COEP Technological University Pune

(A Unitary Public University of Govt. of Maharashtra)

School of Mechanical and Materials Engineering

Curriculum Structure

M.Tech. Materials Engineering

Department of Metallurgy and Materials Engineering

(Effective from: A.Y. 2023-24)

List of Abbreviations

Abbreviation	Title
AEC	Ability Enhancement Course
BS	Basic Science Course
ESC	Engineering Science Course
PCC	Programme Core Course
PEC	Programme Elective Course
PSMC	Programme Specific Mathematics Course
PSBC	Programme Specific Bridge Course
OE/SE	Open/School Elective other than particular program
MDM	Multidisciplinary Minor
VSEC	Vocational and Skill Enhancement Course
HSMC	Humanities Social Science and Management
IKS	Indian Knowledge System
VEC	Value Education Course
RM	Research Methodology
INTR	Internship
PBL	Project
CEA	Community Engagement Activity/Field Project
CCA	Co-curricular & Extracurricular Activities
SLC	Self-Learning Course
MLC	Mandatory Learning Course
LC	Laboratory Course

F. Y. M. Tech. Materials Engineering

Semester -I

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	PSMC	*<tbd>*	Mathematical Modelling in Materials Processing	3	1	0	0	4	30	10	60	--	--
02	PSBC	*<tbd>*	Concepts in Materials Science	3	0	0	1	3	30	10	60	--	--
03	PCC	*<tbd>*	Phase Transformation in Materials	3	1	0	0	4	30	10	60	--	--
04	PCC	*<tbd>*	Corrosion Engineering	3	0	0	0	3	30	10	60	--	--
05	PEC-I	*<tbd>*	Advances in Ceramics Engineering Nanomaterials and Nanocomposites Electronic and Magnetic Materials	3	0	0	1	3	30	10	60	--	--
06	AEC-I	*<tbd>*	Advanced Composites	3	0	0	1	3	30	10	60	--	--
07	LC-I	*<tbd>*	Lab Practice-I	0	0	2	0	1	--	--	--	CIE: 100	
08	LC-II	*<tbd>*	Seminar-I	0	0	2	0	1	--	--	--	CIE: 100	
			Total	**18**	**02**	**04**	**03**	**22**					

Semester -II

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	PCC	*<tbd>*	Characterization Techniques	3	1	0	1	4	30	10	60	--	--
02	PCC	*<tbd>*	Thermodynamics of Materials	3	0	0	0	3	30	10	60	--	--
03	PCC	*<tbd>*	Mechanical Behaviour of Materials	3	0	0	0	3	30	10	60	--	--
04	PEC-II	*<tbd>*	Advanced Fracture Mechanics Light Metals and Alloys Amorphous Materials Engineering Polymers	3	0	0	0	3	30	10	60	--	--
05	PEC-III	*<tbd>*	High Temperature Corrosion Advances in Energy Materials Smart Materials and Structures Biomaterials	3	0	0	0	3	30	10	60	--	--
06	OE	*<tbd>*	Open Elective	3	0	0	2	3	30	10	60	--	--
07	MLC-I	*<tbd>*	Research Methodology and Intellectual Property Rights	2	0	0	0	0	--	--	--	--	--
08	MLC-II	*<tbd>*	Effective Technical Communication	1	0	0	0	0	--	--	--	--	--
09	LC-III	*<tbd>*	Lab Practice-II	0	0	2	0	1	--	--	--	CIE: 100	
10	LC-IV	*<tbd>*	Seminar-II	0	0	2	0	1	--	--	--	CIE: 100	
11	LLC	*<tbd>*	Liberal Learning Course	0	0	0	2	1	--	--	--	CIE: 100	
			Total	**21**	**01**	**04**	**05**	**22**					

Legends: **L-Lecture, T-Tutorial, P-Practical, S-Self Study, Cr-Credits**
ISE-In-Semester-Evaluation, ESE-End-Semester-Evaluation, MSE-Mid-Semester-Evaluation, TA-Teachers' Assessment, CIE-Continuous-Internal Evaluation

Exit option to qualify for PG Diploma in Materials Engineering:

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	Exit Course	*<tbd>*	Eight Weeks Domain Specific Industrial Internship	--	--	--	--	03	--	--	--	CIE: 100	
			Total	**--**	**--**	**--**	**--**	**03**					

S. Y. M. Tech. Materials Engineering

Semester -III

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	SLC-I	*<tbd>*	Massive Open Online Course-I (MOOC-I)#	--	--	--	--	3	40	--	60	--	--
02	VSEC	*<tbd>*	Dissertation Phase-I	--	--	18	12	9	--	--	--	CIE: 100	
			Total	**00**	**00**	**18**	**12**	**12**					

Semester -IV

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	SLC-II	*<tbd>*	Massive Open Online Course-II (MOOC-II)#	--	--	--	--	3	40	--	60	--	--
02	VSEC	*<tbd>*	Dissertation Phase-II	--	--	18	12	9	--	--	--	50	50
			Total	**00**	**00**	**18**	**12**	**12**					

Legends: **L-Lecture, T-Tutorial, P-Practical, S-Self Study, Cr-Credits**
ISE-In-Semester-Evaluation, ESE-End-Semester-Evaluation, MSE-Mid-Semester-Evaluation, TA-Teachers' Assessment, CIE-Continuous-Internal-Evaluation

#Students are encouraged to take NPTEL online courses relevant to the field of specialization and dissertation (in consultation with dissertation/project supervisor). The evaluation of such courses will be done at university level based on the scores obtained in Assignments and Proctored Exam (on NPTEL Portal) as per the university directives. It is also mandatory for the students to pass the final Proctored Exam (on NPTEL Portal) and produce the passing certificate (obtained from NPTEL portal) to the respective department at the time of ESE/final evaluation.

Semester I

Mathematical Modeling in Materials Processes

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

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

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

1. Mathematically model metallurgical processes.
2. Relate the models with on field real shop floor practices.
3. Predict/extrapolate situations using 8modeling methods.
4. Develop insight of the physical & chemical principles of the processes.

Syllabus Contents:
Basics of Mathematical Modeling-Deterministic and stochastic/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: Mat Lab, Sci Lab.

Textbooks/ Reference Books:
Dipak Mazumdar, 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.

Concepts in Materials Science

Teaching Scheme:
Lectures: 3 hr/week
Self-Study: 1 hr/week

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

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

1. Understand basics of the structure- properties relationship.
2. Understand importance of phase diagrams in micro structure design.
3. Analyze, interpret and solve scientific materials data/ problems.
4. 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 independent 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.
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/ 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.

Phase Transformations in Materials

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

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

Course Outcomes:

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

1. Utilize the knowledge of phase transformation in industries and research organizations.
2. Analyze, interpret and present observations on heat treatment.
3. Function in engineering units and science laboratory teams, as well as on multidisciplinaryprojects.

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, Spinodal 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/ Reference Books:

Solid State Phase Transformations by V. Raghavan, Prentice-Hall of India (P) Ltd., N. Delhi, 1987.

Phase Transformation in Metals and Alloys by David A. Porter, Kenneth E. Easterling, and Mohamed Y. Sherif, CRC Press, 3rd Ed. (Indian reprint), 2009.

Materials Science and Engineering, An introduction, by William D. Callisters, Jr., 7th Edition, John Wiley & Sons, Inc, 2011.

Modern Physical Metallurgy and Materials Enginering by R. E. Smallman and R.J. Bishop, 6th Edition, Butterworth Heinemann, 1999.

Recovery Recrystallization & Grain Growth in Metals – P. Cotterill& P. R. Mould- SurreyUniversity Press.

Physical Metallurgy – Cahn, Haasen, North Holland Physics Publication.

Advances in Ceramics Engineering

Teaching Scheme:
Lectures: 3 hr/week
Self-Study: 1 hr/week

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

Course Outcomes:

The student will be able to:

a) Get an in depth knowledge of few of advanced ceramics covered here.
b) Understand the important properties and applications of ceramics.
c) Analyze and solve the problems related to advanced ceramics covered here.
d) Pursue research on any of the topic covered here.

Unit 1 **[8 hrs]**

Dielectric, Ferroelectric and Piezoelectric ceramics technology: Dielectrics: Polarization (electronic, Ionic, dipolar, space charge), Dielectric constant and Loss, High-Q and High- Er Materials, Capacitors AC impedance & its measurement; Piezoelectric and ferroelectrics: Structural origin of the ferroelectric state, Hysteresis, Ferroelectric domains, Piezoelectric figures of merit (piezoelectric strain constant d, the piezoelectric voltage constant g, the electromechanical coupling factor k, the mechanical quality factor QM, and the acoustic impedance Z), Main Dielectric, Ferroelectric and Piezoelectric Ceramics.

Unit 2 **[7hrs]**

Ceramics for Energy and environment technologies: Basic theory of Electrical and Ionic Conductivity in solids, Joncher's power law, Arrhenius equation, Activation energy, Nernst- Einstein relationship, fast ion conductors (FICs)/ solid electrolytes, fuel cell: currently used materials: electrolytes, cathodes, anodes, interconnects, lithium and high energy batteries, Sodium sulphate cell (with β – alumina), Ceramics for energy and environment technologies

Unit 3 **[7hrs]**

Magnetic Ceramics Technology: Spinel Ferrites, Hexagonal Ferrites, Garnet, Processing, Single crystal ferrite, Applications. Critical parameters, Powder synthesis, Effects of composition & Grain size & Porosity on the magnetic behavior.

Unit 4 **[7hrs]**

Mechanical Properties of Ceramics: Plastic Deformation, Viscous Flow and Creep: Introduction, plastic deformation, creep deformation, viscous deformation, plastic deformation of rock salt, fluorite crystal and Al2O3, Creep of single crystal and polycrystalline ceramics, Elasticity, Anelasticity and Strength: Fracture Process, Elastic Deformation & Elasticity, Elastic Moduli, Anelasticity Behavior, Brittle Fracture & Crack propagation, Theoretical strength, Griffith Orwan criteria, Statistical nature of strength, Strength & Fracture surface, Static fatigue, Creep fracture, Effect of microstructure, important structural ceramics.

Unit 5 **[7hrs]**

Thermal and Optical Properties of Ceramics. Thermal Shock Resistance, thermal conductivity,thermal expansion and spalling, slag resistance, Thermal Expansion & Thermal stresses,Temperature Gradient & Thermal stresses, Micro-stresses, Glaze Stresses, Resistance to thermalshock & thermal spalling, Thermally tempered

Glass, Annealing, Chemical strengthening Electromagnetic waves in ceramics, Refractive Index & Dispersion, Reflection & Refraction.Scattering, Refractive Index & Dispersion in Dielectric materials, Boundary Reflectance & Surfacegloss, Opacity & Translucency. Absorption & Color, Bands, Color, Ligand-Field ChemistryColorants, Ceramic Stains, Color specifications, Optical and optoelectronic applications of ceramics such as Lasers, Phosphors, Fiber optics etc.

Unit 6 **[7hrs]**

Ceramics Technology for and for biomedical applications, Membranes and catalytic converter: Bioceramics: Structure of typical human bone, ceramics for artificial bone, requirement for artificial material to bond to living bone, apatite formation, Bio-active materials, nearly inert crystalline ceramics, bioceramic implants for hip and knee prosthesis; hydroxyapatite related ceramics/composites; porous ceramics, bioactive glass and glass ceramics, bioactive cements, calcium phosphate ceramics, carbon base implant materials, ceramics for dental applications, Ceramics for Membranes and catalytic converters.

Reference Books:

a. Shigeyuki Somiya (Editor-in-Chief), Handbook of Advanced Ceramics, VOLUME IIProcessing and their Applications, Elsevier Academic Press, London, UK, 2003.
b. J. Moulson and J. M. Herbert, Electroceramics Materials, Properties, Applications
c. M.W. Barsoum, Fundamentals of Ceramics,
d. R.C. Buchanan, Ceramic Materials for Electronics, Processing, Properties andApplications.
e. C. Barry Carter, M. Grant Norton, Ceramic Materials- Science and Engineering.
f. Physical Ceramics for Engineers - Van Vlack.
g. S. Kumar: Hand book of ceramics; Vol – I & II
h. Y. M. Chiang, D. Birnie III and W. D. Kingery, Physical Ceramics: Principles for CeramicScience and Engineering, Wiley, 1996.

Electronic and Magnetic Materials

Teaching Scheme:
Lectures: 3 hr/week
Self-Study: 1 hr/week

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to understand:
1. Physical basis of electrical, electronic and magnetic properties.
2. Structure of advanced electrical engineering materials.
3. The materials for electrical, electronic and magnetic applications.
4. Use of 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.

Textbooks:
1. William F. Smith - Foundation of Materials Science and Engineering, McGraw-HillInternational Edition, 2nd Edition, 1993.
2. N. Braithwaite and G. Weaver - Materials in Action Series -Electronic Materials, Butterworth's Publication.
3. S. O. Kasap - Principles of Electronic Materials and Devices, Tata McGraw-Hill Publication,2nd Edition, 2002.

Reference Books:
1. Schroder, Klaus, Electronic Magnetic and Thermal properties of Solids, Marcel Dekker, NewYork 1978.
2. Bus chow K.H.J. (Ed.), Handbook of Magnetic Materials, Amsterdam: Elsevier.
3. Electronic Materials Handbook, ASM International, Materials Park, 1989.

Nanomaterials and Nanocomposites

Teaching Scheme:
Lectures: 3 hr/week
Self-Study: 1 h/week

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

Course Outcomes:

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

1. Know the length scale, surface area to volume ratio and properties of nanomaterials.
2. Know the effect of particles size on mechanical, thermal, optical and electrical Properties ofnanomaterials.
3. Know the synthesis and applications of nanomaterials/nanocomposites.
4. Apply the knowledge to prepare and characterize nanomaterials using various tools.
5. Understand the theoretical concepts useful for structural, electronics, optical, magnetic andbio-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 vapor 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:

1. Textbook of Nanoscience and Nanotechnology by B.S. Murty and P. Shankar, Universities Press (India) Private Limited, 2012, 1st Edition.
2. Nanostructures and Nanomaterials: Synthesis, Properties & Applications by Guozhong Cao, Imperial College Press, 2004, 2nd Edition.
3. Introduction to Nanoscience and Nanotechnology by Gabor L. Hornyak, H.F. Tibbals, Joydeep Dutta, John J. Moore, CRC Press, 2008, ISBN-13: 978-1420047790.

4. Introduction to Nanotechnology by Charles P. Poole, Jr., Frank J. Owens, Wiley, 2003, ISBN: 978-0-471-07935-4.
5. Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers and Architects by Daniel L. Schodek, Paulo Ferreira, and Michael Ashby, Butterworth- Heinemann, 2009, 1st Edition.
6. Nanomaterials: An Introduction to Synthesis, Properties and Applications by Dieter Vollath, Wiley-VCH, 2ndEdn, 2013, ISBN: 978-3-527-33379-0.

Reference Books:

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

Advanced Composites

Teaching Scheme:
Lectures: 3 hr/week
Self-Study: 1 h/week

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

Course Outcomes:

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

1. The major constituents & types of composite materials
2. Metallic, ceramic and polymeric materials as matrix materials and their properties andcharacteristics.
3. Processing methods used for PMC, MMC, and CMC manufacturing, their advantages anddisadvantages
4. Composite materials for structural, electrical, electromagnetic, dielectric, optical andmagnetic 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.

Textbooks:

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.
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, NewYork.
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, IOPPublishing Ltd.
4. Composite Materials Science and Engg., Chawla K.K., Second Edition, 1998, Springer Verlag.

Lab Practice I

Teaching Scheme:
Practical: 2hr/week

Examination Scheme:
Continuous Eval.: 100 Marks

Course Outcomes:

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

1. Characterize ferrous and non-ferrous materials.
2. Understand applications of Physical Metallurgy principles in characterization.
3. Hands on training and skill development.
4. 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 onrelevant topics will be conducted.

- Hands on polishing and etching skills for steels, brass, cast iron and aluminum 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.

Seminar I

Teaching Scheme:
Practical/Term work: 2 h/week

Examination Scheme:
Presentation/Term work: 100 Marks

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

1. Find literature and integrate the potential research areas in the field.
2. Develop an ability to communicate effectively in both oral and written forms.
3. 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.

Semester II

Mechanical Behaviour of Materials

Teaching Scheme:
Lectures: 3 hr/week

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

Course Outcomes:

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

1. Analyze mechanical deformation of the materials using analytical treatment.
2. Use mechanical metallurgical concepts in understanding mechanical deformation.
3. Identify failure modes and reasons of failures of engineering components.
4. Incorporate fracture mechanics concepts in the mechanical design.
5. 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, and 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 onfatigue, 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 / Part4, 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.
3. C. Wagnev, Thermodynamics of alloys, Addison Wesley, Cambridge, 1952.
4. F. D. Richardson, Physical Chemistry of Melts in Metallurgy, Academic, N. Y., 1974.

Characterization Techniques

Teaching Scheme:	Examination Scheme:
Lectures: 3 hr/week	MSE and TA: 30 and 10 marks
Tutorial: 1 hr/week	End-Sem Exam: 60 Marks
Self-study: 1 hr/week	

Course Outcomes:

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

1. Use fundamental and applied concepts in materials characterization.
2. Develop an understanding of the sample preparation methods, working principle,operation and applications of important analytical methods.
3. Understand, correlate and interpret the results.

Syllabus Contents:

X-Ray Diffraction (XRD): Scattering by an electron, atom and unit cell. Intensity of diffractedbeam from a crystal. Structure factor and its applications. Indexing of planes, determination ofcrystal structure, crystallite size, residual stresses, phases, textures and preferred orientation.Reciprocal lattice, Relation of reciprocal and Bravais lattice, Diffraction in terms of reciprocallattice and its application to diffraction in electron microscopy, X-ray fluorescence spectroscopy.

Transmission Electron Microscopy (TEM): Types of electron sources, Focusing systems forparallel beams and probes, Image contrast and interpretation of images, Specimen preparationtechniques, 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/ Reference Books:

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, 9th edition, Volume 10 – Materials characterization – ASM International publication.
4. B. L. Gabrial –SEM- A User's manual for material science- American Society for Metals.
5. Characterization of Materials, Volumes 1 And 2, Elton N. Kaufmann, Editor-In-Chief, John Wiley & Sons, 2003.
6. Encyclopedia of Materials Characterization, Materials Characterization Series, Surfaces, Interfaces, Thin Films, Series Editors: C. Richard Brundle and Charles A. Evans, Jr., Butterworth-Heinemann, 1992.

Thermodynamics of Materials

Teaching Scheme:
Lectures: 3 hr/week

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

Course Outcomes:

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

1. Apply laws of thermodynamics to processes and reactions.
2. Calculate thermodynamic properties for various metallurgical processes.
3. Predict feasibility of reactions using chemical equilibrium constant.
4. Formulate thermodynamic system for development of materials.

Syllabus content:

Definitions and concepts in thermodynamics, First law and second law of thermodynamics, Heat capacity, Enthalpy, Heat of reactions, Hess's law, Kirchoff's equation, Third law of thermodynamics, Temperature dependence of heat capacity. Concept of equilibrium, Free energy as criterion for equilibrium and its applications to processing of materials. Solutions: ideal, dilute and regular; Molal and partial molal quantities, Chemical potential, Gibbs-Duhem equations. Free energy-temperature diagrams, oxygen potential. Statistical thermodynamics, Phase equilibrium in one component system, Phase rule, Binary phase diagrams, Free energy versus compositions in binary systems, Ternary phase diagrams. Point defects in crystals, Defects stability,

Defects in nearly stoichiometric and non-stoichiometric compounds, Thermodynamics of surfaces and interfaces, Pressure drop across an interface, Thermodynamics of electrochemical reactions, Electrochemical cell, Determination of thermodynamic quantities using reversible electrochemical cell, EMF cell, electrode potential, electrode processes, Pourbaix diagrams.

Text book and References:

1. D.R. Gaskell, Introduction to Thermodynamics of Materials, 3rd Edition, Talyor & Francis Co.Inc, 2002.
2. D.A. Porter and K.E. Easterling, Phase Transformations in Metals and Alloys, VNR International Reprints 1989.
3. R.A. Swalin, Thermodynamic of Solids, Second edition, John-Wiley and Sons, 1972.
4. O. F. Devereux, Metallurgical thermodynamics, Wiley Interscience, Publication, 1983.
5. G.S. Upadhya and R.K. Dubey, Problems in Metallurgical Thermodynamics and Kinetics,Pergamon Press, Inc.

Advanced Fracture Mechanics

Teaching Scheme:
Lectures: 3 hr/week

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to understand:
1. The basic and advance concepts related to fracture mechanics,
2. Equations governing fracture, crack growth, stress intensity factor and fracture toughness
3. Understand to solve the problems related to advanced fracture mechanics which are of industrial relevance using FEA software

Syllabus Contents:
Introduction to Fracture Mechanics, Elasticity and plasticity theory, Fundamental equations in theory of elasticity and plasticity, Mohr's circle, Stress and Strain tensors, brittle and ductile fracture, strain energy release rate, Griffith theory of brittle fracture, Stress intensity factor in various modes, relation between strain energy release rate and stress intensity factor, application of brittle fracture in advanced one atom thick 2D and heterostructures, concept of DBTT, Classification of fracture mechanics; (i) linear elastic fracture mechanics, and (ii) elastic plastic fracture mechanics, quantifying fracture toughness (i) J-integral, (ii) R-Curve, (iii) CTOD, Fracture in coatings and thin films, Application of the above concepts in designing materials for damage tolerant applications.

N.B: At the end of the semester, it is advised/appreciated that if the students can solve the advanced problems related to fracture mechanics using finite element analysis (FEA) software such as Abaqus and ANSYS. It would be also appreciated if they are able to implement the above concepts in solving the fracture mechanics/crack growth problem using extended finite element method (x-FEM). The respective subject teachers/tutors are highly encouraged to use/demonstrate these problems using FEA software.

Textbooks/Reference Books:

1. R. W. Hertzberg, R. P. Vinci, J. L. Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, 5th Edition, Wiley, 2012, ISBN-10: 0470527803.
2. G. E. Dieter, Mechanical Metallurgy, 3rd Edition, McGrawHill, 2017, ISBN: 0071004068.
3. T. L. Anderson, Fracture Mechanics: Fundamentals and Applications, 4th Edition, CRC Press, 2017, ISBN10: 1498728138.
4. R. J. Sanford, Principles of Fracture Mechanics, 1st Edition, Pearson, 2002, ISBN-10: 0130929921.

Light Metal Alloys

Teaching Scheme:
Lectures: 3 hr/week

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

Course Outcomes:

1. Student will be able to establish correlation between microstructure and mechanicalproperties of various nonferrous materials.
2. Student will acquire knowledge of advanced materials and their strengtheningmechanisms.

Syllabus Contents:

The light Metals: General introduction, production of aluminum, production of magnesium, production of titanium, usage and economics solid/liquid Interface stability, Heat flow, heat evolution, shrinkage, macro and micro segregation Cast Aluminum Alloys: Thermodynamics and kinetics of solidification, homogeneous and heterogeneous nucleation, dendritic growth,, Recent advances in processing: Semi solid processing (SSP), Thixo graphic processing, Designation, temper and characteristics of cast aluminum alloys, Al-Si alloys Al-Cu alloys, Al-Mg alloys, Al-Zn-Mg alloys, Wrought Aluminum Alloys: Production of wrought alloys, Designation of alloys and temper, Work hardening of aluminum and its alloys, Heat treatable and Non heat treatable alloys, Defect in wrought alloys, Joining methods, Special products-air craft, automotive, packaging alloys.

Physical Metallurgy of Aluminum 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/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 McGrawHilledition1976.
4. Semisolid Processing of Alloys edited by Kirkwood.

Amorphous Materials

Teaching Scheme:
Lectures: 3 hr/week

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to:
1. Distinguish between amorphous and crystalline materials.
2. Develop correlations between structure and properties.
3. 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.

Textbooks/ Reference Books:
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, ASMPub., Ohio, 1987.
5. H.H. Liebermann (Ed), Rapidly Solidified Alloys, Marcel Dekker Inc., New York, 1993.

Engineering Polymers

Teaching Scheme:
Lectures: 3 hr/week

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

Course Outcomes:

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

1. Know the structure and properties of engineering polymers
2. Utilize the engineering polymers as matrices for fabricating polymer matrix composites.
3. Test the thermal, mechanical and electrical properties of the engineering polymers.
4. 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/Reference Books:

1. Material Science of Polymers for Engineers, Osswald, Menges, 3rd edition, 2010, HanserPublications.
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.

High Temperature Corrosion

Teaching Scheme:
Lectures: 3 hr/week

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

Course Outcomes:

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

1. Establish correlation between thermodynamic and high temperature corrosion.
2. Solve numerical.
3. Understand concepts and fundamentals in high temperature corrosion.
4. Knowledge of material selection for different corrosive environments and Knowledge ofcorrosion prevention methods.

Syllabus Contents:
Introduction to high Temperature corrosion & oxidation of Metals and Alloys, Thermodynamics & Ellingham diagram, vapor 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, SpecialTreatment. High temp. Materials: superalloys, intermetallics, ceramics.

Textbooks/ Reference Books:

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

Advances in Energy Materials

Teaching Scheme:
Lectures: 3 hr/week

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

Course Outcomes:

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

1. To use various types of nanomaterials energy storage devices.
2. Introduction of Cutting edge technologies through reference books, research papers, monographs and papers published in conferences of an international repute and its implementation to use nanomaterials to fabricate energy storage devices.
3. To improve the multifunctionality of energy storage devices.

Syllabus Contents:

Overview of the types of Nanomaterials and differences between nano and conventional materials, Architectures of nanomaterials and heterostructures with special emphasis on applications to energy storage devices, Characteristics of energy storage materials at micro and nanoscale (i.e., effect of crystal structure and orientation as well as aspect ratio), Surface and bulk aspects related to stability during operations (i.e., morphological and structural), Chemical, Physical and Mechanical Properties of Energy Storage Materials, Synthesis of energy storage materials and micro and nanofabrication of energy storage devices, Working principle and demonstration of advanced electrochemical energy storage devices such as Li/Na-ion batteries, and fuel cells, etc. Performance improvement of these devices using nanomaterial, Current challenges, future perspectives and significant improvement in multifunctional behaviour of energy storage materials.

Reference Books:

1. E. R. Leite, Nanostructured Materials for Electrochemical Energy Production and Storage, Springer, 2009, ISBN: 978-0-387-49323-7.
2. B. E. Conway, Electrochemical Supercapacitors Scientific Fundamentals and Technological Applications, Springer, 1999, ISBN: 9781475730586.
3. D. Linden, T. B. Reddy, Handbook of Batteries, 3 rd Edition, McGraw-Hill, 2002, ISBN-13: 9780071359788.
4. C. G. Granqvist, Handbook of Inorganic Electrochromic Materials, Elsevier, 1995, ISBN: 9780080532905.

Smart Materials and Structures

Teaching Scheme:
Lectures: 3 hr/week

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

Course Outcomes:

At the end of course students will be able to:

1. Understand the synthesis, characterization and properties of smart materials and their applications in smart devices/structures.
2. How to tailor the multifunctionality of such materials by tuning the length scales in these materials.

Syllabus Content:

Smart/intelligent materials/system, Correlation of such materials with humanity, Importance and advances in smart/intelligent materials in biotechnology, biology and clinical translation applications,

Piezoelectric Materials: Introduction, theory, applications of piezoelectric materials (from conventional to the most recent sensors, M/NEMS devices), Smart systems comprising piezoelectric materials

Shape Memory Materials (SMM): Background and theory, shape memory effect, shape memory alloys in machines and structures, shape memory polymers and plastics

Materials for sensors and actuators, micro and nano sensors, smart coatings, stimuli response and mechanisms: self-healing, self-sensing, active triggering or triggered release, and their applications in clinical translations, oil-water repellant industries and early corrosion detection.

Reference Books

1. M.V. Gandhi, and B.S. Thompson, Smart Materials and structures (2nd edition), Chapman & Hall, 1992, ISBN: 0412370107, 9780412370106
2. A. Guran, H.S. Tzou, G.L. Anderson, and M. Natori, Structure Systems: Smart Structures, Devices and System (Part 1), and Materials and Structures (Part 2), World Scientific Publications, 1998, ISBN: 9780340719206
3. U. Gabbert, and H.S. Tzou, Smart Structures and Structuronic System, Kluwer Academic Publishers, 2001, ISBN: 978-0-470-04192- 5
4. H.T. Banks, R.C. Smith, and Y.W. Qang, Smart Material structures: Modeling, Estimation and Control (6th edition), John Wiley & Sons, 1997.

Biomaterials

Teaching Scheme:
Lectures: 3 hr/week

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

Course Outcomes:

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

1. Perform structure-properties relationship of biomaterials
2. Do selection of biomaterials for a particular application
3. Evaluate mechanical properties of biomaterials
4. Correlate 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.

Textbooks/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.

Design and selection of Materials

Teaching Scheme:
Lectures: 3 hr/week
Self-Study: 2 h/week

Examination Scheme:
MSE and TA: 30 and 10 marks
End-Sem Exam: 60 Marks

Course Outcomes:

At the end of course, students will be able to

1. Design process and its relation to material selection.
2. Interpret mechanical properties of materials, and apply these material properties in thedesign of components.
3. Determine the mechanical properties of materials, and apply these material properties inthe design system components.
4. Explain the interrelationship between design, function, materials and process.

Syllabus content:

Materials in Design, Evolution of Engineering Materials, Design process, Types of design, Design flow chart- tools and material data, Interaction between Function, Material, Shape and Process. Revision of engineering materials and properties, Material properties interrelationship charts such as Young's modulus-density, Strength-density, Young‟s modulus-Strength, wear rate- hardness, Young's modulus –relative cost, strength-relative cost and others. Materials selection, selection strategy: material attributes, translation of design requirements, screening attribute limits, ranking by indices, search supporting information ,Local conditions, method of finding indices, Weighted-Properties Method, computer aided selection, structural index; Case studies: table legs, flywheel, springs, elastic hinges, seals, pressure vessels, kiln wall, passive solar heating, precision devices, bearings, heat exchangers, airframes, ship structures, engines and power generation, automobile structures. Materials Substitution, Pugh Method, Cost–Benefit Analysis, Cost basis for selection, causes of failure in service, Specifications and quality control, Selection for static strength, toughness, stiffness, fatigue, creep, corrosion resistance, wear resistance, material databases. Process selection, ranking processes, cost, computer-based process selection, Case studies: fan, pressure vessel, optical table, cast tables, manifold jacket, spark plug insulator. Selection under multiple constraints, conflicting objectives, penalty-functions, exchange constants, Case studies: connecting rods, windings of high field magnets, casing of minidisk player, disk-brake caliper.

Text Books:

- Michael F. Ashby, Materials Selection in Mechanical Design, third edition, Butterworth Heinemann, 2005
- J. Charles, F.A.A. Crane, J. A.G. Furness, Selection and Use of Engineering Materials, thirdedition, Butterworth-Heinemann, 2006.

Reference Books:

- ASM Metals Handbook, Materials Selection and Design, Vol. 20,2010.
- Myer Kutz, Handbook of Materials Selection, John Wiley & Sons, Inc., New York, 2002, ISBN0-471-35924-6.

Research Methodology and Intellectual Property Rights

Teaching Scheme:
Lectures: 2 hr/week

Examination Scheme:
Continuous Evaluation:
Assignments/Presentations/Quiz/Tests

Course Outcomes:

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

a. Understand research problem formulation and approaches of investigation of solutionsfor research problems
b. Learn ethical practices to be followed in research
c. Apply research methodology in case studies
d. Acquire skills required for presentation of research outcomes (report and technical paperwriting, presentation etc.)
e. Infer that tomorrow's world will be ruled by ideas, concept, and creativity
f. Gather knowledge about Intellectual Property Rights which is important for students of engineering in particular as they are tomorrow's technocrats and creator of new technology

   Discover how IPR is regarded as a source of national wealth and mark of an economic leadership in context of global market scenario
g. Study the national & International IP system
h. Summarize that it is an incentive for further research work and investment in R & D, leading to creation of new and better products and generation of economic and social benefits

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.
- Use Design of Experiments /Taguchi Method to plan a set of experiments or simulations or build prototype. Analyze your results and draw conclusions or Build Prototype, Test and Redesign.
- Plagiarism, Research ethics. Effective technical writing, how to write report, Paper.
- Developing a Research Proposal, Format of research proposal, a presentation andassessment by a review committee.
- Introduction to the concepts Property and Intellectual Property, Nature and Importance of Intellectual Property Rights, Objectives and Importance of understanding Intellectual Property Rights.
- Understanding the types of Intellectual Property Rights: -Patents-Indian Patent Office and itsAdministration, Administration of Patent System – Patenting under

Indian Patent Act , Patent Rights and its Scope, Licensing and transfer of technology, Patent information and database. Provisional and Non Provisional Patent Application and Specification, Plant Patenting, Idea Patenting. Integrated Circuits, Industrial Designs, Trademarks (Registered and unregistered trademarks), Copyrights, Traditional Knowledge, Geographical Indications, Trade Secrets, Case Studies.

- New Developments in IPR, Process of Patenting and Development: technological research, innovation, patenting, development,
- International Scenario: WIPO, TRIPs, Patenting under PCT.

Reference Books:

1. Aswani Kumar Bansal : Law of Trademarks in India
2. B L Wadehra : Law Relating to Patents, Trademarks, Copyright, Designs and GeographicalIndications.
3. G.V.G Krishnamurthy : The Law of Trademarks, Copyright, Patents and Design.
4. Satyawrat Ponkse: The Management of Intellectual Property.
5. S K Roy Chaudhary & H K Saharay : The Law of Trademarks, Copyright, Patents
6. Intellectual Property Rights under WTO by T. Ramappa, S. Chand.
7. Manual of Patent Office Practice and Procedure
8. WIPO : WIPO Guide To Using Patent Information
9. Resisting Intellectual Property by Halbert ,Taylor & Francis
10. Industrial Design by Mayall, Mc Graw Hill
11. Product Design by Niebel, Mc Graw Hill
12. Introduction to Design by Asimov, Prentice Hall
13. Intellectual Property in New Technological Age by Robert P. Merges, Peter S. Menell,Mark A. Lemley.

i.

Effective Technical Communication

Teaching Scheme:
Lectures: 1hr/week

Examination Scheme:
Continuous Evaluation:
Assignments/Presentations/Quiz/Tests

Course Outcomes (COs):

After successful completion of the course, students will be able -

1. To produce effective dialogue for business related situations.
2. To use listening, speaking, reading and writing skills for communication purposes andattempt tasks by using functional grammar and vocabulary effectively.
3. To analyze critically different concepts / principles of communication skills.
4. To demonstrate productive skills and have a knack for structured conversations.
5. To appreciate, analyze, evaluate business reports and research papers.

Syllabus content:

Fundamentals of Communication: 7 Cs of communication, common errors in English, enrichingvocabulary, styles and registers.

Aural-Oral Communication: The art of listening, stress and intonation, group discussion, oralpresentation skills.

Reading and Writing: Types of reading, effective writing, business correspondence, interpretationof technical reports and research papers.

Reference Books:

1. Raman Sharma, "Technical Communication", Oxford University Press.
2. Raymond Murphy "Essential English Grammar" (Elementary & Intermediate) CambridgeUniversity Press.
3. Mark Hancock "English Pronunciation in Use" Cambridge University Press.
4. Shirley Taylor, "Model Business Letters, Emails and Other Business Documents" (seventhedition), Prentise Hall.
5. Thomas Huckin, Leslie Olsen "Technical writing and Professional Communications for Non-native speakers of English", McGraw Hill.

Lab Practice II

Teaching Scheme:
Lab/Practical: 2 hr/week

Examination Scheme:
Continuous Eval.: 100 Marks

Laboratory Outcomes:

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

1. Use XRD for crystal structure determination
2. Understand procedures of advanced testing such as wear and fatigue.
3. Hands on training and skill development.
4. Use modern engineering software tools and equipment to analyze Physical Metallurgyproblems
5.

Syllabus Contents:

Any seven experiments from the following area or as identified by course teacher in relevantareas will be conducted.

- XRD studies of Cubic metals,
- Residual stress analysis in cast, wrought, welded and heat-treated components by X-raydiffraction 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.

Seminar II

Teaching Scheme:
Term work/Presentation: 2 hr/week

Examination Scheme:
Term work/Presentation: 100 Marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to:
1. Conduct literature survey and identify the potential research areas in the field.
2. Communicate effectively in both oral and written forms.
3. 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.

Liberal Learning Course

Teaching Scheme:
Contact Period/Practical: 2 hr/week

Examination Scheme:
Continuous Eval.: 100 Marks

Course Outcomes:

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

1. Learn new topics from various disciplines without any structured teaching or tutoring.
2. Understand qualitative attributes of a good learner
3. Understand quantitative measurements of learning approaches and learning styles
4. Understand various sources and avenues to harvest/gather information.
5. 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 5questions (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 Phase – I

Teaching Scheme:
Project Work: 18 hr/week
Self-study: 12 hr/week

Examination Scheme:
Presentation/Term work: 100 Marks

Course Outcomes:

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

1. Carry out in depth literature survey and determine objectives of the project work.
2. Design the experiment to accomplish the set objectives.
3. Effectively utilize the available resources of the Institute as well as other outside agencies(other Institutes, Labs, and Industry etc.)
4. Work independently to manage and complete research project within a given time frame.
5. Communicate effectively in both oral and written forms.

Guidelines:

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.

Massive Open Online Course –I

To be selected in consultation with faculty advisor. Evaluation scheme will depend uponinstructor or host institute.

<u>**Semester-IV**</u>

Dissertation Phase – II

Teaching Scheme:
Project Work: 18 hr/week
Self-study: 12 hr/week

Examination Scheme:
ISE: 50 Marks
ESE: 50 Marks

Course Outcomes:

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

1. Independently conduct experiments, analyze and interpret results.
2. Lean modern characterization techniques, software tools etc.
3. Understand professional and social responsibilities and socio-economic aspects of the workundertaken.
4. Work as part of team necessary for a professional life and to work on multidisciplinaryprojects.
5. Communicate the technical information and knowledge in both written and oral form.
6. Inculcate a habit of lifelong learning of new ideas and applying the same in all workundertaken.

Guidelines:

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.

Massive Open Online Course –II

To be selected in consultation with faculty advisor. Evaluation scheme will depend uponinstructor or host institute.