Introduction: Definition of Biomaterials: Performance of Biomaterials; Brief Historical Background.

Metallic Implant Materials: Stainless Steels; Co-Based Alloys; Ti and Ti-Based Alloys; Dental Metals; Other Metals; Corr osion of Metallic Implants.

Ceramic Implant Materials: Structure–Property Relationship of Ceramics; Aluminum Oxides (Alumina); Zirconium Oxides (Zirconia); Calcium Phosphate; Glass-Ceramics; Other Ceramics; Carbons; Deterioration of Ceramics.

Module II

Polymeric Implant Materials: Polymerization and Properties; Effect of Structural Modification and Temperature on Properties; Polymeric Implant Materials; High-Strength Thermoplastics; Deterioration of Polymers.

Composites as Biomaterials: Structure; Mechanics of Composites; Applications of Composite Biomaterials; Biocompatibility of Composite Biomaterials.

Structure–Property Relationships of Biological Materials: Proteins; Polysaccharides; Structure–Property Relationship of Tissues.

Tissue Response to Implants: Normal Wound- Healing Process; Body Response to Implants; Blood Compatibility; Carcinogenicity.

Module III

Soft Tissue Replacement: Sutures, Skin, and Maxillofacial Implants: Sutures, Surgical Tapes, and Adhesives; Percutaneous and Skin Implants; Maxillofacial and Other Soft-Tissue Augmentation.

Blood Interfacing Implants: Blood Substitutes and Access Catheters; Cardiovascular Grafts and Stents; Blood Vessel Implants; Heart Valve Implants; Heart and Lung Assist Devices; Artificial Organs.

Hard Tissue Replacement: Long Bone Repair : Wires, Pins, and Screws; Fracture Plates; Intramedullary Devices; Acceleration of Bone Healing.

Joints and Teeth: Joint Replacements; Spinal Implants; Dental Restorations and Implants; Interface Problems in Orthopedic and Dental Implants.

Books for reference:

1. *Biomaterials-An Introduction, 3r Ed., by Joon Park & R.S. Lakes, Published by Springer.*
2. *Biomaterials Science:An Introducti on to Materials in Medicine, edited by B.D.Ratner, A.S.Hoffman, F.J.Schoen, J.E.Lem ons, Academic Press.*

Supervise Elective
(Theory)

Supervise Elective (SE) to taken up by the student by his/her choice of any topic which will be provided by the university/College. Only one faculty will be assigned to act as guide. The examination shall be conducted by a panel of three examiners out of which one shall be nominated by the University. There will be no common examination by the University.

Project on internet of things.

SECONDARY STEEL MAKING (HONOURS)

Module I (12 Hours)

Secondary steel making principles and practices: Objectives and techniques adopted in secondary steel making. Ladle metallurgy: Outline of inert gas stirring: CAS/CAS (OB), Ladle furnace, vacuum degassing of steel and related processes.

Module II (14 Hours)

Transport phenomena in ladles: Role of slag and powders in inclusion control: Desulphurization, Dephosphorisation. Modification of inclusion morphologies, production of ultra low carbon, ultra low sulphur, ultra low phosphorus and inclusion free steels.

Module III (14 Hours)

Tundish metallurgy: Evaluation of tundish hydrodynamic performances: Solidification phenomena: Conventional, continuous and near net shape casting phenomena. Powder injection systems. Production of alloy steel through post solidification treatments (VAR, ESR); Refractories used in secondary steel making furnaces, their properties and selection criteria. Process selection in secondary steel making.

Books for Reference

1. *Ghosh A., Secondary Steelmaking- principle & Applications, CRC Press.*
2. *Ghosh A., Principles of Secondary Steelmaking Processing and Casting of Liquid Steel, Oxford & IBH Publication.*
3. *Ghosh Ahindra, Chatterjee A., Ironmaking and Steelmaking Theory and Practices, PHI Pvt. Ltd.*

Seventh Semester								
	Theory					Practical		
Code	**Course Name**	**Hours/ Week L/T**	**Credit Theory**	**University Marks**	**Internal Evaluation**	**Hours/ Week L/T**	**Credit Practical**	**Marks**
GS	Nano Science & Bio Technology	3-1	4	100	50			
PE	Materials for Advanced Applications/Engg. Polymers/Surface Engg.	3-1	4	100	50			
PE	Alternative Routes of Iron Making/Ferroalloys Technology/Electrometallurgy	3-1	4	100	50			
OE	Soft Computing */ Other subjects	3-1	4	100	50			
PC	Advance Lab-II/ Project					8	4	200
	Projects on Internet of Things					8	4	200
Total		16	16	400	200	16	8	400
Total Marks: 1000								
Total Credits: 24								
Honours	Tribology of Materials / Computer Application in Metallurgical Engineering	4	4	100	50			
Minor Specialization								

7th Semester

NANO SCIENCE & BIO TECHNOLOGY

"will be uploaded soon"

7th Semester

SOFT COMPUTING

MODULE-I

Introduction : Soft Computing Constituents and C onventional Artificial Intelligence, Neuro-Fuzzy and Soft Computing Characteristics. Fuzzy Sets: Introduction, Basic Definitions and Te rminology, Set Theoretic Operations, MF Formulation and Parameterization.
Fuzzy Rules & Fuzzy Reasoning: Extension Principle and Fuzzy Relations, Fuzzy If-Then Rules, Fuzzy Reasoning. Fuzzy Inference Systems : Mamdani Fuzzy Models, Sugeno Fuzzy Models, Tsukamoto Fuzzy Models, Other Considerations.
(BOOK-1:- Chap-1: 1.1 to 1.3, Chap-2: 2.1 to 2.4, Chap-3: 3.2 to 3.4 & Chap-4: 4.2 to 4.5)

MODULE-II

Neural Networks: Neuron Abstraction, Neuron Si gnal Functions, Mathematical Preliminaries, Neural Networks Defined, Architectures: Feed forward and Feedback, Salient Properties and Application Domains of Neural Networks, Multi-layered Network Architectures, Back-propagation Learning Algorithm, Practical Considerations in Implementing the BP Algorithm , Structure Growing Algorithms, Universal Function Approximation and Neural Networks, Applications of Feed Forward Neural Networks, Reinforcement Learning, Radial Basis Functi on Networks, Regularization Theory Route to RBFNs, Generalized Radial Basis Function Network, Learning in RBFNs, Associative Learning, Hopfield Network, Content Addressable Memory, Bidirectional Associative Memory, Self Organizing Feature Maps, Applications of the Self Organizing Map.
(BOOK-2:-Chap-3: 3.1 to 3.6, Chap-6: 6.1 to 6.2, 6.5 to 6.6 & 6.8 to 6.10, Chap-8: 8.4 to 8.7, Chap-10: 10.2 & 10.5 to 10.6 & 10.16 and Chap-12: 12.8 to 12.9)

MODULE-III

Regression & Optimization: System Identification: an Introduction, Least Squares Estimator, Geometric Interpretation of LSE, Recursive Least Squares Estimator. Derivative-Free Optimization: Genetic Algorithm s, Simulated Annealing, random Search, Downhill Simplex Search. Adaptive Neuro-Fuzzy Inference Systems (ANFIS): ANFIS Architecture, Hybrid Learning Algorithm.
(BOOK-1:- Chap-5: 5.1, 5.3 to 5.5, Chap-7: 7.2 to 7.5 and Chap-12: 12.2 to 12.3)

Text Books:

1. *"Neuro-Fuzzy and Soft Computing " By J.-S.R.Jang, C.-T.Sun & E. Mizutani, PHI*
2. *" Neural Networks: A Classroom Approach" By Satish Kumar, TMH Education*

1. *Reference Book:*
1. *" Neural Networks Fuzzy Logic & Genetic Algorithms; Synthesis &*
2. *Applications, S.Rajasekaran & G.A. VijayaLaxmi Pai, Prentice Hall, India,*
3. *May'2006- LakshmiPai*

2. *Principle of Soft Computing, S.N. Sivanandan & S.N. Deepa, Wiley India*
4. *Edition,2010*

7th Semester

MATERIALS FOR ADVANCED APPLICATIONS

Module – I (14 hours)

Introduction: The urge for advancement in materials development and processing, Special and high temperature alloys: Ti alloys: physical and mechanical properties, thermo-mechanical treatment of Ti-alloys, Ti shape memory alloys, Fe based super alloys, Ni based alloys, Co based alloys, engineering applications at elevated temperatures, High Entropy Alloys.

Metallic Foams: Material Definition and Processing, Characterization of cellular metals, Material properties and applications.

Module – II (12 hours)

Carbon and alloy steels: high strength low alloy structural steels, medium-high carbon ferrite-pearlite steels, common alloy steels, Tool steels: classification, composition, structure, properties, heat treatment and uses of different types of tool steels, Special steels: heat resisting steels, Hadfield manganese steels, TRIP steels, maraging steels, dual phase steels.

Module –III (12 hours)

Composite Materials: Material definition and classifications, Advanced polymer composite, Ceramic composite, Metal matrix composite, Nanocomposite, Applications. Coatings and thin films: Definition, Classification of applications, Bio-Materials: Various types of biomaterials, Biopolymer, Bioceramics, Nanostructured bio-materials, Classes of materials used in medicine, Application of materials in medicine and dentistry, Various materials and coatings for implants.

Books for reference:

5. *Engineering Materials – properties and selection by K.G. Budinski and M.K. Budinski, PHI.*
6. *Intermetallic Compounds, Volume 1- 4, by J. H. Westbrook (Editor), R. L. Fleischer (Editor), Wiley.*
7. *Structure-Property Relations in Nonferrous Metals by Alan Russell, Kok Loong Lee, Wiley.*
8. *Physical Metallurgy Principles by R. E. Reed-Hill*
9. *Structure and Properties of Alloys by R. M. Brick, R. B. Gordon and A. Phillips*
10. *Introduction to Materials Science and Engineering by J. F. Shackelford.*
11. *Physical Metallurgy of Steels by W.C.Leslie, McGraw-Hill.*
12. *Introduction to Physical Metallurgy by S.H.Avener, McGraw-Hill.*
13. *Introduction to Material Science and Engineering by Callister, Wiley,Edited by B.D. Ratner, A.S. Hoffman, F.J. Sckoen, and J.E.L Emons, Biomaterials Science,*
14. *An Introduction to Materials in Medicine, Academic Press, Second edition, 2004.*

7th Semester

ENGINEERING POLYMERS

Module I (14 hours)

Characteristics of Polymers Introduction to polymers structures and polymer technical merits; structures; Physical behaviour: Crystallization, Melting, Glass Transition Phenomena and mixing behavior; Factors affecting Melting and Glass Transition Temperatures. Mechanical Behaviour: Stress–Strain Behaviour, Macroscopic Deformation, Viscoelastic Deformation – viscoelasticity; Viscoelastic Relaxation Modulus; Viscoelastic Creep, Fracture of Polymers, Impact Strength, Fatigue, Tear Strength and Hardness. Mechanisms of Deformation And Strengthening Of Polymers : Deformation of Semicrystalline Polymers- Mechanism of Elastic Deformation, Mechanism of Plastic Deformation. Factors That Influence the Mechanical Properties of Semicrystalline Polymers- Molecular Weight, Degree of Crystallinity, Predeformation by Drawing, Heat Treating. Deformation of Elastomers, Vulcanization; Chemical behaviour.

Module II (14 hours)

Polymers in advanced engineering Polymer Matrix Composites (PMCs); Types, Manufacturing, Processing methods, Interfaces, Properties, Applications, Toughening Mechanisms, Matrix – Reinforcement Interface, Wettability, Interactions at Interface, Interfacial Bonding Types, Interfacial Strength Tests, The role of the interface. Conductive Polymers, Liquid crystal polymers, Industrial Polymer adhesive, Polymer in biomedical applications, Ultrahigh Molecular Weight Polymers, high performance polymers.

Module III (10 hours)

Synthesis and Processing of Polymers Polymerization: Addition polymerization, Condensation Polymerization Polymer Additives: Fillers, Plasticizers, Stabilizers, Colorants, Flame Retardants,

Forming Techniques for Plastics: Moulding – Compression and Transfer Moulding; Injection Moulding, Reaction and Reinforced Reaction Injection Moulding, Thermoforming, Extrusion, Blow Moulding, Casting. Fabrication of Elastomers. Fabrication of Fibers and Films: Spinning, Calendaring.

Books for reference:

1. *Introduction to Polymers by Young and Lovell, Nelson Thomes.*
2. *Materials Science and Engineering - An Introduction by William D. Callister, Jr., John Wiley & Sons.*
3. *Plastics: Materials and Processing by Brent A Strong, Prentice Hall Inc., USA. 1997.*
4. *An Introduction to Polymer Chemistry by Raymond Seymour, McGraw-Hill Book Co., New York, USA,1971.*
5. *Handbook of Plastics, Elastomers and Composites by Charles A Harper, McGraw-Hill Publishing Co., USA, 1997.*
6. *Principles of Polymer Engineering by McCrum N.G., Buckley C P. and Bucknall C.B., Oxford University Press, UK, 1992.*

7th Semester

SURFACE ENGINEERING

Module – I (12 hours)

Importance and necessity of surface engineering; classification and scope of surface engineering in metals, ceramics, polymers and composites, Surface dependent engineering properties, - wear, friction, corrosion, fatigue, reflectivity, emissivity; common surface initiated engineering failures; mechanism of surface degradation.

Module – II (12 hours)

Conventional surface engineering methods: carburising, nitriding, cyaniding, diffusion coating, hot dipping, galvanizing. Scope and application of conventional surface engineering techniques in engineering materials; advantages and limitations of conventional processes. surface modification by directed energy beams like ion, electron and laser beams; energy transfer, beam configuration and modes, surface integration, heat and mass transfer (composition and temperature profile) during directed energy beam irradiation; novelty of composition and microstructure; post irradiation characterization (microstructural & compositional) and testing/evaluation of surface-properties; structure-property correlation.

Module –III (12 hours)

Recent trends in surface engineering: Coatings and Thin Films and their applications; Stress, defect formation and surface evolution; classification of Processing routes; Physical/chemical vapour deposition, plasma spray coating, plasma assisted ion implantation, Sol-gel processing, Langmuir-Blodgett films, Electrodeposition; Characterization; Thickness, residual stress, morphology, adhesion.

Books for Reference:

1. *Surface engineering of metals - principles, equipments, technologies, by Tadeusz Burakowski and Tadeusz Wierzchon, CRC press.*
2. *ASM Handbook on Surface Engineering.*
3. *M. Ohring, Materials Science of Thin Films, 2nd Edition, Academic Press, 2002.*
4. *L. I. Tushinsky, I. Kovensky, A. Plokhov, V. Sindeyev, P. Reshedko, Coated Metal: Structure and Properties of Metal-Coating Compositions, Springer, Germany, 2002.*

7th Semester

ALTERNATIVE ROUTES OF IRON MAKING

Module I (12 Hours)
Characteristics of raw materials and their preparation. Thermodynamics and Kinetics aspects.
Direct Reduction Processes:

Reduction of Iron bearing materials in shaft furnace, rotary kiln, retort and fluidized bed with special reference to reductant, energy consumption and operational problems.

Module II (14 Hours)
Commercially available processes: like SL/RN, ACCAR, Krup-CODIR, Kinglon Meter, MIDREX, HyL, Purofer, Iron Carbide, etc.
Uses of DRI in steel making, iron making and foundries; effect on DRI on EAF performance and product characteristics.

Module III (12 Hours)
Smelting Reduction Processes:
COREX, ROMELT, Fluidized bed reactors, Hismelt etc. Present status of alternative methods of iron making in India.

Books for reference:

1. *Alternative Routes to Iron Making by A.Sarangi and B.Sarangi, PHI-2016*
2. *Beyond the Blast Furnace by Amit Chatterjee.*
3. *Direct Reduction of Iron, Editiors: Jerome Feinman & Donald R.Mac Rae, Allied Publishers Ltd.*

7th Semester

FERROALLOYS TECHNOLOGY

Module I (14 Hours)

Survey of Ferro-alloy industries in India and their future prospects. Physico-chemical principles of ferro-alloy making, principles of carbothermic and metallothermic reduction.

Ferro-alloy furnaces: Submerged arc furnaces, selection for transformer capacity, secondary voltage and current, furnace dimensions, size and spacing of electrodes, mechanical equipments, charging devices and dust collection system.

Electrodes used in ferro-alloy furnaces: graphitised and self baking electrodes, properties and uses.

Module II (12 Hours)

Production of ferro-manganese, ferrochrome, ferrosilicon and silico-calcium by carbothermy, production of FeCr, FeTi, FeB, FeNb, FeMo, and FeV by metallothermy. Recovery of vanadium from ores and production of FeV.

Module III (10 Hours)

Charge calculation in production of ferro-alloys. Use of plasma arc for production of ferro-alloys. Use of ferro-alloys in Iron and Steel industries (deoxidation and alloy making).

Books for reference:

1. *Production of Ferro-Alloys by Riss and Khodorovasky.*
2. *Production of Ferro-Alloys by V.P. Elyutin.*
3. *Electro-metallurgy of Steel and Ferro-Alloys, Vol. 2, by F.P.Edneral.*
4. *Ferro-Alloy Industries in India, Symposium NML, Jamshedpur, 1962.*
5. *Proc. Symp. of All India Seminar on Recent Trends in Ferro-Alloys Technology,*

7th Semester

ELECTROMETALLURGY

Module I (12 Hours)
Principles of Electrochemistry: Equilibrium Potential; Nernst Equation; Polarization and over voltage; EMF and Galvanic Series.

Module II (12 Hours)
Electroplating: Principles of electrodeposition of single Metals and alloys; preplating operations; plating baths; throwing power; electroless plating; electroforming; testing of electrodeposits; Anodic Electrometallurgical Processes-Anodizing, Electro-cleaning, Electro-polishing, Electrolytic etching, Electrolytic machining and grinding

Module III (12 Hours)
Electro winning and Electro refining: special features of electrochemical extraction & refining of metals and electrochemical extraction & refining of important metals like copper, zinc and aluminium.

Books for Reference:

1. *Introduction to Electrochemistry, by S. Glasstone.*
2. *An Introduction to Electrometallurgy, by Sharan & Narain, Standard Publishers Distributors, Delhi*
3. *Electrochemical Engineering, by Mantell.*
4. *Principles of Electroplating and Electroforming, by Blum and Hogaboom.*
1. *5.Fundamental aspects of electrometallurgy, by K.I.Popov, S.S. Djokic, B.N.Grgur, Kluwer Academic / Plenum Publishers*

7th Semester

ENTREPRENEURSHIP DEVELOPMENT

Module I: Understanding Entrepreneurship (10Hrs)

Concept of Entrepreneurship, Motivation for Economic Development and Entrepreneurial Achievement, Enterprise and Society
Why and how to start Business – Entrepreneurial traits and skills, Mind Vrs Money in Commencing New Ventures, Entrepreneurial success and failures, Environmental dynamics and change.

Entrepreneurial Process
Step by step approach to entrepreneurial start up Decision for Entrepreneurial start up.

Module II: Setting up of a small Business Enterprise. (10Hrs)

Identifying the Business opportunity - Business opportunities in various sectors,formalitiesfor setting up small enterprises in manufacturing and services, Environmental pollution and allied regulatory and non-regulatory clearances for new venture promotion in SME sector.
Writing a Business plan, components of a B-Plan, determining Bankability of the project.

Module III: Institutional Support for SME. (10Hrs)

Central / State level Institution promoting SME. Management in small business. Marketing Management, problems & strategies
Problems of HRM – Relevant Labour – laws.

Sickness in Small Enterprises.
Causes and symptoms of sickness – cures of sickness. Govt. policies on revival of sickness and remedial measures.

Reference Books:

1. *Entrepreneurship Development, Small Business Enterprises, Chavantimath, Pearson.*
2. *Entrepreneurial Development, S.S. Khanka, S Chand*
3. *Entrepreneurship, Barringer BR, Ireland R.D., Pearson*
4. *Entrepreneurship, David H Holt, PHI*
5. *Entrepreneurship, Kurilko, D.F. and Attodgets RM, Cengage*
6. *The Dynamics of Entrepreneurial Development & Management, Vasant Desai, HPH.*
7. *Entrepreneurship, Roy, Oxford*
8. *Entrepreneurship, Hisrich, Peters, Shepherd, TMH*

7th Semester

MARKETING MANAGEMENT

Objective of the Course: The course aims at introducing the basic concepts of marketing to the undergraduate students in engineering. The learning shall help the students in better designing, manufacturing and selling product/ service packages keeping competitive market, customers and cost in view.

Module – I (10 hours)
Marketing Management: Concept, Process, Functions and relevance in the current context. Marketing Environment: Elements of micro and macro environment
Competition Analysis: Factors contributing to competition, porter's five forces model, Identifying and analyzing competitors.

Marketing Planning : Exploring Opportunity, Product –market selection, Marketing Planning Process.

Market Research and Information Systems: Research Process, The Internet and World Wide Web based Information collection and processing, Database, Data Warehouses and Data Mining, Global Market Research.

Consumer Behavior: Factors influencing consumer behavior, consumer decision process. Organizational buying behavior.

Module II (10 hours)
Market Segmentation, Targeting and Positioning: Definition, Bases of segmenting consumer and Industrial markets. Target Market strategies: Market Positioning.
Market Demand Forecasting: Key Terms, Forecasting Tools: Short term tools: Moving average and Exponential smoothing methods, Long-term forecasting Tools: Time series analysis, Econometrics methods, Qualitative tools : Buying Intention Survey, Sales Force Opinion and Delphi Techniques.

Product Planning : Product Life Cycle, New Product Development Process, Branding Strategy, Positioning a Brand, Brand Equity, Packaging and Labeling, Product-mix and Product Line, Planned Obsolescence.

Module – III (10 hours)
Pricing Decision: Objectives and Factors influencing pricing, Pricing method and strategies.
Integrated Marketing Communication(IMC)- Concept of IMC, the marketing communication process, Promotion Mix, elements of promotion mix, Direct marketing.

Channels of Distributions: Types of intermediaries, functions of distribution channels, channel levels, Designing Distribution Channels, Physical Distribution, Supply Chain Management (Basic only).

Trends in Marketing: Green Marketing, Customer Relationship Management, E-marketing, Rural Marketing and Service Marketing (concepts only)

Text Book:

1. Etzel , Walker ,Stanton and Pandit, Marketing, 14/e, Tata McGraw Hill.
2. Saxena, "Marketing Management" Tata McGraw Hill, 4/e.

Reference

1. *Grewal, Levy, 'Marketing' Tata McGraw Hill, special Indian edition.*
2. *Karunakaran "Marketing Management", Himalaya Publishing House, 2010/e.*
3. *Kotler, Keller,Koshy and Jha, "Marketing Management", 13/e, Pearson Education.*

7th Semester

INDUSTRIAL INSTRUMENTATION

Module 1 (18 Hours)

Introduction:Functional Units, Classification, Performance characteristics, Dynamic Calibration, Errors: An Overview, Statistical Error Analysis, Reliability and Related Topics (Chapter 1 of Text book)
Instruments for Analysis:Introduction, Gas Analysers, Liquid Analysers, X-ray Methods, Chromatography (Chapter 8 of Text Book)

Module II: (10 Hours)

Telemetry:Introduction, Pneumatic Means, Electrical Means, Frequency Telemetring, Multiplexing, Modulation, Modulation of Digital Data, Transmission Channels, Briefing of a Telemetry System in Operation, Wireless I/O (Chapter 10 of Text Book)

Module III: (10 Hours)

Power Plant Instruments:Introduction, The Power Plant Scheme, Pressure, Temperature, Flow and Level, Vibration and Expansion, Analysis, Flue Gas Analysis (Chapter 12 of Text Book)
Hazard and Safety:Initial consideration, Enclosures, Intrinsic Safety, Prevention of Ignition, Methods of Production, Analysis Evaluation and Construction (Chapter 13 of Text Book)

Text Book:

1. *Principles of Industrial Instrumentation, Third Edition, D Patranabis, Tata McGraw Hill Education Private Limited, New Delhi*

Reference Books:

1. *Process/Industrial Instruments and Controls Handbook, Gregory K. Mc Millian Editor-in-Chief, Douglas M. Considine Late Editor-in-Chief*

7th Semester

PROCESS SIMULATION AND MODELING

Module I

Modeling: Fundamentals of mathematical models and formulation – Continuity equation, Equation of motion, Transport equations, Energy equation, Equations of state, Equilibrium, Chemical kinetics and their applications; Lumped and distributed parameter models – Fluid systems, C.S.T.R. (single, series, isothermal, constant hold up, variable hold up, gas phase pressurized and non-isothermal), Single component vaporizer, Multi-component flash drum, Batch reactor, Reactor with mass transfer, Ideal binary distillation column, Batch distillation, Heat exchanger, etc;

Module II

Optimization: Single variable optimization (analytical, dichotomous search, fibonacci, golden section, regula falsi), Multivariable optimization (analytical, geometric programming, linear programming), Convergence methods (Newton's methods, direct substitution, Wegstein's method).

Module III

Simulation:; Techniques of digital simulation – Information flow, from process to information flow diagram, From information flow diagram to numerical form, Recycles, Calculation of a recycle set, etc.

Essential Reading:

1. *W. L. Luyben, Process Modelling, Simulation and Control for Chemical Engineers, McGraw Hill, 1990.*

Suggested Readings:

1. *B. V. Babu, Process Plant Simulation, Oxford University Press, 2004.*
2. *S. S. Rao, Engineering Optimization: Theory and practice, New Age Publishers, 1999.*
3. *A. Hussain and K. Gangaiah, Optimisation Techniques for Chemical Engineers, Macmillan, 2001.*
4. *B. W. Bequette, Process Control: Modeling, Design and Simulation. Prentice-Hall*

7th Semester

ADVANCE LAB II/PROJECT
"will be uploaded soon"

7th Semester

INDUSTRIAL LECTURE

7th Semester

PREPARING FOR INTERVIEW

7th Semester

TRIBOLOGY OF MATERIALS (HONOURS)

Module I (12 Hours)
Background and importance of Tribology; A system approach to Tribology; Characterization of tribosurfaces; mechanics of solid contacts; Hertzian and non-hertzian contact. Contact pressure and deformation in non-
conformal contacts, friction in contacting rough surfaces, sliding and rolling friction, various laws and theory of friction and frictional heat generation; role of contact temperature.

Module II (12 Hours)
Different modes of wear; Wear and wear types; Mechanisms of wear - Adhesive, brasive, corrosive, erosion, fatigue, fretting, etc., Wear of metals and non-metals. Wear models - asperity contact, constant and variable wear rate, geometrical influence in wear models, wear damage. Wear in various mechanical components, wear controlling techniques. Tribological testing techniques and analysis of the worn surfaces.

Module III (12 Hours)
Different wear resistant materials; recent research results illustrating the performance of surface coatings, bulk materials and composite materials in tribological contacts. Lubrication; Importance and properties of lubricants.

Books for reference:

1. *K.C. Ludema, Friction, Wear, Lubrication - A Text book in Tribology, CRC press.*
2. *Jamal Takadoum, Materials and Surface Engineering in Tribology.*
3. *Hutchins, Tribology.*
4. *Bharat Bhusan, Principle and Application of Tribology.*
5. *Bharat Bhusan, Introduction to Tribology.*

7th Semester

COMPUTER APPLICATION IN METALLURGICAL ENGINEERING (HONOURS)

Transport phenomena based modeling: Model formulation based on heat, mass and momentum transfer, governing equations and boundary conditions. Numerical solution of differential equations, process related numerical problems

Stress analysis. Mesoscopic Modeling: CA based modeling, Monte Carlo simulation, application to metallurgical processes. Classical molecular dynamics modeling and its application in materials. Optimization and control. Elements of modern Artificial Intelligence(AI) related techniques.
Introduction to genetic algorithm and Artificial Neural Nets.

Text Books:

1. *S. Yip (Ed.): Handbook of Materials Modeling, Spinger, 2005*
2. *Santosh K. Gupta: Numerical Methods for Engineers, New Age International (P) Limited, New Delhi, 1998.*