M. Tech. (Metallurgy) Curriculum Structure

Specialization: Process Metallurgy

(w. e. f. 2015-16)

List of Abbreviations

OEC/ILE - Institute level Open Elective Course
PSMC - Program Specific Mathematics Course
PCC - Program Core Course
DEC - Department Elective Course
LLC - Liberal Learning (Self learning) Course
MLC - Mandatory Learning Course (Non-credit course)
LC - Laboratory Course

Semester-I

Sr. No.	Course Type/ Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1.	OEC	1. Nano Materials and Nano technology Or 2. Laser Materials Processing Or 3. Advanced Composites	3	--	--	3
2.	PSMC	Heat and Mass Transfer	3	1	--	4
3.	PCC1/ DEC	1. Concepts in Materials Science Or 2. Theory and Practice of Sintering Or 3. Electronic and Magnetic Materials	3	--	--	3
4.	PCC 2	Solidification Processing &Material Joining	3	--	--	3
5.	PCC 3	Advances In Iron and Steel making	3	1	--	4
6.	LC1	Lab Practice I	--	---	4	2
	LC2	Seminar I			2	1
7.	MLC	Research Methodology	1	--	--	0
8.	MLC	Humanities	1	--	--	0
Sub Total			**17**	**2**	**6**	**20**
Total			**25**			**20**

Semester-II

Sr.No	Course Type/Code	Course Name	Teaching Scheme L	T	P	Credits
1.	PCC 1	Characterization Techniques	3	1	--	4
2.	PCC 2	Surface Processing of Materials	3		--	3
3.	PCC 3	Mechanical Behaviour of Materials	3	--	--	3
4.	DEC1	Light Metals and Alloys or Secondary Steel Making or Advanced Metallurgical Thermodynamics	3	--		3
5.	DEC2	Nuclear Materials or Advances in Metal working or High Temperature Corrosion	3	--	--	3
6.	LC1	Lab Practice II	--		4	2
7.	LC2	Seminar II			2	1
8.	MLC	Intellectual Property Rights	1	--	--	0
9	LLC	Liberal Learning Course	1	--	--	1
		Sub Total	**17**	**1**	6	**20**
				24		**20**

Semester-III

Sr. No.	Course Code	Course Name	Teaching Scheme L	T	P	Credits
1.	Dissertation	Dissertation Phase – I	--	--	--	16
		Total	**--**	**--**	**--**	**16**

Semester-IV

Sr. No.	Course Code	Course Name	Teaching Scheme L	T	P	Credits
1.	Dissertation	Dissertation Phase – II	--	--	--	18
		Total	**--**	**--**	**--**	**18**

Total credits:

Sem I	Sem II	Sem III	Sem IV	Total
20	20	16	18	74

(OEC/ILE) Nano Materials and Nanotechnology

Teaching Scheme:

Lectures: 3 hrs/week

Examination Scheme:

T1, T2/Assignments/Presentation- 20 marks each

End-Sem Exam – 60

Course Outcomes:

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

CO1: Know the length scale, surface area to volume ratio and properties of nanomaterials.
CO2: Know the effect of particles size on mechanical, thermal, optical and electrical properties of nano materials.
CO3: Know the synthesis and applications of nanomaterials/nanocomposites.
CO4: Apply the knowledge to prepare and characterize nanomaterials using various tools.
CO5: Understand the theoretical concepts useful for structural, electronics, optical, magnetic and bio-medical fields, nanocomposites etc.

Syllabus Contents:

- Definition, length scales, classification of nano materials, effect of particle size on thermal, mechanical, electrical, magnetic, and optical properties of the nano materials, Inspiration from Nature about nanotechnology (or Nano Biotechnology).
- Synthesis of nano materials: Top down approaches and Bottom-up approaches, Synthesis and applications of nano wires, Synthesis, purification and applications of carbon nano tube (CNT), Fabrication of Clay-polymer and CNT-polymer nano composites.
- Characterization of Nano materials; X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), scanning probe microscopy (SPM), Raman spectroscopy, UV-visible spectroscopy, Laser particle size analyzer, and specific surface area analyzer (BET).
- Applications of nano materials in nano composites, electrical/electronics, solar cells, computer chips, display, nano fluids, Ferro fluids, hydrogen storage, fuel cell, antibacterial fabrics, sensors, magnetic tapes, nano composite coating for wear and corrosion resistance, cosmetic and construction industries.
- Pros and cons of the nano materials and nanotechnology for the human being.

TEXTBOOKS:

- Textbook of Nanoscience and Nanotechnology by B. S. Murty and P. Shankar, Universities Press (India) Private Limited, 2012, 1st Edition.
- Nanostructures and Nano materials: Synthesis, Properties & Applications by Guozhong Cao, Imperial College Press, 2004, 2nd Edition.
- Introduction to Nanoscience and Nanotechnology by Gabor L. Hornyak, H.F. Tibbals, Joydeep Dutta, John J. Moore, CRC Press, 2008, ISBN-13: 978-1420047790.
- Introduction to Nanotechnology by Charles P. Poole, Jr. Frank J. Owens, Wiley, 2003, ISBN: 978-0-471-07935-4.

- Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers and Architects by Daniel L. Schodek, Paulo Ferreira, and Michael Ashby, Butterworth-Heinemann, 2009, 1st Edition.
- Nanomaterials: An Introduction to Synthesis, Properties and Applications by Dieter Vollath, Wiley-VCH, 2ndEdition, 2013, ISBN: 978-3-527-33379-0.

REFERENCE BOOKS:

- Nanoscale Materials in Chemistry edited by Kenneth J. Klabunde and Ryan M. Richards, 2ndedn, John Wiley and Sons, 2009.
- Nanocrystalline Materials by A I Gusev and A A Rempel, Cambridge International Science Publishing, 1st Indian edition by Viva Books Pvt. Ltd. 2008.
- Springer Handbook of Nanotechnology by Bharat Bhushan, Springer, 3rd Edition, 2010.
- Carbon Nanotubes: Synthesis, Characterization and Applications by Kamal K. Kar Research Publishing Services; 1st edition, 2011, ISBN-13: 978-9810863975.

(OEC/ILE) Laser Material Processing

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 hrs/week	T1, T2/Assignments - 20 marks each
	End-Sem Exam – 60

Course Outcomes:

At the end of the course, students will able to;

CO1: Utilize the knowledge of lasers to apply in industries and research organizations for material processing.

CO2: Analyze, interpret and present observations about laser processing parameters on the structure and properties of processed components.

CO3: Demonstrate the ability to function in engineering industries and science laboratory teams, as well as on multidisciplinary projects.

CO4: Have the confidence to apply laser engineering solutions in global and societal contexts.

Syllabus Contents:

- Industrial lasers, construction, Types of lasers such as CO_2 laser, Solid state lasers, Diode laser and fiber laser.
- Interaction of lasers with materials, Laser beam optics and characteristics – wavelength, coherence, mode and beam diameter, polarization; effect of wavelength, surface films, surface roughness, Spot size, focus, collimator, scanning systems, fiber

delivery systems.

- Heat flow theory: one-dimensional model, stationary point source models, moving point source models, Keyhole model, models for flow and stress.
- Applications of lasers in industry: process, mechanism, laser requirements, variations, performance and practical solutions, capabilities, advantages and limitations. Laser cutting, Laser welding, Laser Surface treatment, rapid prototyping, laser bending, and laser cleaning.
- Process automation, online control Laser safety, standards, safety limits, laser classification.

TEXTBOOKS:

- William M. Steen, 'Laser Material Processing', Springer International edition, ISBN: 978-81-8128-8806, 2008.

REFERENCE BOOKS:

- Metals Handbook Vol. 6, 'Welding, Brazing and Soldering', ASM, Metals Pak, OH 1993.
- Powell J. 'CO_2 Laser cutting', Carl Hanser Verlag, Munich, 1990.
- Carlsaw H.S. and Jaeger J.C. 'Conduction of heat in solids', Oxford University Press (UK).

(OEC/ILE) Advanced Composites

Teaching Scheme:

Lectures: 3 hrs/week

Examination Scheme:

T1, T2/Assignments -20 marks each

End-Sem Exam – 60

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

CO1 : Basic knowledge, the major constituents & types of composite materials

CO2 :Knowledge of metallic, ceramic and polymeric materials as matrix materials and their properties and characteristics.

CO3 : Knowledge of processing methods used for PMC, MMC, and CMC manufacturing, their advantages and disadvantages.

CO4: Knowledge of composite materials for structural, electrical, electromagnetic, dielectric, optical and magnetic applications

Syllabus Contents:

- Composite materials in engineering, reinforcements and the reinforcement matrix interface - natural and synthetic fibers, synthetic organic and inorganic fibers, particulate and whisker reinforcements, reinforcement-matrix interface.
- Polymer matrix composites(PMC) – polymer matrices, processing of polymer matrix composites, characteristics and applications, composites with metallic matrices - metal matrix composites processing (MMC), Interface reactions, properties of MMCs, characteristics and application, Ceramic matrix composites (CMC)- processing and structure of monolithic materials, processing of CMCs, some commercial CMCs.
- Mechanical properties in composites, large particle composites and the rule of mixtures for elastic constants, Mechanical properties of fiber reinforced composites, Effect of fiber length, Critical fiber length, Strength of continuous and aligned fiber composites, Discontinuous and aligned fiber composites, Toughening Mechanism, Impact Resistance, Fatigue and Environmental Effects.
- Structural Composites: Cement matrix composites, Steel Reinforced Concrete, Pre-stressed concrete, Thermal Control, Vibration reduction. Polymer matrix composites- vibration damping.
- Composite materials for Electrical, Electromagnetic and Dielectric applications, Microelectronics and Resistance heating, Electrical insulation, capacitors, piezoelectric, ferroelectric functions, electromagnetic windows, solid electrolytes, microwave switching.
- Composite materials for optical and magnetic applications, optical waveguide, optical filters and lasers, multilayer for magnetic applications.

TEXT BOOKS:

1. Principles of Materials Science and Engineering, William F. Smith, Third Edition, 2002, McGraw-Hill
2. Composite Materials: Engineering and Science, Matthews F.L., and Rawlings R. D., 1999, Wood head publishing Limited, Cambridge England.
3. Composite Materials-Functional Materials for Modern Technology, DDL Chung, Springer- Verlag Publications London (England)
4. The nature and Properties of Engg. Materials, Jastrzebaski, John Wiley & Sons, New York.

REFERENCE BOOKS:

1. Composite Materials Handbook, Mel M. Schwartz (R), 2nd Edition, 1992, McGraw-Hill, New York.
2. Mechanics of Composite Materials, Autar K. Kaw, 1997, CRC Press, New York.
3. Fundamentals of Fiber Reinforced Composite Materials, A. R. Bunsell, J. Renard, 2005, IOP Publishing Ltd.
4. Composite Materials Science and Engg., K.K. Chawla, Second Edition, 1998, Springer Verlag

(PSMC) Heat and Mass Transfer

Teaching Scheme :

Lectures: 3 hrs/week

Tutorial 1 hr/week

Examination Scheme:

T1, T2/Assignments - 20 marks each

End-Sem Exam – 60

Course Outcomes: At the end of the course,

CO1: Students will able to understand and apply constitutive laws as to applied to fluid flow, heat and mass transfer.
CO2: Students will able to develop empirical equations using the knowledge of dimensionless analysis approach for 18odeling certain physical phenomena.
CO3: Students will able to analyse and quantify the kinetics of the processes.
CO4: Students will able to determine the concentration profile and mass conduction equation analogous to heat conduction equation.
CO5: Students will able develop and design energy efficient systems.
CO6: Students will able to perform shell balances for heat, momentum and mass transfer to obtain differential equation describing the velocity, temperature and concentration gradient.
CO7: Students will able to use to Navier-Stoke equation for solving fluid problems.

Syllabus Contents:

- Review of basic concepts in heat, mass and momentum transfer, Integral mass, momentum and energy balances, Equation of continuity & motion, Concept of stream function and vorticity, Concept of laminar and turbulent flow, Boundary layer theory.
- Advanced topics in convective, conductive and radiation heat transfer, view factor, simultaneous heat and mass transfer. Diffusion- Flicks Law and Diffusivity of materials, Diffusion in Solids, Mass Transfer in fluids systems.
- Reaction Kinetics-Concepts Rate constant and order of reaction, reaction mechanism, reaction rate theories.

Application of above principles to selected topics in metallurgical engg.-heat exchangers, flames and furnaces, slag-metal reactions, chimney draft, flow through packed and fluidized bed, motion of gas bubbles in liquid, reduction of haematite pellets in packed bed etc.

TEXT and REFERENCE BOOKS:

1. Geiger G.H.and Poirier D.R., Transport Phenomena in Materials Processing, Addison Wesley, 1994.
2. A.K. Mohanty, Rate Processes in Metallurgy, Prentice Hall, New Delhi, 2000.
3. Bird R.B., Stewart W.E. and Lightfoot E.N., Transport Phenomena, Wiley, 1960.
4. H.S. Ray, Kinetics of Metallurgical Reactions, Oxford & IBH, New Delhi, 1993.
5. R.I.L. Guthrie, Engineering in Process Metallurgy, Oxford Science, 1992.

6. J.R. Welty, R.E. Wilson, C.E. Wicks, Fundamentals of Momentum, Heat and Mass Transfer, Wiley, 1976.

(PCC 1/DEC) Concepts in Materials Science

Teaching Scheme:

Lectures: 3 hrs/week

Examination Scheme:

T1, T2/Assignments - 20 marks each

End-Sem Exam – 60

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

CO1 :Understand basics of the structure- properties relationship

CO2 : Understand importance of phase diagrams in micro structure design

CO3 : Analyze, interpret and solve scientific materials data/ problems.

CO4 : Apply principles of heat treatments of steels

Syllabus Contents:

- Introduction to engineering materials & their properties.
- Crystalline versus non crystalline solids, Unit cell, Crystal systems, Bravais lattice, Fundamental reasons behind classification of lattice, Miller indices for directions & planes, Close-packed planes & directions, Packing efficiency, Interstitial voids, Role of X-ray diffraction in determining crystal structures.
- Deformation of metals, Understanding of some material-properties in dependent of inter atomic bonding forces/energies, Stiffness versus modulus, Theoretical/ideal strength versus actual strength of metals, Crystal defects, Role of dislocations in deformation, Strengthening Mechanisms, Role of Cottrell atmosphere on strength of steel Objectives & classification,
- System, Phases & structural constituent of phase diagram, Temperature–Pressure phase diagram of iron & Clausius–Clapeyron equation for boundary between phase regions of temperature-versus-pressure phase diagrams, Gibbs phase rule, Lever rule, Solid solutions, Hume-Rothery rules, Isomorphous, Eutectic, Peritectic & Eutectoid system, Equilibrium diagrams for non-ferrous alloys, Experimental methods of determining phase diagrams,
- Iron–Carbon equilibrium diagram, Steels & Cast-irons. Gibbs free-energy curves for pure system, Solidification of pure metals, Nucleation, Growth, Growth of the new phase, Solidification of alloys, Nucleation-, growth- & overall transformation- rates, TTT & CCT diagrams.
- Definition, Purpose & classification of heat treatment processes for various types of steels, Bainite & Martensite formation, Introduction & applications of various case hardening &

surface hardening treatments, Precipitation Hardening, Heat treatment defects.

TEXT and REFERENCE BOOKS:

- V. Raghvan, Materials Science And Engineering, Prentice Hall of India Publishing 5th Edition, 2006.
- Askland & Phule, Material Science & Engineering of materials 4th Edition.
- Reed Hill, Physical Metallurgy 4th Edition, 2009.
- S.H. Avner, Introduction to Physical Metallurgy 2nd Edition, 1974.
- W.D. Callister, Materials Science and Engineering 8th Edition, 2006.
- D.A. Porter & K.E. Easterling, Phase Transformations in Metals & Alloys 3rd Edition, 1992.

(PCC1 /DEC) Theory and Practice of Sintering

Teaching Scheme:

Lectures: 3 hrs/week

Examination Scheme:

T1, T2/assignments – 20 marks each,

End-Sem Exam – 60

Course Outcomes:

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

CO1: Control the various processing parameters so as to control the microstructure developed during sintering

CO2: Apply the various densifying and non-densifying mechanisms to control density/porosity

CO3: Select appropriate method of sintering for required applications.

CO4: Develop correlations between structure and properties.

CO5: Work effectively in any PM/Ceramics industry

Syllabus Contents:

- Science and Technology of the sintering of materials- Driving force and variables, role of defects, Kroger-Vink Notation, diffusion, chemical potential, Ambipolar Diffusion.
- Mechanisms of Sintering, Theoretical Analysis of Sintering - Development of scaling laws and their application. Grain Growth and Microstructure Control, Normal and abnormal grain growth, Mechanisms Controlling the Boundary Mobility, Grain Growth and Pore Evolution in Porous Solids, Simultaneous Densification and Grain Growth,
- Fabrication Principles for Ceramics/metals with Controlled Microstructure, Microstructure development models and maps, Derivation of sintering and grain growth models and a critical review of their uses and limitations. Mapping approaches. Coverage of single phase, multiphase and composite systems.

- Liquid-Phase Sintering- Stages, Thermodynamic And Kinetic Factors, Basic Mechanisms, Use of Phase Diagrams, Activated Sintering, Vitrification, Solid Solution Additives
- Sintering With Chemical Reaction- Reaction Sintering. Viscous sintering, Viscous Sintering with Crystallization, Pressure Sintering, Microwave sintering, Gases in pores and sintering atmospheres, Plasma Sintering, Additive manufacturing,
- Case studies of specific ceramic and metal systems

TEXTBOOKS:

- Randall German, Powder Metallurgy Science, Metal Powder Industry; 2 Sub Edition, 1994.
- Randall German, Powder Metallurgy & Particulate Materials Processing, Metal Powder Industry, 2005
- M. N. Rahaman, Ceramic Processing and Sintering, 2nd Edition, Marcel Dekker Inc., NY, 2003.
- W.D. Kingery, H.K. Bowen and D.R. Uhlman, Introduction to Ceramics, Ceramic Science and Technology, John Wiley and Sons, Singapore, 1991.
- M.W. Barsoum, Fundamentals of Ceramics, 2nd Edition, IoP Publications, UK, 2003

REFERENCE BOOKS:

- Randall German, Sintering Theory and Practice, Wiley-Inter science; 1 Edition, 1996.
- ASM Handbook: Volume 7: Powder Metal Technologies and Applications (Asm Handbook), ASM International; 2nd Edition, 1998.
- Claus G. Goetzel, Treatise on Powder Metallurgy, VOLUME II, III, Applied and Physical Powder Metallurgy, Interscience Publishers Inc., New York, 1950

(PCC1/DEC) Electronic and Magnetic Materials

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2/Assignments – 20 marks each, End-Sem Exam – 60

Course outcomes:

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

CO1: Understand physical basis of electrical, electronic and magnetic properties.

CO2: Understand structure of advanced electrical engineering materials.

CO3: Suggest the materials for electrical, electronic and magnetic applications.

CO4: Use solid state principles for design of electrical, electronic and magnetic materials.

Syllabus Contents:

- Electrical and Thermal Conduction In Solid metal and conduction by electrons, Resistivity and its Temperature dependence. Temperature coefficient of Resistivity, Impurity Effect, Resistivity Mixture Rule, Skin Effect. Electrical Conductivity of Non-Metals: Ionic Crystals and Glasses, Semiconductors, Thermal Conductivity, Thermal Resistance.
- Semiconductors, Extrinsic, Intrinsic, Semiconductor Devices, Compound Semiconductor, Microelectronic Devices Such as LED, CMOS, MOSFETS, BPT etc, Manufacturing Methods.
- Magnetic Properties: Magnetic Field and Quantities, Classification of Magnetic Materials, Ferromagnetism Origin, Exchange Interaction, Saturation Magnetization, Curie Temperature, Ferromagnetic Domains, Magnetostriction, Demagnetization.
- Magnetic Alloys: Soft and Hard Magnetic materials, Ferrites, Magnetic Recording Materials, Magnetic Resonance Imaging. Superconductivity: Zero Resistance, Meissner Effect, Type I and II Superconductors, BCS Theory.
- Optical Properties of Materials: Light and Electromagnetic Spectrum, Refraction, Absorption, Transmission and Reflection of Light, Luminescence, Laser, and Optical Fibers. Optical Anisotropy, Electrooptic Effect, Electrooptic Ceramics, Antireflection Coating on Solar Cell.
- Dielectric Materials and Insulation: Polarization, Relative Permitivity, Polarization Mechanisms, Dielectric Constant, Dielectric Loss, Capacitors and Insulators, Piezoelectric, Ferro Electric and Pyroelectric Materials.

TEXT BOOKS:

- William F. Smith - Foundation of Materials Science and Engineering, Mc Graw-Hill International Edition, 2nd Edition, 1993.
- N. Braithwaite and G. Weaver - Materials in Action Series -Electronic Materials, Butterworths Publication.
- S. O. Kasap - Principles of Electronic Materials and Devices, Tata Mc Graw-Hill Publication, 2nd Edition, 2002.

REFERENCE BOOKS:

- Schroder, Klaus, Electronic Magnetic and Thermal properties of Solids, Marcel Dekker, New York 1978.
- Buschow K.H.J. (Ed.), Handbook of Magnetic Materials, Amsterdam: Elsevier. Electronic Materials Handbook, ASM International, Materials Park, 1989.

(PCC 2) Solidification Processing and Material Joining

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1, T2/Assignments - 20 marks each
End-Sem Exam – 60

Course Outcomes:

At the end of the course, students will demonstrate the ability-
CO1: To establish correlation between process parameters to resultant structure and properties of the joints.
CO2: To solve numerical problems related to casting design and weld metal profile.
CO3: To understand concepts and process capabilities of casting and welding of various engineering materials.
CO4: To know materials and process selection for manufacturing of different components by casting and welding.
CO5: To know pre-treatment and post heat treatment of castings and welded joints in relation to metallurgical and residual stress relieving.
CO6: To understand casting and welding defects and their remedial measures.

Syllabus Contents:

- Solidification process for manufacturing.
- The basics of solidification, fluid dynamics, solidification stages, effect of mould material, shrinkage, segregation and casting defects and their remedies manufacturing, continuous casting, die casting, semi-solid processing,
- Fusion and solid state welding processes involving solidification, Heat Flow during Welding, Chemical Reactions in the Welding Zone, Weld Pool Convection and Evaporation,
- Weld Residual Stresses, Distortion and Fatigue, different weld zones, Fusion Zone, Partially Melted Zone, Heat Affected Zone.
- Weldability tests, defects and their remedies.

TEXTBOOKS:

- J. Campbell: Casting, Butterworth - Haneman, London, (England) 1993
- M.C. Flemings: Solidification Processing , McGraw Hill, 197 Sindo Kou – 'Welding Metallurgy', Second Edition, John Wiley & Sons, Inc. 2003
- Kenneth Easterling – 'Introduction to the Physical Metallurgy of Welding (Monographs in Materials)'. Butterworth-Heinemann Ltd, 1983.

REFERENCE BOOKS:

- ASM Handbook Volume 15 -'Casting', ASM INTERNATIONAL, Metals Park Ohio, 1988
- ASM Handbook Volume 6-'Welding, Brazing, And Soldering', ASM INTERNATIONAL, Metals Park Ohio, 1993.

(PCC 3) Advances in Iron and Steel Making

Teaching Scheme:

Lectures: 3 hrs/week

Examination Scheme:

T1, T2/Assignments - 20 marks each

End-Sem Exam – 60

Course Outcomes:

At the end of the course-

CO1: Students will able to design alloy chemistry for manufacturing /procurement of desired composition of the steel as per the specification.

CO2: Students will able to decide raw materials quality and sequence of refining for making clean steel.

CO3: Students will able to control the cost of the steel by careful selection of the raw materials and other necessary ingredients required for steel manufacturing.

CO4: Students will able to understand metallurgical benefits of ingot and continuous cast products.

CO5: Students will able to devise ways for energy conservation and environmental pollution.

Syllabus Contents:

- Raw Materials for Steel making, Refractories, Scrap, Fluxes, Sponge Iron production, Electric Furnace Steel Making, Construction, Operation, Transformer Rating, Primary and Secondary Circuit, Power Factor, Thermal efficiency of the furnace.
- Ladle Metallurgy: Construction and Operation of LRF, Principle of Steel making and Refining Technology, Gases removal, Deoxidation of Steel and Non-Metallic inclusions, Role of Slag Composition on Quality of Steel, Processes-AOD, VOD& VD.
- Continuous Casting M/Cs: Operation and Construction, bloom, Billet, Slab and Thin strip Caster, primary and Secondary Cooling, Process parameters of the caster. Ingot Casting: Types of Moulds,
- Defects in Cast Product, Electromagnetic Stirring (EMS) for Quality improvement, Types of EMS, Selection Advantages, and Disadvantages. Dust generation from Furnaces and environmental impacts

Reference Books:

1. Steel Making –V. Kudrin, Mir. Publisher
2. Introduction to Modern Steel Making- Dr.R.H.Tupkari, Khanna Publishers
3. Electrometallurgy-I - By Edneral
4. Continuous Casting Vol-III - J.J.Moore
5. Continuous Casting of Steel – By Irving W.R.,
6. Electric Furnace Steel Making (Vol I & III) Higgins.

(LC 1) Lab Practice I

Teaching Scheme: Practical : 4 hrs/week

Examination Scheme: Marks – 100

Laboratory Outcomes: At the end of the laboratory work, students will demonstrate the ability- CO1: To design and conduct characterization CO2: To experiments for different materials. CO3: To demonstrate an advanced and applied knowledge in Physical metallurgy. CO4: Self-education and clearly understand the value of lifelong learning. CO5: To learn modern engineering software tools CO6: To analyze metallurgical problems.
List of Experiments/Assignments: Any seven experiments from the following area OR as identified by course teacher in relevant areas will be conducted. • Inclusion rating in Ferrous and Non-ferrous alloys • Estimation of phases in Ferrous and Non-ferrous alloys • Measurement of case depth and plating thickness • Advanced techniques for chemical analysis • Vacuum emission spectroscopy • Atomic absorption spectroscopy • Carbon sulfur analyzer • Study of Vacuum melting and casting of metals • Characterization of metal powders • Measurement and control of parameters like temperature, resistivity, • dimensional change etc., • Precipitation heat treatment of Aluminum alloys, Thermal analysis of steels

(LC 2) Seminar I

Teaching Scheme: Practical: 2 hrs/ week

Examination scheme: Term work: 100 marks

Course Outcomes: At the end of the course, students will be able to: CO1: Find literature and integrate the potential research areas in the field. CO2: Develop an ability to communicate effectively in both oral and written forms. CO3: To define research problem.
Syllabus Contents: A report on the topic of current international interest related with the field needs to be submitted. Subsequently student will do a presentation of 15 minutes followed by question answer session.

(MLC 1) Research Methodology

Teaching Scheme
Lectures: 1 hr/week

Examination Scheme
Marks: 100

Course Outcomes:

At the end of the course, students will be able to-

CO1: Understand research problem formulation.
CO2: Analyze research related
CO3: Follow research ethics

Syllabus Contents:

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Effective literature studies approaches, analysis

Plagiarism , Research ethics

Effective technical writing, how to write report.

References:

1. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction", Juta and Company Ltd, 2004
2. Stuart Melville and Wayne Goddard, "Research methodology: An Introduction for Science and Engineering Students", Juta and Company Ltd.
3. Ranjit Kumar, "Research Methodology: A Step by Step Guide for Beginners", SAGE Publications, 2nd edition, 2005

(MLC 2) Humanities

Teaching Scheme
Lectures: 1 hr/week

Examination Scheme
T1, T2 – 20 marks each, End-Sem Exam – 60

Course Outcomes:

At the end of the course, students will appreciate and understand, with special reference to the engineering profession-

CO1: The development of Civilization, Culture and Social Order over the Centuries
CO2: The development of Technology and its impact on the Society's Culture and vice-versa, as well as the concept of Globalization and its effects.
CO3: The process of Industrialization and Urbanization, their positive and negative effects, like social problems, etc.

Syllabus Contents:

Introduction:
The meaning of Humanities and its scope. The importance of Humanities in Society in general and for Engineers in particular.

Social Science and Development:
Development of Human Civilization over the centuries – Society and the place of man in society – Culture and its meaning -- Process of social and cultural change in modern India -- Development of technology, Industrialization and Urbanization -- Impact of development of Science and Technology on culture and civilization -- Urban Sociology and Industrial Sociology – the meaning of Social Responsibility and Corporate
Social Responsibility – Engineers' role in value formation and their effects on society.

Introduction to Industrial Psychology:
The inevitability of Social Change and its effects -- Social problems resulting from economic development and social change (e.g. overpopulated cities, no skilled farmers, unemployment, loss of skills due to automation, addictions and abuses, illiteracy, too much cash flow, stressful working schedules, nuclear families etc.) – Job Satisfaction -- The meaning of Motivation as a means to manage the effects of change – Various theories of Motivation and their applications at the workplace (e.g. Maslow's Hierarchy of Needs, McGregor's Theory X and Y, The Hawthorne Experiments, etc.) – The need to enrich jobs through skill and versatility enhancement – Ergonomics as a link between Engineering and Psychology

References:

1. Jude Paramjit S. and Sharma Satish K., "Ed: Dimensions of Social Change"
2. Raman Sharma, "Social Changes in India"
3. Singh Narendar, "Industrial Psychology", Tata McGraw-Hill, New Delhi, 2011
4. Ram Ahuja, "Social Problems in India"

SEMESTER II

(PCC 1) Characterization Techniques

Teaching Scheme:
Lectures: 3 hrs/week
Tutorial – 1 hr/week

Examination Scheme:
T1, T2/assignments – 20 marks each,
End-Sem Exam - 60

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

CO1: Use fundamental and applied concepts in materials characterization.

CO2: Develop an understanding of the sample preparation methods, working principle, operation and applications of important analytical methods.

CO3: Understand, correlate and interpret the results.

Syllabus Contents:

- **X-Ray Diffraction (XRD):** Scattering by an electron, atom and unit cell. Intensity of diffracted beam from a crystal. Structure factor & its applications. Indexing of planes. Reciprocal lattice. Relation of reciprocal & Bravais lattice. Diffraction in terms of reciprocal lattice. Application to diffraction in electron microscopy. Use of x-rays in; textures & preferred orientation.
- **Transmission Electron Microscopy (TEM):** Types of Electron sources. Focusing systems for parallel beams & probes. Image contrast & interpretation of images. Specimen preparation techniques, Contrast theory for electron microscopes. Kikuchi lines.
- **Scanning Electron Microscope (SEM):** Working, detectors, Back Scattered & secondary electron imaging. channeling patterns. Specimen preparation techniques, Microanalysis (EDS, WDS).
- **Introduction to Modern Techniques**: scanning transmission electron microscope. High voltage Electron microscopy, EELS, FIM. Techniques of surface analysis such as XPS, AES, SIMS, Tunneling & related methods (SPM and AFM),
- **Thermal analysis**: TG/DTA/DSC/ dilatometer and related techniques.

TEXTBOOKS:

- B. D. Cullity- Elements of X-ray diffraction- Addison Wesley Publications 3rd edition
- P.J. Goodhew, J. Humphreys, R. Beanland, Electron Microscopy and Analysis, 3rd edition, Taylor and Francis, London (England)
- Edited by E. Metcalfe- Microstructure Characterization – The Institute of Metals, USA ASM Metals Handbook, 9th edition , volume 10 – Materials characterization – ASM International publication.
- B. L. Gabrial –SEM- A Users manual for material science- American Society for Metals.
- Metals and Material Science, Process, Applications – Smallman and Bishop.

(PCC 2) Surface Processing of Materials

Teaching Scheme:

Lectures: 3 hrs/week

Examination Scheme:

T1, T2/Assignments - 20 marks each

End-Sem Exam – 60

Course Outcomes:

CO1**:** To understand concepts and fundamentals in surface engineering.

CO2: Able to solve numerical and apply knowledge of surface engineering

Syllabus Content:

- Importance of surface processing in modifying the properties of engineering components subjected to abrasion, wear, corrosion and fatigue, Preparation of the substrate for surface processing: Physical, chemical, electrochemical.
- Various methods of surface modifications such as: Physical Vapor Deposition, Chemical Vapor Deposition (Chromium, Nickel, Titanium, Copper etc.), Ion Implantation method, Coatings for high temperature performance, Electrochemical and spark discharge processes, Plasma coating methods, Organic and Powder coatings, Thermal barrier coating, Advanced electron beam techniques, Laser surface processing, Coating on plastics.
- Applications of these methods in the fields like Mechanical, Metallurgical engineering, optical, electronics and surgical instruments, medicine and biotechnology.
- Comparison of solar induced surface transformation of materials (SISTM) in processing of electronic materials with other direct energy methods such as Ions, Laser, Electron beam and Thin film deposition.
- Techniques for evaluation and characterization**.**

TEXTBOOKS:

- Edited By J. R. Davis-Surface Engineering for Corrosion and Wear Resistance, ASM International, 2001
- George J. Rudzki -Surface Finishing Systems. metal and non-metal finishing handbook-guide Metals Park : ASM, 1983
- James A. Murphy- Surface Preparation and Finishes for Metal, McGraw-Hill, New York (USA) 1971

REFERENCE BOOKS:

- H . Hochman- Ion plating & implantation application to material- ASM .
- P. G. Sheasby and R. Pinner - Surface treatment and finishing of Aluminium and its alloy, Volume-2, 5th ed., ASM, Metals Park, 1987
- K. E. Thelning -Steel and its Heat Treatment Bofors Handbook, London Butterworths, 1975
- Keith Austin - Surface Engineering Hand Book, London : Kogan Page, 1998.

(PCC 3) Mechanical Behaviour of Materials

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1, T2/Assignments – 20 marks each,
End-Sem Exam – 60

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

CO1: Analyze mechanical deformation of the materials using analytical treatment.

CO2: Use mechanical metallurgical concepts in understanding mechanical deformation.

CO3: Identify failure modes and reasons of failures of engineering components.

CO4: Incorporate fracture mechanics concepts in the mechanical design.

CO5: Use micro structural principles for the design of fracture and creep resistant materials.

Syllabus Contents:
Mechanical properties of materials, Theory of plasticity: The flow curve, yielding criteria for ductile metals, Plastic deformation of single crystal and polycrystalline materials, Deformation by slips, Deformation by twinning, strain hardening of single crystals. Dislocation theory: Dislocations in FCC, HCP and BCC lattice, forces on dislocations, forces between dislocations, dislocation climb, intersection of dislocations, Jogs, multiplication of dislocations, dislocation pile-ups. Strengthening mechanisms: Strengthening of grain boundaries, yield point phenomenon, strain aging, solid solution strengthening, strengthening from fine particles, fiber strengthening, martensitic strengthening. Fracture mechanics and fracture toughness evaluation: Strain energy release rate, stress intensity factor, fracture toughness and design, K_{IC} Plain-strain toughness testing, crack opening displacement, probabilistic aspects of fracture mechanics, toughness of materials. Fatigue of metals: Stress cycles, S-N curve, statistical nature of fatigue, low cycle fatigue, structural features of fatigue, fatigue crack propagation, effect of stress concentration on fatigue, size effect, surface effects and fatigue, effect of metallurgical variables on fatigue, corrosion fatigue, effect of temperature on fatigue. Creep and Stress rupture: High temperature materials problem, time dependent mechanical behavior, creep curve, stress rupture, structural changes during creep, mechanisms of creep deformation, deformation mechanism maps, fracture at elevated temperature, high temperature alloys and Fractography-important aspects.

TEXTBOOKS:

1. Mechanical Metallurgy – Geroge E. Dieter , SI Metric Edition ,1988, McGraw Hill Book Co Ltd , U.K.
2. Mechanical Behaviour of Materials, Marc Andre Meyers and Kishan Kumar Chawala, Second Edition, 2009 , Cambridge University Press, U.K.

REFERENCE BOOKS:

1. The Indian Academy of Sciences Proceedings : Engineering Science – Alloy Design , Vol 3 / Part 4, December 1980 and Vol 4 / Part 1, April 1981,Published by The Indian Academy of Sciences, Bangalore- 560080
2. Dislocations and Mechanical Behaviour of Materials, M.N. Shetty, 2013 , PHI Learning Pvt Ltd, New Delhi -110092

(DEC I) Light Metal Alloys

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2/Assignments – 20 marks each, End-Sem Exam – 60

Course Outcome:

CO1: Student will be able to establish correlation between microstructure and mechanical properties of various nonferrous materials.

CO2: Student will acquire knowledge of advanced materials and their strengthening mechanisms.

Syllabus Contents:

The light Metals: General introduction, production of aluminium, production of magnesium, production of titanium, usage and economics

Cast Aluminum Alloys: Thermodynamics and kinetics of solidification, homogeneous and heterogeneous nucleation, dendritic growth, solid/liquid Interface stability, Heat flow, heat evolution, shrinkage, macro and micro segregation, Recent advances in processing: Semisolid processing (SSP), Thixographic processing, Designation, temper and characteristics of cast aluminum alloys, Al-Si alloys Al-Cu alloys, Al-Mg alloys, Al-Zn-Mg alloys,

Wrought Aluminium Alloys: Production of wrought alloys, Designation of alloys and tempers, Work hardening of aluminium and its alloys, Heat treatable and Non heat treatable alloys, Defect in wrought alloys, Joining methods, Special products-aircraft ,automotive, packaging etc alloys.

Physical Metallurgy of Aluminium alloys: Principles of age hardening, Aging Processes, Corrosion, Mechanical behavior, Microstructures of different Al -alloys

Magnesium alloys: Introduction to alloying behavior, Melting and casting ,Alloy designation and tempers, Zirconium free and zirconium containing casting alloys, Wrought alloys, latest trends in applications of Mg alloy,Heat treatment ,applications

Titanium alloys: Introduction, alpha alloys, alpha –beta alloys, beta alloys, fabrication, Heat treatments, Applications

BOOKS and REFERENCES:

1. I.J.Polmear, Light Alloys, Butterworth Heinemann, Fourth Edition
2. Handbook of Aluminium –Part-I
3. R.W.Heine, C.R.Loper, P.C.Rosenthal, Principles of Metal Casting ,Tata McGraw Hill edition1976
4. Semisolid Processing of Alloys edited by Kirkwood.

(DEC I) Secondary Steel Making

Teaching Scheme
Lectures: 3 hrs/week
Tutorial: 1hr/week

Examination Scheme
T1-20 marks,
T2: Assignments: 20 marks
End-Sem Exam - 60

Course Outcomes:

At the end of the course,
CO1: Student will understand the Importance of SSM and appreciate no Steel is processed into product without SSM.
CO2: Given a condition of Liquid steel after tapping, Student will be able to decide on the parameters to be set/calculate additions for further processing and predict final chemistry and cleanliness in terms of O_2, N_2 & H_2.
CO3: Student will be exposed to advanced methods of making super clean steel.

Syllabus Contents:

- Ladle Preparation & Preheating for Secondary Steel operations, Refractories required to withstand the temperatures, Advances in Refractories for Improved life.
- Transport Phenomena during taping of Liquid Steel- Estimation of Gas absorption during tapping. Importance of Slag free tapping.
- Thermodynamics & Kinetics of Deoxidation. Types & selection of Deoxidizers, Metallurgical & Thermodynamic conditions for Good Desulphurization and synthetic slag. Wire Injection Techniques for increased efficiency of Deoxidation &Desulphurization. Practical aspects in handling of Liquid steel and safety precautions to be adopted in Industry.
- Specific Stirring Power of IGP and types of Porous Plugs Stoke's Law for floatation of oxide inclusions. Exogenous & Endogenous Inclusions. Modification of Inclusion Morphology. Thermodynamics of Degassing of Liquid Steel. Tank degassing vs Circulatory Degassing. Stream Degassing for vacuum teeming of Ingots. Performance Indicies for Clean Steel.
- Principles of ESR & VAR. Advantages over traditional Secondary Steel Making vs Costs involved.

TEXTBOOKS:

- Ahindra Ghosh & Amit Chatterjee - Iron and Steel Making – Theory & Practice, PHI Leasing Private Ltd.,2012
- Dipak Mazumdar- A First Course in Iron and Steel Making, Universities Press(India) Pvt. Ltd.
- Ahindra Ghosh - Secondary Steel Making: Principles & Applications, CRC Press.

(DEC1) Advanced Metallurgical Thermodynamics

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1, T2/Assignments – 20 marks each
End-Sem Exam – 60

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

CO1: Determine the heat of reaction, change of internal energy, entropy, and enthalpy.
CO2: Apply Maxwell equation in developing certain thermodynamic relation .
CO3: Determine activity of solute in dilute as well as concentrated solution.
CO4: Understand phase equilibria of Unary, binary and multi component systems.
CO5: Understand the thermodynamics of Phase Transformations in metallurgy

Syllabus Contents:

- Basics: First, second and third laws of thermodynamics, Maxwell's relations, Clausius-Clayperon equation.
- Solutions: solution models, regular, sub-regular, cluster variation models, multi-parameter models, quasi-chemical theory, statistical thermodynamics, multi component systems.
- Equilibrium Concepts: Unary, binary and multi component systems, phase equilibria, evolution of phase diagrams, metastable phase diagrams, calculation of phase diagrams, thermodynamics of defects.
- Thermodynamics of Phase Transformations: Melting and solidification, precipitation, eutectoid, massive, spinodal, martensitic, order disorder transformations and glass transition. First and second order transitions.
- Heterogeneous Systems: Equilibrium constant, Ellingham diagrams and their application to commercially important reactions.

TEXT BOOKS:

- D.R.Gaskell, Introduction to Thermodynamics of Materials, III Edition,MCGraw Hill Book Co.Inc.
- Ahindra Ghosh, Text book of Materials & Metallurgical Thermodynamics, Prentice Hall India.
- R.A. Swalin, Thermodynamics of Solids, 2nd ed., Wiley, New York, 1972
- D.A. Porter and K.E. Easterling and Mohamed Y. Sherif, Phase Transformations in Metals and Alloys, CRC Press, 3rd Ed. (Indian reprint), 2009.
- A. Ghosh, H.S. Ray, Principles of Extractive Metallurgy, New Age Int.(P) Ltd., New Delhi, 1991

REFERENCE BOOKS:

- L.S.Darken and R.W.Gurry, Physical Chemistry of Metals, McGraw- Hill, 1958.
- R.H.Parker, An Introduction to Chemical Metallurgy: Pergamon Press, Inc.
- G.S.Upadhya and R.K.Dubey, Problems in Metallurgical Thermodynamics and Kinetics, Pergamon Press, Inc.
- Thermodynamics of Materials Volume I and II, David V.Ragone, John Wiley & Sons, Inc.1995.

(DEC 2) Nuclear Materials

Teaching Scheme

Lectures: 3 hrs/week

Examination Scheme

T1, T2/Assignments - 20 marks each

End-Sem Exam – 60

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

CO1: Understand the use of nuclear energy as a major source of energy of the future.

CO2: Understand nuclear reactions, design & working of nuclear reactors and about various materials required for its major components.

CO3: Understand the manufacturing processes & the fabrication methods employed for the Production of various materials used in the reactor.

Syllabus Contents:

- Indian Atomic power plants. Nuclear power plants in India and future trends. Nuclear reactions as sources of energetic particles, nuclear stability, radioactive decay.
- Nuclear fission and fusion, brief outline of reactor types design and technology, and their particular demands for high-performance materials.
- Introduction to materials issues associated with nuclear power generation. Materials for fuel, cladding, moderator, coolant, shield, pressure vessel; Materials selection influenced by the need for a low capture cross-section for neutrons. The unique conditions in nuclear plant, including the first wall of a fusion reactor.
- Effects of radiation on physical and mechanical properties; Enhanced diffusivity, creep, phase stability, radiation hardening, em britllement and corrosion. Radiation growth in uranium and graphite, thermal ratcheting of reactor fuel assemblies. Annealing processes. Wigner energy release in graphite.
- Nuclear metallurgy; Structures and properties of materials with special relevance for nuclear power generation: uranium and other actinides, beryllium, zirconium, rare-earth elements, graphite. The materials of nuclear fuels and nuclear fuel element fabrication. Reprocessing of nuclear fuel elements. Radiation-resistant construction steels; Overview of structural-integrity issues. Fracture mechanics and non-destructive testing. Stress-corrosion cracking.
- World energy supply, fission, fusion, future directions for nuclear power generation, including use of thorium. Nuclear waste and its containment: Stability and dissolution of nuclear waste glasses. Synroc phases. Radionuclide-adapted mineral structures for fission products. Radiation damage in zircon and related materials.

TEXT and REFERENCE BOOKS:

- Bennet, D. J. & Thomson, J. R. , Elements of Nuclear Power Longman 3rd Edition 1989.
- Benedict, M, Pigford, T.H. & Levi H.W., Nuclear Chemical Engineering, Mcgraw-Hill 2nd Edition 1981.
- Glasstone, S. & Sesonske, A., Nuclear Reactor Engineering Vols 1-2 Chapman & Hall 4th Edition, 1994.

- Harms, A. A., Principles Of Nuclear Science And Engineering RSP/Wiley 1987
  Martin, A. & Harbison, S. A., Introduction To Radiation Protection Chapman & Hall 4th Edition 1996.
- Nuttall, W.J., Nuclear Renaissance: Technologies And Policies For The Future of Nuclear Power, IOP, 2005.

(DEC 2) Advances in Metal Working

Teaching Scheme:	Examination Scheme:
Lectures: 3 hrs/week	T1, T2/Assignments – 20 marks each, End-Sem Exam – 60

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

CO1: Analyze mechanics of metal under simple as well as complex loading conditions.

CO2: Predict causes of metal working defects and to find remedies to overcome these defects.

CO3: Design plastic forming conditions for the metals and their alloys.

Syllabus Contents: Metal working fundamentals : Mechanics of metal working, Flow stress determination, Temperature and Strain rate effects, Metallurgical structure, Deformation Zone Geometry , Friction and Lubrication, Hydrostatic pressure, workability, residual stresses, Experimental techniques , Forging : Forging in plain stain, calculations of forging loads in Closed die forging ,residual stresses in forgings, Forging defects, Rolling: Forces and Geometrical Relationships in rolling , Analysis of Rolling load and variables, Problems and Defects in rolled products, Theories of cold and hot rolling, Rolling mill control. Extrusion : Analysis of extrusion , Deformation , Lubrication and defects in extrusion, production of seam less pipe and tubing, Drawing of rods, wires and tubes : Analysis of wire and tube drawing , residual stresses in rod, wire and tubes. Sheet metal forming: Forming limit criteria and Defects in formed components.

TEXTBOOKS:

1. Mechanical Metallurgy – Geroge E. Dieter , SI Metric Edition ,1988, McGraw Hill Book Co Ltd , U.K.
2. Mechanical Behaviour of Materials, Marc Andre Meyers and Kishan Kumar Chawala, Second Edition, 2009 , Cambridge University Press, U.K.

REFERENCE BOOKS :

Metals Hand Book, Vol 4, ASM, Metals Park, Ohio, 2000.

(DEC 2) High Temperature Corrosion

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1, T2/Assignments – 20 marks each,
End-Sem Exam – 60

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

CO1: Establish correlation between thermodynamic and high temperature corrosion.

CO2: Solve numerical.

CO3: Understand concepts and fundamentals in high temperature corrosion.

CO4: knowledge of material selection for different corrosive environments and Knowledge of corrosion prevention methods.

Syllabus Contents: Introduction to high Temperature corrosion & oxidation of Metals and Alloys, Thermodynamics & Ellingham diagram, vapour species diagram, Isothermal stability diagram, Rate Laws, Kinetics and Mechanics. Wagner's parabolic law of Oxidation. Derivation and Limitations, Role of Diffusion and Defect structure of oxides in Oxidation, multiple scale formation & cracking. Forms of Corrosion with Special reference to External and Internal Oxidation. Stress Corrosion cracking, hydrogen Embrittlement, Corrosion Fatigue, Liquid Metal Embrittlement, Hot Corrosion, Corrosion in Mixed Gaseous Environment. Prevention of Corrosion, Material Selection and Design, Alteration of Environment, Inhibition, Metallic and Ceramic Paints, Coatings, Special Treatment. High temp. Materials: super alloys, inter metallic, ceramics.

TEXT and REFERENCE BOOKS:

- R.Aris-Mathematical Modelling Techniques, Pitman, London 1978.
- Oxidation of Metals-by Kofstadt
- High Temperature Oxidation of Metals and Alloys –by N.Birks and Meir
- Fundamentals of Corrosion- Scully
- Riedel H. – Fracture of High Temp., Springer-Verlag, Berlin ,1987.
- J.M.West-Basic Corrosion & Oxidation, 2nd Edition, Ellis Harwood Publication, 1986.
- ASM Metals H.B., Vol. 13, ASM international, Metals park, Ohio, 1986.

(LC 1) Lab Practice – II

Teaching Scheme

Practical : 4 hrs/week

Examination Scheme

Marks – 100

Course Outcomes:

CO1: This course helps students, to design and conduct characterization experiments for different materials.

CO2: In this Course, students will demonstrate an advanced and applied knowledge in Physical Metallurgy.

CO3: Students will be capable of self-education and clearly understand the value of lifelong learning.

CO4: Students will be familiar with modern engineering software tools and equipment to analyze Metallurgy problems.

List of Experiments/Assignments:

Any ***seven*** experiments from the following area OR as identified by course teacher in relevant areas will be conducted.

- XRD studies of Cubic metals
- Residual stress analysis in cast, wrought, welded and heat treated components by X-ray diffraction techniques
- X-ray radiography of various finished components
- Quantification of retained austenite in hardened components by X-ray diffraction techniques
- Studies of fracture by SEM
- Wear testing of surface treated components by Pin On- Disc techniques
- Low cycle fatigue test and fracture toughness measurement
- Selection of materials and processes, failure analysis – case studies
- Study of Oxidation: weight gain after oxidation as a function of temperature
- Time and gaseous atmosphere, data analysis, find possible mechanisms.
- A short project where every student will take up one modeling problem and do a small project on his own. For this they may spend 4-6 weeks of the time on their own and submit a short report

(LC 2) Seminar II

Teaching Scheme: Practical: 2 hrs/ week

Examination scheme: Term work: 100 marks

Course Outcomes: At the end of the course, students will demonstrate the ability to: CO1: Conduct literature survey and identify the potential research areas in the field. CO2: Communicate effectively in both oral and written forms. CO3: Cultivate the interest of the students towards Research and Development
Syllabus Contents: A report on the topic of current international interest related with the field needs to be submitted. Subsequently, student will do a presentation of fifteen minutes followed by question answer session.

(MLC) Intellectual Property Rights

Teaching Scheme Lectures: 1 hr/week

Examination Scheme Marks: 100

Course Outcomes: At the end of the course, students will demonstrate the ability to: CO1: Understand that today's world is controlled by Computer, Information Technology, but tomorrow's world will be ruled by ideas, concept, and creativity. CO2: Understand that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular. CO3: Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.
Syllabus Contents: Introduction − Nature of Intellectual Property: Patents, Designs, Trademarks and Copyright. Process of Patenting and Development: Technological research, Innovation, Patenting, Development. International Scenario − International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT. Patent Rights − Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR − Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge, Case Studies.

References:

1. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd , 2007
2. Mayall , “Industrial Design”, McGraw Hill
3. Niebel , “Product Design”, McGraw Hill
4. Asimov , “Introduction to Design”, Prentice Hall
5. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, Aspen Publishers, 6th Edition.
6. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand.

(LLC) Liberal Learning Course

Teaching Scheme	**Examination Scheme**
Contact Period: 1 hr/week	T1, T2 – 20 marks each, End-Sem Exam – 60

Course Outcomes:

At the end of the course, students will be able to-

CO1: Learn new topics from various disciplines without any structured teaching or tutoring.

CO2: Understand qualitative attributes of a good learner

CO3: Understand quantitative measurements of learning approaches and learning styles

CO4: Understand various sources and avenues to harvest/gather information.

CO5: Assess yourself at various stages of learning

Course Features:

- 10 Areas, Sub areas in each
- Voluntary selection
- Areas (Sub areas):
    1. Agriculture (Landscaping, Farming, etc.)
    2. Business (Management, Entrepreneurship, etc.)
    3. Defense (Study about functioning of Armed Forces)
    4. Education (Education system, Policies, Importance, etc.)
    5. Fine Arts (Painting, Sculpting, Sketching, etc.)
    6. Linguistics
    7. Medicine and Health (Diseases, Remedies, Nutrition, Dietetics, etc.)
    8. Performing Arts (Music, Dance, Instruments, Drama, etc.)
    9. Philosophy
    10. Social Sciences (History, Political Sc., Archeology, Geography, Civics, Economics, etc.)

Evaluation:

- **T1:** A brief format about your reason for selecting the area, sub area, topic and a list of 5 questions (20 marks)
- **T2:** Identify and meet an expert (in or outside college) in your choice of topic and give a write up about their ideas regarding your topic (video /audio recording of your conversation permitted (20 marks)
- **ESE:** Presentation in the form of PPT, demonstration, performance, charts, etc. in front of everyone involved in your sub area and one external expert (60 marks)

Resources:

- Expert (s), Books, Texts, Newspaper, Magazines, Research Papers, Journal, Discussion with peers or faculty, Internet, etc.

Semester III

(Dissertation) Dissertation Phase – I

Teaching Scheme:
Nil

Examination Scheme:
Term work: 100 Marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

CO1: Carry out in depth literature survey and determine objectives of the project work.

CO2: Design the experiment to accomplish the set objectives.

CO3: Effectively utilize the available resources of the Institute as well as other outside agencies (other Institutes, Labs, and Industry etc.)

CO4: Work independently to manage and complete research project within a given time frame.

CO5: Communicate effectively in both oral and written forms.

Syllabus Contents:

The Dissertation has to be the bonafide work of the student himself. The students shall be assigned a project which will test their ability to formulate objectives based on literature survey and their creativity on the basis of the experiments they design/simulation and models developed by them. The project work shall be defined on the basis of literature survey (on the basis of previous work done at international level in related area by referring books, journal papers, patents and web resources search) to locate for the lacunas/shortcomings etc. and its feasibility in the dept., may be on seeking the help of external agencies such as industry/R&D labs/higher level academic institutes etc. At the end of the Dissertation Phase-I, student shall submit a write-up in prescribed format. Evaluation will be on the basis of the attendance, literature survey and objectives, experimental planning (and work done), set up created if any, and presentation- viva voce (understanding of the concepts) of the student.

Semester IV

(Dissertation) Dissertation Phase – II

Teaching Scheme:	**Examination Scheme:**
Nil	Term work: 100 Marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to:

CO1: Independently conduct experiments, analyze and interpret results.

CO2: Lean modern characterization techniques, software tools etc.

CO3: Understand professional and social responsibilities and socio-economic aspects of the work undertaken.

CO4: Work as part of team necessary for a professional life and to work on multidisciplinary projects.

CO5: Communicate the technical information and knowledge in both written and oral form.

CO6: Inculcate a habit of lifelong learning of new ideas and applying the same in all work undertaken.

Syllabus Contents:
The Dissertation has to be the bonafide work of the student himself. At the end of the Dissertation Phase-II, student shall submit a write-up in prescribed format. Due care will be taken to check plagiarism, giving proper reference wherever other's work is cited, properly arranging the references inclusive of all essential details. Evaluation will be on the basis of the attendance, accomplishment of objectives, quality and quantity of the experimental work done, analysis and interpretation of experimental results and presentation- viva voce of the student.

There are 04 non-departmental subjects as given below which are dealt at institute level.

- **(MLC) Intellectual Property Rights**
- **(LLC) Liberal Learning Course**
- **(MLC 2) Humanities**
- **(MLC 1) Research Methodology**