M. Tech. (Metallurgy) Curriculum Structure

Specialization: Materials Engineering

(w. e. f. 2016-17)

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 category	Course name	Contact hours			Credits
			L	T	P	
01	OEC	a) Nano Materials &Nano Technology b) Laser Materials Processing c) Powder Metallurgy	3	-	-	3
02	PSMC	Mathematical Modeling in Materials Processes	3	1	-	4
03	PCC 1/ DEC	a) Concepts in Materials Science b) Ceramics Engineering c) Electronic and Magnetic Materials	3	-	-	3
04	PCC 2	Corrosion Engineering	3	-	-	3
05	PCC 3	Phase Transformations in Materials	3	1	-	4
06	LC 1	Lab Practice – I			4	2
07	LC 2	Seminar –I	-	-	2	1
08	MLC 1	Research Methodology	1	-	-	0
09	MLC 2	Humanities	1	-	-	0
		Sub Total	**17**	**2**	**6**	**-**
		Total	**25**			**20**

Semester II

Sr. No.	Course category	Course name	Contact hours			Credits
			L	T	P	
01	PCC 1	Characterization Techniques	3	1	-	4
02	PCC 2	Advanced Composites	3	-	-	3
03	PCC 3	Mechanical Behavior of Materials	3	-	-	3
04	DEC1	a) Biomaterials b) Amorphous Materials c) Thermodynamics of Materials	3	-	-	3
05	DEC2	a) Nuclear Materials b) Engineering Polymers c) High Temperatu re Corrosion	3	-	-	3
06	LC1	Lab Practice – II	-	-	4	2

07	LC2	Seminar – II	-	-	2	1
08	MLC	Intellectual Property Rights	1	-	-	0
09	LLC	Liberal Learning Course	1	-	-	1
		Sub Total	**17**	**1**	**6**	**-**
		Total	**24**			**20**

Semester III

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

Semester IV

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

Total credits:

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

SEMESTER- I

(OEC/ILE) Nanomaterials and Nanotechnology

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: 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 nanomaterials. 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 nanomaterials, effect of particle size on thermal, mechanical, electrical, magnetic, and optical properties of the nanomaterials, Inspiration from Nature about nanotechnology (or NanoBiotechnology). Synthesis of nanomaterials: Top down approaches like ball milling, severe plastic deformation, lithography (optical, UV-visible, Deep-UV visible, X-ray, e-beam), soft lithography etc., Bottom-up approaches like inert gas condensation, chemical vapour deposition, colloidal method, sol-gel method, and atomic layer deposition (ALD) and Laser nanomanufacturing. Synthesis and applications of nanowires; Synthesis, purification and applications of carbon nanotube (CNT); Synthesis of expanded graphite (EG)/graphene. Fabrication of nanocomposites; Clay-polymer, metal-polymer, CNT-polymer, EG-polymer and CNT-metal. Characterization of Nanomaterials; 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 nanomaterials in nanocomposites, electrical/electronics, solar cells, computer chips, display, nanofluids, ferrofluids, hydrogen storage, fuel cell, antibacterial fabrics, sensors, magnetic tapes, nanocomposite coating for wear and corrosion resistance, cosmetic and construction industries. Pros and cons of the nanomaterials 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 Nanomaterials: 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, 2ndEdn, 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 ARempel, Cambridge International Science Publishing, 1st Indian edition by Viva Books Pvt. Ltd. 2008.
- Springer Handbook of Nanotechnology by Bharat Bhushan, Springer, 3rdedn, 2010.
- Carbon Nanotubes: Synthesis, Characterization and Applications by Kamal K. Kar, Research Publishing Services; 1stedn, 2011, ISBN-13: 978-9810863975.

(OEC/ILE) Laser Materials Processing

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 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 HanserVerlag, Munich, 1990.
- Carlsaw H.S. and Jaeger J.C. 'Conduction of heat in solids', Oxford University Press (UK

(OEC/ILE) Powder Metallurgy

Teaching Scheme
Lectures: 3 hrs/week

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

Course Outcomes:

The student will be able to learn the Powder Manufacturing methods,

CO1: The student will be able to know the powder and finished PM product's characterization techniques,

CO2: The student will be able to understand the powder conditioning and consolidation methods to obtain the finished products

CO3:The student will be able to comprehend various methods of consolidation and the secondary operations performed on PM parts

CO4: The student will be able to develop awareness on manufacturing and applications of a few important P/M components: properties and their dependence on processing and microstructure.

Syllabus Contents:

Manufacture of metal powders: Conventional and modern methods, Powder characterization techniques, Powder Conditioning (mixing. blending, granulation etc.), Powder compaction: Mechanical, thermal and thermo-mechanical compacting processes, New methods of consolidation, Sintering theories, mechanisms, types, variables, Secondary operations Performed on Powder Metallurgical components, Heat treatment of PM components, Manufacturing and applications of important P/M components (Porous PM bearing, Cemented carbide tools, Electrical contact materials etc.)

Text Books:

1. Anish Upadhayaya , Gopal S. Upadhayaya, Powder Metallurgy: Science, Technology, and Materials, Universities Press, 2011.
2. Randall German, Powder Metallurgy Science, Metal Powder Industry; 2 Sub edition, 1994.
3. Randall German, Powder Metallurgy & Particulate Materials Processing, Metal Powder Industry, 2005
4. F. Thumler, R. Oberacker, An Introduction to Powder Metallurgy, Institute of Materials (Great Britain), 1993.
5. Cemented Tungsten carbide Production, properties & testing – Gopal S. Upadhayay

Reference Books:

1. Randall German, Sintering Theory and Practice, Wiley-Interscience; 1 edition, 1996.
2. ASM Handbook: Volume 7: Powder Metal Technologies and Applications, 2nd edition, 1998.

3. Claus G. Goetzel, Treatise on Powder Metallurgy, VOLUME II, III, Applied and Physical Powder Metallurgy, Interscience Publishers Inc., New York, 1950.
4. L. Sands, C. R. Shakespeare, Powder Metallurgy - practice and applications, Newnes, 1966.

(PSMC) Mathematical Modeling in Materials Processes

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 : Mathematically model metallurgical processes.

CO2 : Relate the models with on field real shop floor practices.

CO3 : Predict/extrapolate situations using 8modeling methods.

CO4 : Develop insight of the physical & chemical principles of the processes

Syllabus Contents:

Basics of Mathematical Modeling-Deterministic and stochaistic/probabilistic models. Mathematical formulation of Liquid state Metallurgical Processes of Iron Making,Primary Steel Making & Secondary Steel Making using Momentum,Mass & Energy Balance.Principles of Computational Fluid flow and setting up the governing equation with boundary conditions. Formulation of Laminar and Turbulent flows. Case Studies of Tapping of Liquid steel, melting behavior of additions,IGP. Mathematical Modeling of Solidification of Steel in Sand Moulds, Ingot Moulds & Concast. Mathematical formulation of Solid state processes of Heat treatment & Microstructure evolution, Diffusion & Kinetics. Formulation of Rolling and Forging operations. Discritized Methods of Taylor's series expansion, polynomial Interpolation & least square approximation for numerical computation of Non linear algebraic equations, ODE & PDE. Statistical methods for validating models. Introduction to FEM,FDM,FVM and Computer packages: MatLab, Sci Lab

Textbooks:

- DipakMazumdar,JamesW.Evans- Modelling of Steel Making Processes, CRC Publication,1st Edition,2010
- H.K.Versteeg , W.Malalsekera-An Introduction to Computational Fluid Dynamics, Longman Scientific & Technical, 1st Edition 1995.
  S.C.Chapra,R.P.Canale-Numerical Methods for Engineers, McGraw Hill India Pvt. Ltd.,5th Edition,2007

(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 noncrystalline 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 independent of interatomic 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
- 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.

Textbooks:

- 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.

(PCC 1/DEC) Ceramics Engineering

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 to:

CO1: know the importance of chemistry/stoichiometry, bonding, crystal structure and microstructure of ceramic materials in arriving at the final properties,

CO2: learn the ceramic processing techniques starting from powder making to fabrication the finished products,

CO3: control the various processing parameters so as to control the microstructure developed during sintering

CO4: analyze and solve the problems related to ceramics engineering

CO5: understand the important properties and applications of ceramics

Syllabus Contents:

Introduction to ceramics: Comparison of properties with metals and polymers, bonding-covalent and ionic, important ceramics structures, coordination, ionic radii, Ambipolar Diffusion, Kroger Vink notation of point defects, defect reactions.

Effect of Chemical Forces on Physical Properties: Melting Points, Thermal Expansion & Surface Energy. Thermodynamic and Kinetic Considerations: Free Energy, Chemical Equilibrium, Chemical Stability Domains, Gibbs-Duhem Relation for Binary Oxides, Kinetic Considerations, Phase diagrams and their importance.

Ceramic powder processing methods: Ball milling, Sol-gel, Polymer pyrolysis, Coprecipitation, Hydrothermal synthesis, Spray Drying/pyrolysis, DMO and Reaction Bonding, Powder characterization by BET and Laser particle size analyzer.

Forming methods: Conventional compaction route (ceramics route) and Novel processing techniques to finished products - Slip and Tape casting, gel casting, CIP, HIPping, extrusion, injection moulding and spray forming, additive manufacturing.

Sintering theory and microstructure development: Driving force and variables, Different mass transport mechanisms, Sintering parameters-Materials and Processing, Role of defects during sintering, Solid and liquid phase sintering, Grain growth and Ostwald ripening, pore-grain boundary interactions.

Important ceramics - properties and applications: Structural ceramics - deformation behaviour and toughening of ceramics, Measuring elastic modulus and flexural strength, Weibull modulus, Ionic conducting, Dielectric-ferroelectric and piezoelectric ceramics.

Textbooks:

- C. Barry Carter, M. Grant Norton, Ceramic Materials- Science and Engineering, Second Edition, Springer New York, 2013
- 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
- C.J. Brinker, D.E.Clark, and D.R. Ulrich, Better Ceramics through Chemistry, North Holland, 1984.
- F.F.Y. Wang, Ceramic Fabrication Processes, Academic Press, 1976.
- J. Reed, Introduction to the Principles of Ceramic Processing, 2nd Ed., John Wiley & Sons. 1995.

(PCC1/DEC) Electronic and Magnetic 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 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, factors affecting electrical resistivity, 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, solar cell and die sensitize solar cells, BPT etc, Manufacturing Methods and Applications. Magnetic properties and magnetic alloys, Soft and Hard Magnetic materials, Ferrites, Magnetic Recording Materials, and Magnetic Resonance Imaging. Superconductivity: Zero Resistance, Meissner Effect, Type I and II Superconductors, BCS Theory. Dielectric Materials and Insulation: Polarization, Relative Permittivity, 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, McGraw-Hill International Edition, 2nd Edition,1993.
- N. Braithwaite and G. Weaver - Materials in Action Series -Electronic Materials, ButterworthsPublication.
- S. O. Kasap - Principles of Electronic Materials and Devices, Tata McGraw-Hill Publication, 2nd Edition, 2002.

Reference Books:

- Schroder, Klaus, Electronic Magnetic and Thermal properties of Solids, Marcel Dekker, New York1978.
- Buschow K.H.J. (Ed.), Handbook of Magnetic Materials, Amsterdam: Elsevier.
- Electronic Materials Handbook**,** ASM International, Materials Park, 1989.

(PCC 2) Corrosion Engineering

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: Establish correlation between thermodynamics and corrosion.

CO2 : Solve numerical.

CO3: Understand concepts and fundamentals in corrosion.

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

Syllabus Content:

Thermodynamics and Kinetics of Electrode Processes- Polarization Curves, Concept of Over-Potential, Kinetics Of Passivity and Transpassivity, Nernst's Equation, Emf Series, Evan's Corrosion

Diagram, Galvanic Series. Pourbiax Diagram for Metal Water System, Applications and Limitations, Various Forms of Corrosion Such as Galvanic Corrosion, Crevice Corrosion, Pitting Corrosion, Intergranular Corrosion, Selective Leaching, Erosion Corrosion, Hydrogen Damage Etc. Mechanical, Metallurgical and Environmental Aspects. Material Selection for Specific Corrosion Applications Such as Marine Industry, Petrochemical Industry, High Temperature Service, Chemical Industry and Selection of Suitable Design for Corrosion Control, Principles of Protection, Inhibition, Coating Application Methods Including Electrophoretic Coating for Corrosion Control. Corrosion Testing by Physical and Electrochemical Methods such as ASTM standard methods likeG-8, G-5, G-1 etc. and their equivalents, Surface Preparation, Exposure Technique, Corrosion Rate Measurements. High Temperature Corrosion in Different Atmosphere, Effect of Doping, Alloying Elements, Coating Methods for High Temperature Corrosion Protection, Hot Corrosion.

Textbooks:

- M. Fontana - Corrosion Engineering, 2^{nd} ed., Mc Grew Hill, 1987
- H.H.Uhlig - Corrosion and Corrosion Control, 3^{rd} ed., Wiley, 1986

Reference Books:

- D.R. Jones - Principals and Prevention of Corrosion, 2nd intl. Ed., Prentice Hall International Singapore
- L.L.Shrier- Corrosion Volume I & II, 1994, Butterworths, London

(PCC 3) Phase Transformations in Materials

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	**T1, T2/Assignments – 20 marks each,**
Tutorial: 1 hr/week	**End-Sem Exam – 60**

Course Outcomes:

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

CO1: Utilize the knowledge of phase transformation in industries and research organizations.

CO2: Analyze, interpret and present observations on heat treatment.

CO3: Function in engineering units and science laboratory teams, as well as on multidisciplinary projects.

Syllabus Contents:

Basics of solution thermodynamics, concept of excess free energy, regular solution model, Binary and ternary phase diagrams and interpretations of tie line in ternary isotherms, Kinetics of phase transformation, Classification of phase transformations, Mechanism of diffusion in solids, steady state and non-steady state diffusion, factor affecting diffusion rate, Kirkendall effect. Energy aspects of homogeneous and heterogeneous nucleation, Fraction transformed at constant rates of nucleation and growth, Nucleation in solids. Austenite to pearlite transformation, temperature effect on pearlite transformation, Austenite to bainite transformation. Martensitic transformation: Crystallographic aspects and mechanism of atom movements, comparison between twinning and martensitic transformation, Effect of grain size, Plastic deformation, arrested cooling on kinetics. Order-Disordered transformations: Common structures in ordered alloys, variation of order with temperature, Determination of degree of ordering. Effect of ordering on properties, applications. Precipitation hardening: Structural changes, Mechanism and integration of reactions, Effect of retrogression, Double peaks, Spinoidal decomposition. Recovery, Recrystallization and grain growth: Property changes, Driving forces, N-G aspects, Annealing twins, textures in cold worked and annealed alloys, polygonization, Phase transformations in ceramics

Textbooks:

1. Solid State Phase Transformations by V. Raghavan, Prentice-Hall of India (P) Ltd., N. Delhi, 1987.
2. Phase Transformation in Metals and Alloys by David A. Porter, Kenneth E. Easterling, and Mohamed Y. Sherif, CRC Press, 3rd Ed. (Indian reprint), 2009.
3. Materials Science and Engineering, An introduction, by William D. Callisters, Jr., 7th Edition, John Wiley & Sons, Inc, 2011.
4. Modern Physical Metallurgy and Materials Enginering by R. E. Smallman and R.J. Bishop, 6th Edition, Butterworth Heinemann, 1999.
5. Recovery Recrystallization & Grain Growth in Metals – P. Cotterill& P. R. Mould- Surrey University Press
6. Physical Metallurgy – Cahn, Haasen, North Holland Physics Publication.

(LC 1) Lab Practice I

Teaching Scheme

Practical: 4 hrs/week

Examination Scheme

Term work: 100 Marks

Course Outcomes:

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

CO1 : Characterize ferrous and non ferrous materials.

CO2 : Understand Applications of Physical Metallurgy principles in characterization .

CO3 : Hands on training and skill development.

CO4 : Use modern engineering software tools and equipment to analyze Physical Metallurgy problems

Syllabus Contents:

- Any seven experiments from the following areas OR as identified by the course teacher on relevant topics will be conducted. Hands on polishing and etching skills for steels, brass, cast iron and aluminium samples, 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, NDT methods such as ultrasonic testing, magnetic particle inspection etc.

(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. Minimum five latest papers from reputed journals are to be referred while writing a consolidated report of the finding. The seminar report format is expected similar to dissertation report. Subsequently student will do a presentation of 15 minutes followed by question answer session. Evaluation will be on the basis of report and presentation before a panel of examiners.

(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 information.

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, Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

References:

1. Stuart Melville and Wayne Goddard, "Research methodology: An Introduction for Science and Engineering Students", Juta and Company Ltd.
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction", Juta and Company Ltd, 2004.
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	**Examination Scheme**
Lectures: 3 hrs/week	**T1, T2/Assignments – 20 marks each,**
Tutorial: 1 hr/week	**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 Content:

X-Ray Diffraction (XRD): Scattering by an electron, atom and unit cell. Intensity of diffracted beam from a crystal. Structure factor and its applications. Indexing of planes, determination of crystal structure, crystallite size, residual stresses, phases, textures and preferred orientation. Reciprocal lattice, Relation of reciprocal and Bravais lattice, Diffraction in terms of reciprocal lattice and its application to diffraction in electron microscopy, X-ray fluorescence spectroscopy. Transmission Electron Microscopy (TEM): Types of electron sources, Focusing systems for parallel beams and probes, Image contrast and interpretation of images, Specimen preparation techniques, Contrast theory for electron microscopes, Kikuchi lines and applications of TEM.

Scanning Electron Microscope (SEM): Working, detectors, Back Scattered and secondary electron imaging, channeling patterns, Specimen preparation techniques, Applications, Microanalysis (EDS, WDS). Introduction to Modern Techniques: scanning transmission electron microscope. High voltage Electron microscopy, EELS, Techniques of surface analysis such as XPS, scanning probe microscopy (SPM and AFM), Raman and FTIR spectroscopy. Thermal analysis: TG/DTA/DSC/ dilatometer techniques.

Textbooks:

1. B. D. Cullity- Elements of X-ray diffraction- Addison Wesley Publications

2. P.J. Goodhew, J. Humphreys, R. Beanland, Electron Microscopy and Analysis, 3rd Ed., Taylor and Francis, London
3. Edited by E. Metcalfe- Microstructure Characterization – The Institute of Metals, USA ASM Metals Handbook, 9thedition , Volume 10 – Materials characterization – ASM International publication.
4. B. L. Gabrial –SEM- A Users manual for material science- American Society for Metals.
5. Metals and Material Science , Process, Applications – Smallman and Bishop

(PCC 2) 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 disadvant
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, Woodhead Publishing Limited, Cambridge England.
3. Composite Materials-Functional Materials for Modern Technology, DDL Chung, Springer- Verlag Publications London
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. omposite Materials Science and Engg., Chawla K.K., Second Edition, 1998, Springer Verlag

(PCC 3) Mechanical Behavior 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.

Text Books:

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 KumarChawala, 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

(DEC1) Biomaterials

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 structure properties relationship of biomaterials

CO2 : Understand selection of biomaterials for a particular application

CO3 : Understand mechanical properties of biomaterials

CO4 : Understand biocompatibility of the materials for the intended application.

Syllabus Contents:

Structure and property relationships of different classes of biomaterials; Interactions of materials with the human body, Classification of Biomaterials, Composite materials and applications; Nanostructured biomaterials, Criteria for selection of biomaterials for specific medical applications, Concepts of Biocompatibility, Evaluation of biocompatibility, mechanical properties of biomaterials, corrosion and biodegradation, simulated body fluids and their effect on biodegradation, Orthopedic implants, dental materials, vascular grafts, ocular materials, drug delivery carriers, introduction to tissue regeneration scaffolds.

TEXT BOOKS/REFERENCE BOOKS:

1. Biomaterials Science: An Introduction to Materials in Medicine, 3rd Edition, Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, 2013, Academic press, UK.
2. Biomaterials, Medical Devices & Tissue Engineering: An integrated approach. Fredrick H. Silver, 1994, Chapman & Hall, UK.

(DEC 1) Amorphous 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 : Distinguish between amorphous and crystalline materials.
CO2 : Develop correlations between structure and properties.
CO3 :Use the subject knowledge to fabricate application specific materials.

Syllabus Contents:

Network structure of various oxide glasses, Stevel's parameters and kinetic criterion of glass formation, Role of oxides in glass composition, Melting, refining and forming of oxide glasses, Viscoelastic behaviour and mechanical properties, Thermal, dielectric and optical properties of glasses, Coloured and photosensitive glasses, glass fibre technology, Glass-ceramics and glasses for electronic applications, Preparation of metallic glasses by rapid solidification, Synthesis of amorphous alloys by mechanical alloying, Properties and applications of amorphous alloys, Microcrystalline and nanocrystalline materials.

References:

1) H. Scholze, Glass: Nature, Structure and Properties, Springer-Verlag, New York, 1991.
2) J. Zarzycki, Glasses and the Vitreous State, Cambridge Univ. Press, 1991.
3) S.J. Schneider Jr., Ceramics and Glasses, Engineered Materials Handbook, Vol. 4, ASM Intl., Ohio, 1991.

4) F.H. Froes and S.J. Savage (Eds.), Processing of Structural Metals by Rapid Solidification, ASM Pub., Ohio, 1987.
5) H.H. Liebermann (Ed), Rapidly Solidified Alloys, Marcel Dekker Inc., New York, 1993

(DEC1) Thermodynamics 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 : 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 multicomponent 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, multicomponent systems.
- Equilibrium Concepts: Unary, binary and multicomponent systems, phase equilibria, evolution of phase diagrams, metastable phase diagrams, calculation of phase diagrams, thermodynamics of defects.
- 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 HallIndia.
- R.A. Swalin, Thermodynamics of Solids, 2nd ed., Wiley, New York, 1972
- D.A. Porter and K.E. Easterlingand 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, embrittlement 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 4thEdition 1996.
- Nuttall, W.J., Nuclear Renaissance: Technologies And Policies For The Future of Nuclear Power, IOP, 2005.

(DEC 2) Engineering Polymers

Teaching Scheme:
Lectures:3hrs/week

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

Course Outcomes:

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

CO1: know the structure and properties of engineering polymers
CO2: utilize the engineering polymers as matrices for fabricating polymer matrix composites.
CO3: test the thermal properties of the engineering polymers.
CO4: test the mechanical and electrical properties of the engineering polymers.
CO5: process the engineering polymers.

Syllabus Contents:

Introduction to structure, classification, and molecular weight of polymers, molecular bonds and inter-molecular attraction, arrangement of polymer molecules in thermoplastic polymers, amorphous thermoplastics, semi-crystalline thermoplastics, thermosets and cross-linked elastomers. Specialty-polymers, Basic theory of Fourier Transform Infrared Spectroscopy (FTIR), Polymer Additives; Flame Retardants, Stabilizers, Antistatic Agents, Fillers, Blowing Agents etc. Thermal properties of polymers; Specific heat, Thermal conductivity, Thermal diffusivity, Linear coefficient of thermal expansion, Thermal penetration, Glass transition temperature, Melting temperature. Measuring instrument for thermal properties: Mechanical Behavior of Polymers; Basic Concepts of Stress and Strain, Viscoelastic Behavior of Polymers, Stress Relaxation Test, Effects of Structure and Composition on Mechanical Properties, Impact Strength and Impact Test Methods, Creep Rupture and Creep Rupture Tests, Fatigue and Fatigue Test Methods, Environmental Effects on Polymer Failure etc. Thermal Degradation of Polymers. Electrical properties of polymers, Electric breakdown, Electrostatic charge, Electromagnetic Interference (EMI) Shielding, Magnetic properties, Measuring instrument for electrical properties. Polymer processing; extrusion, blow molding, injection molding, thermoforming, calendaring, spinning, casting, hot compaction, cold compaction/sintering. Solidification and Crystallization of thermoplastics. Structure, properties and applications of engineering polymers; polyamide polyester, polycarbonate, polyurethane, polyetherketon, PPS. PES, Conducting polymers etc.

Textbooks:

1. Material Science of Polymers for Engineers, Osswald, Menges, 3rd edition, 2010, Hanser Publications.
2. Principles of Materials Science and Engineering, William F. Smith, 3rd edition, 2002, McGraw-Hill.
3. Composite Materials-Functional Materials for Modern Technology, D.D.L .Chung, 2003, Springer- Verlag Publications,London, Great Britain.
4. The nature and Properties of Engg. Materials, Z.D. Jastrzebaski, 1959, John Wiley & Sons, New York.

(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: superalloys, intermetallics, ceramics.

References:

- 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.

(LC1) Lab Practice II

Teaching Scheme | **Examination Scheme**

Practical: 4 hrs/week | **Term work: 100 Marks**

Laboratory Outcomes:

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

CO1 : Use XRD for crystal structure determination

CO2: Understand procedures of advanced testing such as wear and fatigue.

CO3: Hands on training and skill development.

CO4: Use modern engineering software tools and equipment to analyze Physical Metallurgy problems

Syllabus Contents:

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 | **Examination Scheme**

Practical: 2 hrs/week | **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. Minimum five latest papers from reputed journals are to be referred while writing a consolidated report of the finding. The seminar report format is expected similar to dissertation report. Subsequently student will do a presentation of 15 minutes followed by question answer session. Evaluation will be on the basis of report and presentation before a panel of examiners.

(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
Contact Period: 1 hr/week

Examination Scheme
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 formatabout 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)

SEMESTER- III

(Dissertation) Dissertation Phase – I

Teaching Scheme	**Examination Scheme**
Nil	**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. For evaluation of the Dissertation Phase-I, student should submit a write-up in their own words 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. For evaluation of the Dissertation Phase-II, student shall submit a write-up in their own words in a 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 1) Research Methodology**
- **(MLC 2) Humanities**
- **(MLC-3) Intellectual Property Rights**
- **(LLC) Liberal Learning Course**