COEP Technological University Pune

(A Unitary Public University of Govt. of Maharashtra)

School of Mechanical and Materials Engineering

Curriculum Structure
M.Tech. Process Metallurgy

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. Process Metallurgy

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>*	Heat and Mass Transfer	3	1	0	2	4	30	10	60	--	--
02	PSBC	*<tbd>*	Concepts in Materials Science	3	0	0	1	3	30	10	60	--	--
03	PCC	*<tbd>*	Solidification Processing and Materials Joining	3	0	0	1	3	30	10	60	--	--
04	PCC	*<tbd>*	Advances in Iron and Steel Making	3	1	0	1	4	30	10	60	--	--
05	PEC-I	*<tbd>*	Powder Metallurgy Heat Treatment and Technology 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**	**07**	**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 Tribology and Wear Surface Science of Engineering Materials	3	0	0	0	3	30	10	60	--	--
05	PEC-III	<tbd>	High Temperature Corrosion High Pressure Die Casting Modelling of Engineering Materials Advances in Metal Working	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 Process Metallurgy:

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	--	--	--	--	3	--	--	--	CIE: 100	
			Total	**--**	**--**	**--**	**--**	**03**					

S. Y. M. Tech. Process Metallurgy

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

Heat and Mass Transfer

Teaching Scheme:
Lectures: 3 hr/week
Tutorial: 1 hr/week
Self-Study: 2 hr/week

Examination scheme:
MSE and TA: 30 and 10 Marks
ESE: 60 Marks

Course Outcomes:

At the end of the course Students will able to:

1. Understand and apply constitutive laws as to applied to fluid flow, heat and masstransfer.
2. Develop empirical equations using the knowledge of dimensionless analysis approach for modeling certain physical phenomena.
3. Analyze and quantify the kinetics of the processes.
4. Determine the concentration profile and mass conduction equation analogous to heatconduction equation.
5. Develop and design energy efficient systems.
6. Perform shell balances for heat, momentum and mass transfer to obtain differential equation describing the velocity, temperature and concentration gradient.
7. Use to Navier-Stoke equation for solving fluid problems.

Syllabus Contents:

- Review of basic concepts in heat, mass and momentum transfer, Integral mass, momentum and energy balances, Equation of continuity & motion, Concept of stream function and vorticity, Concept of laminar and turbulent flow, Boundary layer theory.
- Advanced topics in convective, conductive and radiation heat transfer, view factor, simultaneous heat and mass transfer. Diffusion- Flicks Law and Diffusivity of materials, Diffusion in Solids, Mass Transfer in fluids systems.
- Reaction Kinetics-Concepts Rate constant and order of reaction, reaction mechanism and reaction rate theories.
- Application of above principles to selected topics in metallurgical engineering- heat exchangers, flames and furnaces, slag-metal reactions, chimney draft, flow through packed and fluidized bed, motion of gas bubbles in liquid, reduction of haematite pellets in packed bed etc.

Text/Reference Books:

1. Geiger G.H.and Poirier D.R., Transport Phenomena in Materials Processing, Addison Wesley,1994.
2. A.K. Mohanty, Rate Processes in Metallurgy, Prentice Hall, New Delhi, 2000.
3. Bird R.B., Stewart W.E. and Lightfoot E.N., Transport Phenomena, Wiley, 1960.
4. H.S. Ray, Kinetics of Metallurgical Reactions, Oxford & IBH, New Delhi, 1993.
5. R.I.L. Guthrie, Engineering in Process Metallurgy, Oxford Science, 1992.9
6. J.R. Welty, R.E. Wilson, C.E. Wicks, Fundamentals of Momentum, Heat and Mass Transfer, Wiley.

Concepts in Materials Science

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

Examination scheme:
MSE and TA: 30 and 10 Marks
ESE: 60 Marks

Course Outcomes:

At the end of the course, students will be able 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 in dependent of inter atomic bonding forces/energies, Stiffness versus modulus, Theoretical/ideal strength versus actual strength of metals, Crystal defects, Role of dislocations in deformation, Strengthening Mechanisms, Role of Cottrell atmosphere on strength of steel Objectives& classification,
- System, Phases & structural constituent of phase diagram, Temperature–Pressure phase diagram of iron & Clausius–Clapeyron equation for boundary between phase regions of temperature-versus-pressure phase diagrams, Gibbs phase rule, Lever rule, Solid solutions, Hume-Rothery rules, Isomorphous, Eutectic, Peritectic & Eutectoid system, Equilibrium diagrams for non-ferrous alloys, Experimental methods of determining phase diagrams,
- Iron–Carbon equilibrium diagram, Steels & Cast-irons. Gibbs free-energy curves for pure system, Solidification of pure metals, Nucleation, Growth, Growth of the new phase, Solidification of alloys, Nucleation-, growth- & overall transformation- rates, TTT & CCTdiagrams.
- Definition, Purpose & classification of heat treatment processes for various types of steels, Bainite and Martensite formation, Introduction & applications of various case hardening &10surface hardening treatments, Precipitation Hardening, Heat treatment defects.

Text/Reference Books:

1. V. Raghvan, Materials Science and Engineering, Prentice Hall of India Publishing 5thEdition, 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.

Solidification Processing and Material Joining

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

Examination scheme:
MSE and TA: 30 and 10 Marks
ESE: 60 Marks

Course Outcomes:

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

1. Establish correlation between process parameters to resultant structure and properties ofthe joints.
2. Solve numerical problems related to casting design and weld metal profile.
3. Understand concepts and process capabilities of casting and welding of variousengineering materials.
4. Know materials and process selection for manufacturing of different components bycasting and welding.
5. Know pre-treatment and post heat treatment of castings and welded joints in relation tometallurgical and residual stress relieving.
6. Understand casting and welding defects and their remedial measures.

Syllabus Contents:

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

Textbooks:

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

Reference Books:

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

Advances in Iron and Steel Making

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

Examination scheme:
MSE and TA: 30 and 10 Marks
ESE: 60 Marks

Course Outcomes:

At the end of the course students will able to:

1. Design alloy chemistry for manufacturing /procurement of desired composition of thesteel as per the specification.
2. Decide raw materials quality and sequence of refining for making clean steel.
3. Control the cost of the steel by careful selection of the raw materials and other necessaryingredients required for steel manufacturing.
4. Understand metallurgical benefits of ingot and continuous cast products.
5. Devise ways for energy conservation and environmental pollution.

Syllabus Contents:

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

Textbooks/Reference Books:

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

Powder Metallurgy

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

Examination scheme:
MSE and TA: 30 and 10 Marks
ESE: 60 Marks

Course Outcomes:

The student will be able to:

1. Learn the Powder Manufacturing methods,
2. The student will be able to know the powder and finished PM product's characterization techniques,
3. The student will be able to understand the powder conditioning and consolidation methods to obtain the finished products
4. The student will be able to comprehend various methods of consolidation and the secondary operations performed on PM parts
5. The student will be able to develop awareness on manufacturing and applications of a few important P/M components: properties and their dependence on processing and microstructure.

Syllabus Contents:

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

Textbooks:

1. Anish Upadhayaya, Gopal S. Upadhayaya, Powder Metallurgy: Science, Technology, andMaterials, Universities Press, 2011.
2. Randall German, Powder Metallurgy Science, Metal Powder Industry; 2 Sub edition, 1994.
3. Randall German, Powder Metallurgy & Particulate Materials Processing, Metal PowderIndustry, 2005.

Reference Books:

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

Electronic and Magnetic Materials

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

Examination Scheme:
MSE and TA: 30 and 10 Marks
ESE: 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.

Heat Treatment Technology

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

Examination scheme:
MSE and TA: 30 and 10 Marks
ESE: 60 Marks

Course Outcomes:

At the end of course, students will be able to

1. Understand the basic principles of various heat treatments.
2. Analyze the effect of heat treatment processes on the structure and properties of materials
3. Understand the basics of heat treatments given to micro-lloy steel, dual phase steel, toolsteel maraging steel and stainless steel
4. Understand the fundamentals of surface heat treatments given to steels
5. Analyse effect of furnace atmospheres on heat treatment processes and reasons behinddefects after heat treatments.

Syllabus content:

Heat treatment of plain carbon steels: Annealing, Isothermal and subcritical Annealing types, Normalizing, Hardening Heat Treatment: Quenching process, characteristics and kinetics of martensitic transformation, Bain model, retained austenite and its effect,Tempering and subzero treatment. Hardenability: Mass effect, Grossman method, Critical and ideal critical diameter, Jominy End Quench method, Use and Significance of Hardenability data, Effect of grain size and composition, Residual stresses, Quench cracking, Case studies of design changes for hardening. Classification of alloying elements and their effects on Iron–Iron carbide phase diagram, TTT Diagram and CCT Diagram, General Heat treatments such as Annealing, Normalizing, Hardening, Tempering, Austempering, Martempering, Hardenability concept, Stages of Quenching and their effects, Types of quenching media such as oils, polymers; Cooling characteristics of quenching media, Control of quenching parameters, quenching fixtures, Dimensional changes during hardening and tempering. Introduction to classification and Heat treatment of Low alloy steels: Micro- alloyed (HSLA), Dual phase steels, Free cutting steels, Spring steels; bearing steel, Tool Steel: Selection criteria and properties of Tool steels, Classification of Tool Steels: Cold work, Hot Work Tool Steels, High Speed Steels and Stellites; Heat treatments of Die and Tool steels, Secondary hardness and Red Hardness, Subzero treatment, Super High Speed Steels, TRIP Steels. Stainless Steels: Fe-Cr, Fe-Ni Phase Diagram, Schaeffler Diagram and its modifications, Classification of Stainless Steels, sensitization, Heat treatment of stainless steels, Precipitation Hardening Stainless Steels, Marageing Steels, Superalloys and their heat treatment. Surface hardening: Carburizing, Carburizing atmosphere and Heat treatment after Case Hardening, Bainite control in case, Case depth measurement, ASTM E1077-01 Depth of carburization, Drip Feed Carburizing, dimensional changes during case hardening; Nitriding, Carbonitriding, Tufftriding, Nitrocarburising, Plasma Nitriding; Induction Hardening, Flame Hardening, Laser Hardening, Selection of steels for these treatments and their applications. Classification of atmospheres for heat treatments, Generation of atmospheres and their applications. In situ atmosphere generation, Thermodynamics and Kinetics of atmospheres, Control and monitoring of Furnace Atmospheres: Infrared controller, Gas chromatography, Dew point analyzer and Oxygen probe analyzer Heat treating furnaces: Salt bath furnace, Fluidized bed furnace, Sealed Quench furnace, Vacuum furnace, Heat Treatment Defects such as Distortion, Residual stresses, quench cracks and Design for Heat treatment.

Text Books:

1. Heat Treatment of Metals, Vijendra Singh, 2007, Standard Publishers and Distributors, NewDelhi.
2. R.A. Higgins, Engineering Metallurgy, Part I, App. Physical Met, ELBS, 5th ed., 1983.

Reference Books:

2. Steel and its Heat Treatment -K.EThelning, Butterworth, London.
3. Handbook of Heat Treatment of Steels – Prabhudev-Tata McGraw Hill. New Delhi, 1988.
4. Heat Treatment of Ferrous Alloys, Brooks, Washington: Hemisphere Pub., 1979
5. ASM Metals Handbook – Heat treatment, Metals Park Ohio Pub.
6. ASM Metals Handbook – Steels, Metals Park Ohio Pub.

Advanced Composites

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

Examination Scheme:
MSE and TA: 30 and 10 Marks
ESE: 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: 2 hr/week

Examination Scheme:
Continuous Eval.: 100 Marks

Laboratory Outcomes:

At the end of the laboratory work, students will demonstrate the ability to:

1. Design and conduct characterization
2. Experiments for different materials.
3. Demonstrate an advanced and applied knowledge in physical metallurgy.
4. Self-education and clearly understand the value of lifelong learning.
5. Learn modern engineering software tools
6. Analyze metallurgical problems.

List of Experiments/Assignments:

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

- Inclusion rating in Ferrous and Non-ferrous alloys
- Estimation of phases in Ferrous and Non-ferrous alloys
- Measurement of case depth and plating thickness
- Advanced techniques for chemical analysis
- Vacuum emission spectroscopy
- Atomic absorption spectroscopy
- Carbon sulfur analyzer
- Study of Vacuum melting and casting of metals
- Characterization of metal powders
- Measurement and control of parameters like temperature, resistivity,
- dimensional change etc.,
- Precipitation heat treatment of Aluminum alloys, Thermal analysis of steels

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 be able 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:
Lectures: 3 hr/week
Tutorial: 1 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. 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.

High Pressure Die-casting Technology

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 process parameters to resultant die casting.
2. Solve numerical problems related to die casting design .
3. Understand concepts and process capabilities of casting
4. Know pre-treatment and post heat treatments of die castings
5. Understand die casting defects and their remedial measures.

Syllabus Contents:

1. Introduction. Evolution of die-casting processes. Permanent mold casting. Die-casting of low melting metals and alloys, Zinc and lead alloys. Die-casting of aluminum alloys. Hot-chamber and cold-chamber pressure die casting methods. Low pressures die casting developments. General advantages and limitations of high-pressure die-casting methods.

2. High pressure die-casting machines. Plate type and toggle type machines. Range of pressures and capacities of HPDC machines. PQ2 analysis of machine capacity. Basic process and pressure-time cycles. Hydraulic systems. General control systems in HPDC machines.

3. Alloys for HPDC method. Zinc alloys. Aluminum alloys. Alloys with short and long melting temperature ranges. Hot shortness and related solidification problems. Common Aluminum die-casting alloys. Magnesium and Aluminum-magnesium alloys.

4. Melting methods and melt quality problems in aluminum alloys, charge calculation for alloy preparation, raw materials, quality, cost of production and energy consumption Scrap, ingots, master alloys, degassing agents and other additives. Gas content measurement. Densitometry for casting quality. Analytical methods for routine heat quality records. Basic factors in the process of solidification in metallic molds. Solidification: Controlled solidification, Microstructure Development, etc., Inspection/Quality Check: mechanical/ Microstructural/ physical/ Chemical properties, NDT, etc.

5. Dies for High pressure die-casting processes. Common alloys for HPDC dies and their heat-treatment. CAD systems for HPDC die design. Provision of cooling channels, inserts and supports in die-design. Die-coats and die-casting consumables.

6. High Integrity Die Castings. Advanced methods for high integrity and quality aluminum pressure die-castings. Squeeze casting, Semi-solid casting methods, Rheo-casting, vacuum die casting systems.

Text-books:

1. Degarmo, E. Paul; Black, J T.; Kohser, Ronald A. (2003), Materials and Processes inManufacturing (9th ed.), Wiley, ISBN 0-471-65653-4.
2. Andresen, Bill (2005), Die Casting Engineering, New York: Marcel Dekker, ISBN 978-0-8247-5935-3.
3. Alan Kaye and Arthur Street , Die Casting Metallurgy, Butter worths Monographs inMaterials, 1982.
4. Davis, J. (1995), Tool Materials, Materials Park: ASM International, ISBN 978-0-87170-545-7.

References

1. ASM Metals Handbook, 9th Edition, Vol 15: Casting , 2008 , Metals Park, Ohio, U.S,A.
2. *Brevick, Jerald; Mount-Campbell, Clark; Mobley, Carroll , 2004 ,* Energy Consumption of DieCasting Operations (PDF)*, Ohio State University.*
3. *North American Die Casting Association, Arlington Heights, Illinois IL 60004, USA.: Publications and Handbooks, 2015*

Surface Science of Engineering Materials

Teaching Scheme:
Lectures: 3 hr/week

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

Course Outcomes:

1. To understand concepts and fundamentals in surface engineering.
2. Able to solve numerical and apply knowledge of surface engineering

Syllabus Content:

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

Textbooks:

1. Edited by J. R. Davis-Surface Engineering for Corrosion and Wear Resistance, ASMInternational, 2001.
2. George J. Rudzki -Surface Finishing Systems. metal and non-metal finishing handbook-guideMetals Park: ASM, 1983.
3. James A. Murphy- Surface Preparation and Finishes for Metal, McGraw-Hill, New York(USA)m 1971.

Reference Books:

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

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 be able 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, Special Treatment. High temp. Materials: super alloys, inter metallic, ceramics.

Text & Reference Books:

1. R.Aris-Mathematical Modeling 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.

Tribology and Wear

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 able to:

1. Basic and advance concepts related to wear and tribology
2. Design of wear resistant material/coatings

Syllabus Contents:

Basics and fundamental principles of friction and wear, Wear mechanisms (adhesive, abrasive, oxidation, corrosion, and erosion), Fretting and fatigue wear, Materials against wear and friction, wear resistant (hard) coatings, conventional methods to prevent the wear such as carburization, and carbonitriding, basic principles and advances in CVD, PVD, plasma spraying/nitriding, ion implantation, laser surface alloying, economics of wear resistant materials/coatings, future perspectives on designing wear resistant materials.

Reference Books:

1. M. Cartier, Handbook of Surface Treatment and Coatings, Tribology in Practice S. (Hardback), ISBN: 9781860583759.
2. G. Franz, Low Pressure Plasmas and Microstructuring Technology, Hardback, ISBN 13: 9783540858485, ISBN: 3540858482.
3. V. Raghavan, Materials Science and Engineering, PHI Learning Private Limited, New Delhi, 2009, ISBN: 8120324552.
4. W. D. Callister, Materials Science and Engineering, Wiley India (P) Ltd., ISBN: 9788126510764.

Modelling of Engineering 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 course students will be able to:

1. Understand the basics of modeling and computational simulation in materials science andengineering
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 modeling

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, multi scale 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, Quasi chemical 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, over fitting, 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, 4thEdition, 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: AnIntroduction to Microstructure Evolution, Academic Press, 2007.
4. G.J. Schmitz and U. Prahl, Integrative Computational Materials Engineering: Concepts andApplications of a Modular Simulation Platform, Wiley.

Advances in Metal Working

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 be able to:

1. Analyze mechanics of metal under simple as well as complex loading conditions.
2. Predict causes of metal working defects and to find remedies to overcome these defects.
3. Design plastic forming conditions for the metals and their alloys.

Syllabus Contents:

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

Textbooks:

1. Mechanical Metallurgy – Geroge E. Dieter, SI Metric Edition,1988, McGraw HillBook CoLtd,U.K.
2. Mechanical Behaviour of Materials, Marc Andre Meyers and Kishan Kumar Chawala,SecondEdition, 2009 , Cambridge University Press, U.K.

Reference Books:

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

Design and Selection of Materials

Teaching Scheme:
Lectures: 3 hr/week
Self-study: 2 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. Design process and its relation to material selection.
2. Interpret mechanical properties of materials, and apply these material properties inthe design of components.
3. Determine the mechanical properties of materials, and apply these materialproperties 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 pluginsulator. 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:

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

Reference Books:

1. ASM Metals Handbook, Materials Selection and Design, Vol. 20,2010
2. 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:
Lectures: 4 hr/week

Examination Scheme:
Oral/term work Marks 100

Course Outcomes:

1. This course helps students, to design and conduct characterization experiments for differentmaterials.
2. In this Course, students will demonstrate an advanced and applied knowledge in PhysicalMetallurgy.
3. Students will be capable of self-education and clearly understand the value of lifelonglearning.
4. Students will be familiar with modern engineering software tools and equipment to analyzeMetallurgy problems.

List of Experiments/Assignments:

Any ***seven*** experiments from the following area OR as identified by course teacher in relevant areaswill 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 ashort 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.

Semester-IV

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 upon instructor or host institute.