College of Engineering, Pune

(An Autonomous Institute of Govt. of Maharashtra, Permanently Affiliated to S.P. Pune University)

Department of Metallurgy and Materials Science

Curriculum Structure & Detailed Syllabus (PG Program)

M.Tech.

(Effective from: A.Y. 2019-20)

Vision and Mission of the Department

Vision:

To achieve global excellence in quality of Metallurgical and Materials engineering education imparted and become the leading Department in the nation in frontier areas of Metallurgical and Materials engineering technology that offers relevant training, research and development for the students, society and country.

Mission:

- To foster creativity, innovation, productivity, and build an awareness of social responsibilities in students necessary for the development of the individual and the country.
- To provide students the highest quality knowledge base and skill set of the fundamental and applied concepts of the Metallurgical and Materials engineering field towards achieving professional excellence.
- To make the students capable of offering technical support to the industry and accept the challenges of changing modern technologies.
- To inculcate capabilities in students to function as educators and scientists instrumental in invention of new technologies in the country and also to function as entrepreneurs.

Goals:

- To create an ecosystem for all graduates /post graduates students to make them industry employable and able to generate employment by becoming an entrepreneur.
- All faculty of the department to be doctorate degree holder by 2020.
- To promote 25 % students for pursuing higher studies and career in research organization.
- To strengthen teaching learning process by conducting and attending FDPs /Conferences / Workshops etc. for faculty
- To publish one UGC approved journal paper /IPR/product by each faculty per year.
- To complete one collaborative research project at least once in two years per faculty.
- To complete one consultancy project per faculty per year.
- To promote participation of faculty and students in activities organized by professional bodies and also encourage for social driven projects.
- To promote outreach activities for strengthening industry institute interaction.

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Department of Metallurgy and Materials Science

(Materials Engineering-Started in 2017)

Earlier 'Physical Metallurgy- started in 1954'

Curriculum Structure & Detailed Syllabus (PG Program)

M.Tech. – Materials Engineering

(Effective from: A.Y. 2019-20)

Program Education Objectives (PEOs)

The Postgraduate students will demonstrate

I. To provide students with in-depth knowledge of Materials Engineering such as scientific principles of fabrication, phase transformations, mechanical treatment, heat treatment, structure-property correlations and service behaviour of various types of materials necessary to formulate, solve and analyze critical engineering problems.

II. To train the students for successful careers in metallurgical and manufacturing industry, academics, in the field of research and development that meet the needs of Indian and multinational companies, R&D organizations and also prepare them for higher studies.

III. To make the students capable of solving unfamiliar problems through literature survey, deciding a suitable research methodology and conducting interdisciplinary/collaborative-multidisciplinary scientific research as per the need.

IV. To inculcate in students the art of reflective learning, build hands-on experimental skills, make them familiar with modern engineering software tools and equipments, so as to make them capable of working independently or as a part of a team for successful project implementations in their professional life.

V. To inculcate in student's leadership qualities, techno-economical considerations, an aptitude for life-long learning, and introduce in them the professional ethics and codes.

VI. To develop the students' abilities in communicating technical information in both written and oral form.

Program Outcomes (POs)

The Postgraduate Students will demonstrate

a. Acquire in-depth knowledge of Materials Engineering so as to develop an ability to discriminate, evaluate, analyze and synthesize existing and futuristic needs in global perspective towards improvement of materials.
b. Critically analyze complex engineering problems related to Materials Engineering and apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.
c. Think laterally and originally, conceptualize and solve engineering problems related to Materials Engineering to evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.
d. Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in the field of Materials Engineering and other domains of engineering.
e. Create, select, learn and apply appropriate fabrication techniques, resources, and modern characterization techniques and software-tools including prediction and

modelling to Materials Engineering and allied engineering activities with an understanding of the limitations.

f. Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
g. Demonstrate knowledge and understanding of engineering and techno-economical aspects and apply the same to one's own work, as a member and leader in a team, implement projects efficiently in Materials Engineering and other domains of engineering.
h. Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
i. Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
j. Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
k. Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

Correlation between the PEOs and the POs

PO / PEO	a	b	c	d	e	f	g	h	i	J	k
I	✓	✓	✓		✓		✓				
II	✓	✓	✓	✓	✓	✓	✓				
III	✓	✓	✓	✓	✓	✓					
IV				✓	✓				✓	✓	✓
V							✓		✓	✓	✓
VI	✓	✓	✓					✓			

Note: The cells filled in with ✓ indicate the fulfilment/correlation of the concerned PEO with the PO.

List of Abbreviations

Abbreviation	Title	No of courses	Credits	% of Credits
PSMC	Program Specific Mathematics Course	1	4	5.9%
PSBC	Program Specific Bridge Course	1	3	4.4%
DEC	Department Elective Course	3	9	13.2%
MLC	Mandatory Learning Course	2	0	0%
PCC	Program Core Course	6	22	32.4%
LC	Laboratory Course	2	2	2.9%
IOC	Interdisciplinary Open Course	1	3	4.4%
LLC	Liberal Learning Course	1	1	1.5%
SLC	Self Learning Course	2	6	8.8%
SBC	Skill Based Course	2	18	26.5%

Semester I

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme L	T	P	Credits
1.	PSMC	MME-19001	Mathematical Modeling in Materials Processes	3	1	0	4
2.	PSBC	MME-19002	Concepts in Materials Science	3	0	0	3
3.	DEC	MME(DE)-19001 MME(DE)-19002 MME(DE)-19003	Department Elective -I a) Advances in Ceramics Engineering b) Electronic and Magnetic Materials c) Nano Materials and Nano Technology	3	0	0	3
4	PCC	MME-19003	Advanced Composites	3	0	0	3
5.	PCC	MME-19007	Corrosion Engineering	3	0	0	3
6.	PCC	MME-19004	Phase Transformations in Materials	3	1	0	4
7.	LC	MME-19005	Lab Practice – I	0	0	2	1
8.	LC	MME-19006	Seminar –I	0	0	2	1
			Total	18	2	4	22

Interdisciplinary Open Course (IOC): Every department shall offer one IOC course (in Engineering/Science/Technology). A student can opt for an IOC course offered by a department except the one offered by his /her department.

Semester II

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme L	T	P	Credits
1.	IOC		Interdisciplinary Open Course	3	0	0	3
2.	DEC	MME(DE)-19004 MME(DE)-19005 MME(DE)-19006 MME(DE)-19007	Department Elective –II a) Nuclear Materials b) Light Metals and Alloys c) Amorphous Materials d) Engineering Polymers	3	0	0	3
3.	DEC	MME(DE)-19008 MME(DE)-19009 MME(DE)-19010 MME(DE)-19011	Department Elective –III a) High Temperature Corrosion b) Laser Material Processing c) Modeling of Engineering Materials d) Biomaterials	3	0	0	3
4.	MLC	ML-19011	Research Methodology and Intellectual Property Rights	2	0	0	0
5.	MLC	ML-19012	Effective Technical Communication	1	0	0	0
6.	LLC	LL-19001	Liberal Learning Course	1	0	0	1
7.	PCC	MME-19008	Mechanical Behavior of Materials	3	0	0	3
8.	PCC	MME-19009	Characterization Techniques	3	0	0	3
9.	PCC	MME-19010	Thermodynamics of Materials	3	0	0	3
10.	LC	MME-19011	Lab Practice – II	0	0	4	2
11.	LC	MME-19012	Seminar – II	0	0	2	1
			Total	22	0	6	22

* Ioc Offered to other programs

Semester-III

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1.	SBC	MME-20001	Dissertation Phase-I	--	--	18	9
2.	SLC	MME(OC)-20001	Massive Open Online Course -I (To be decided in consultation with the faculty advisor)	3	--	--	3
			Total	3	--	18	12

Semester-IV

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1.	SBC	MME-20002	Dissertation Phase-II	--	--	18	9
2.	SLC	MME(OC)-20002	Massive Open Online Course -II (To be decided in consultation with the faculty advisor)	3	--	--	3
			Total	3	--	18	12

Semester I

(MME-19001) 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 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:

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

(MME-19002) Concepts in Materials Science

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1, T2/Assignments: 20 marks each
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.
- 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/ Reference Books:

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

(MME(DE)-19001) Advances in Ceramics Engineering

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1, T2/Assignments: 20 marks each
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 Al_2O_3, 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 thermal shock & 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 & Surface gloss, Opacity & Translucency. Absorption & Color, Bands, Color, Ligand-Field Chemistry Colorants, 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 II Processing 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 and Applications.
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 Ceramic Science and Engineering, Wiley, 1996.

(MME(DE)-19002) Electronic and Magnetic Materials

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1, T2/Assignments: 20 marks each
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-Hill International 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, New York 1978.
2. Bus chow K.H.J. (Ed.), Handbook of Magnetic Materials, Amsterdam: Elsevier.
3. Electronic Materials Handbook, ASM International, Materials Park, 1989.

(MME(DE)-19003) Nano Materials and Nano Technology

Teaching Scheme:
Lectures: 3 Hrs/week

Examination Scheme:
T1, T2/Assignments: 20 Marks each
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 of nanomaterials.
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 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 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 Science Publishing, 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.

(MME-19003) Advanced Composites

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1, T2/Assignments: 20 marks each
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 and characteristics.
3. Processing methods used for PMC, MMC, and CMC manufacturing, their advantages and disadvantages
4. 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.

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, New York.
2. Mechanics of Composite Materials, Autar K. Kaw, 1997, CRC Press, New York.
3. Fundamentals of Fiber Reinforced Composite Materials, A. R. Bunsell, J. Renard, 2005, IOP Publishing Ltd.
4. Composite Materials Science and Engg., Chawla K.K., Second Edition, 1998, Springer Verlag.

(MME-19007) Corrosion Engineering

Teaching Scheme:
Lectures: 3 hrs/week

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

Course Outcomes:
At the end of the course, students will demonstrate the ability to:
1. Establish correlation between thermodynamics and corrosion.
2. Solve numerical.
3. Understand concepts and fundamentals in corrosion.
4. Use the knowledge of material selection for different corrosive environments and knowledge of corrosion prevention methods.

Syllabus Contents:
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:
1. M. Fontana - Corrosion Engineering, 2nd ed., Mc Grew Hill, 1987.
2. H.H.Uhlig - Corrosion and Corrosion Control, 3rd ed., Wiley, 1986.

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

(MME-19004) Phase Transformations in Materials

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

Examination Scheme:
T1, T2/Assignments: 20 marks each
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 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/ Reference Books:

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.

(MME-19005) Lab Practice I

Teaching Scheme:	**Examination Scheme:**
Practical: 2hrs/week	Term work: 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 on relevant 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 andplating 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.

(MME-19006) Seminar I

Teaching Scheme:	**Examination Scheme:**
Practical: 2hrs/week	Presentation/Term work: 100 Mark

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

(IOC) Design and selection of Materials

Teaching Scheme:
Lectures:3Hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
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 the design of components.
3. Determine the mechanical properties of materials, and apply these material properties in the 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 calliper.

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, third edition, 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, ISBN 0-471-35924-6.

(MME(DE)-19004)Nuclear Materials

Teaching Scheme:
Lectures: 3 hrs/week

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

Course Outcomes:

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

1. The use of nuclear energy as a major source of energy of the future.
2. Nuclear reactions, design & working of nuclear reactors and about various materials required for its major components.
3. 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, embritllement 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, includinguse 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.

Textbooks/Reference Books:

1. Bennet, D. J. & Thomson, J. R., Elements of Nuclear Power Longman 3rd Edition 1989.
2. Benedict, M, Pigford, T.H. & Levi H.W., Nuclear Chemical Engineering, Mcgraw-Hill 2nd Edition 1981.
3. Glasstone, S. &Sesonske, A., Nuclear Reactor Engineering Vol. 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.
4. Nuttall, W.J., Nuclear Renaissance: Technologies and Policies for the Future of Nuclear Power, IOP, 2005.

(MME(DE)-19005) Light Metal Alloys

Teaching Scheme:
Lectures: 3 Hrs/week

Examination Scheme:
T1 and T2/assignments: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

1. Student will be able to establish correlation between microstructure and mechanical properties of various nonferrous materials.
2. Student will acquire knowledge of advanced materials and their strengthening mechanisms.

Syllabus Contents:

The light Metals: General introduction, production of aluminium, production of magnesium,production of titanium, usage and economics
solid/liquid Interface stability, Heat flow, heatevolution, shrinkage, macro and micro segregation
Cast Aluminum Alloys: Thermodynamics and kinetics of solidification, homogeneous andheterogeneous nucleation, dendritic growth,, Recent advances in processing: Semisolidprocessing (SSP), Thixographic processing, Designation, temper and characteristics of castaluminum alloys, Al-Si alloys Al-Cu alloys, Al-Mg alloys, Al-Zn-Mg alloys,
Wrought Aluminium Alloys: Production of wrought alloys, Designation of alloys andtempers, Work hardening of aluminium and its alloys, Heat treatable and Non heat treatablealloys, Defect in wrought alloys, Joining methods, Special products-aircraft,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 designationand tempers, Zirconium free and zirconium containing casting alloys, Wrought alloys, latesttrends in applications of Mg alloy,Heat treatment ,applications
Titanium alloys: Introduction, alpha alloys, alpha –beta alloys, beta alloys, fabrication, Heattreatments, 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 McGraw Hilledition1976.
4. Semisolid Processing of Alloys edited by Kirkwood.

(MME(DE)-19006) Amorphous Materials

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2/Assignments: 20 marks each
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, ASM Pub., Ohio, 1987.
5. H.H. Liebermann (Ed), Rapidly Solidified Alloys, Marcel Dekker Inc., New York, 1993.

(MME(DE)-19007) Engineering Polymers

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2/Assignments: 20 marks each
	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, 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.

(MME(DE)-19008) High Temperature Corrosion

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1, T2/Assignments: 20 marks each
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 numericals.
3. Understand concepts and fundamentals in high temperature corrosion.
4. 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, 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, Special Treatment. 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.

(MME(DE)-19009) Laser Materials Processing

Teaching Scheme:
Lectures: 3 hrs/week

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

Course Outcomes:

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

1. Utilize the knowledge of lasers to apply in industries and research organizations for material processing.
2. Analyze, interpret and present observations about laser processing parameters on the structure and properties of processed components.
3. Demonstrate the ability to function in engineering industries and science laboratory teams, as well as on multidisciplinary projects.
4. Have the confidence to apply laser engineering solutions in global and societal contexts.

Syllabus Contents:

- Industrial lasers, construction, Types of lasers such as CO2 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:

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

Reference Books:

1. Metals Handbook Vol. 6, 'Welding, Brazing and Soldering', ASM, Metals Pak, OH 1993
2. Powell J. 'CO2 Laser cutting', Carl Hanser Verlag, Munich, 1990.
3. Carlsaw H.S. and Jaeger J.C. 'Conduction of heat in solids', Oxford University Press (UK).

(MME(DE)-19010) Modelling of Engineering Materials

Teaching Scheme:
Lectures: 3 Hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

At the end of course students will be able to:

1. Understand the basics of modeling and computational simulation in materials science and engineering.
2. Find approximate solutions to the problems and to interpret and visualize the solutions.
3. Apply Monte Carlo and Molecular Dynamics Methods to solve materials problem.
4. Apply neural networks for material modelling.

Syllabus Content:

Introduction of modeling:Setting up of mathematical model, Simple linear model, Non-linear model and breakdown of analytical solutions, Integrated Computational Materials Engineering (ICME), macroscale, mesoscale, microscale, nanoscale and electronic scale.

Introduction to Material Modeling: General aspects of materials modeling, modeling regimes, multiscale modelling, constructing a model, the early chemists' models, the modern model, the modeling of alloys.

Model based on Metallurgical Thermodynamics:The thermodynamic functions, models of solutions, ideal solution, regular solutions, computation of phase diagrams, Quasichemical solution models, introduction to phase field modelling.

Monte Carlo and Molecular Dynamics Methods: Thermodynamics and Statistical Mechanics of Atomistic Simulations, Role of Computer Simulations, Monte Carlo Methods, Markov Process, The Metropolis MC method, Accelerating the MC Method, Molecular Dynamics Methods, The Molecular Dynamics Algorithm

Finite Elements Methods:Stiffness Matrix Formulation, Single Spring, Spring in a System of Springs, System of Two Springs, Minimizing Potential Energy, Element Attributes, Applications of FEM to thermal analysis and stress analysis.

Application of neural networks to material modeling: Physical and empirical models, linear regression, neural networks, overfitting, miscellany, Gaussian distributions, straight line in a Bayesian framework, application to sold state transformations in steel.

Text Books

1. C. Lakshman Rao and A.P. Deshpande, Modelling of Engineering Materials, Wiley, 2014.
2. Z.H. Barber, Introduction to Materials Modeling, Maney Publishing, London, 2005.

Reference Books

1. Harry Bhadeshia and Robert Honeycombe, Steels: Microstructure and Properties, 4th Edition, Butterworth-Heinemann, 2017.
2. Chapra, S.C. &Canale, R. P.,Numerical Methods for Engineers, Tata McGraw Hill Publication (5th Edition).
3. Janssens, Raabe, Kozeschnik, Miodownik, Nestler, Computational Materials Engineering: An Introduction to Microstructure Evolution, Academic Press, 2007.

4. G.J. Schmitz and U. Prahl, Integrative Computational Materials Engineering: Concepts and Applications of a Modular Simulation Platform, Wiley.

(MME(DE)-19011) Biomaterials

Teaching Scheme:	Examination Scheme:
Lectures: 3 hrs/week	T1, T2/Assignments: 20 marks each 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.

(ML-19011) Research Methodology and Intellectual Property Rights

Teaching Scheme	Examination Scheme
Lectures: 2 hrs/week	Continuous evaluation Assignments/Presentation/Quiz/Test

Course Outcomes:

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

a. Understand research problem formulation and approaches of investigation of solutions for 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 paper writing, 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
g. Discover how IPR is regarded as a source of national wealth and mark of an economic

leadership in context of global market scenario

h. Study the national & International IP system
i. 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 and assessment 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 its Administration, 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 Geographical Indications.
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.

(ML-19012) Effective Technical Communication

Teaching Scheme:
Lectures: 1hr / week

Examination Scheme:
100M: 4 Assignments (25M each)

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 and attempt 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, enriching vocabulary, styles and registers.

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

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

Reference Books:

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

(LL-19001) Liberal Learning Course

Teaching Scheme:
Contact Period: 1 hr/week

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

(MME-19008) Mechanical Behaviour of Materials

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 hrs/week	T1, T2/Assignments: 20 marks each
	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 on fatigue, size effect, surface effects and fatigue, effect of metallurgical variables on fatigue, corrosion fatigue, effect of temperature on fatigue. Creep and Stress rupture: High temperature materials problem, time dependent mechanical behavior, creep curve, stress rupture, structural changes during creep, mechanisms of creep deformation, deformation mechanism maps, fracture at elevated temperature, high temperature alloys and Fractography - important aspects.

Textbooks:

1. Mechanical Metallurgy– Geroge E. Dieter, SI Metric Edition, 1988, McGraw Hill Book Co Ltd, U.K.
2. Mechanical Behaviour of Materials, Marc Andre Meyers and KishanKumarChawala, 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 andVol 4 / Part 1, April 1981,Published byThe Indian Academy of Sciences, Bangalore- 560080.
2. Dislocations and Mechanical Behaviour of Materials, M.N. Shetty, 2013, PHI Learning Pvt Ltd, New Delhi -110092.
1. C. Wagnev, Thermodynamics of alloys, Addison Wesley, Cambridge, 1952.
2. F. D. Richardson, Physical Chemistry of Melts in Metallurgy, Academic, N. Y., 1974.

(MME-19009) Characterization Techniques

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

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 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/ 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. Encyclopaedia of Materials Characterization, Materials Characterization Series, Surfaces, Interfaces, Thin Films, Series Editors: C. Richard Brundle and Charles A. Evans, Jr., Butterworth-Heinemann, 1992.
7. Introduction to Thermal Analysis, Techniques and Applications, Edited by Micheal E. Brown, Kluver Academic Publication, 2004.

(MME-19010) Thermodynamics of Materials

Teaching Scheme:
Lectures: 3 Hrs/week

Examination Scheme:
T1 and T2/assignments: 20 Marks each
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.

(MME-19011) Lab Practice II

Teaching Scheme:
Practical: 4hrs/week

Examination Scheme:
Oral/Term Work: 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 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.

(MME-19012) Seminar II

Teaching Scheme:
Practical: 2hrs/week

Examination Scheme:
Presentation/ Term Work: 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.

Semester-III

(MME-20001) Dissertation Phase – I

Teaching Scheme:
Nil

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.

(MME(OC)-20001) Massive Open Online Course –I

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

Semester-VI

(MME-20002) Dissertation Phase – II

Teaching Scheme:
Nil

Examination Scheme:
External Viva-voce: 100 Marks
Term Work: 100 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 work undertaken.
4. Work as part of team necessary for a professional life and to work on multidisciplinary projects.
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 work undertaken.

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.

(MME(OC)-20002) Massive Open Online Course –II

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