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.

College of Engineering, Pune

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

Department of Metallurgy and Materials Science
(Process Metallurgy-started in 1987)

Curriculum Structure & Detailed Syllabus (PG Program)
M.Tech.- Process Metallurgy

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

Programme Educational Objectives (PEOs) set by the Department:

I. To impart students the in-depth knowledge of science and technology of synthesis and processing of various materials, so as to control their properties while manufacturing the products and also to formulate, solve and analyze critical engineering problems.

II. To train the students for successful careers in materials processing 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 students 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.

Programme Outcomes (POs):

a. Acquire in-depth knowledge of materials processing aspects of various materials and 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 science and technology of synthesis and processing of various materials, 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 science and technology of synthesis and processing of various materials, 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 science and technology of synthesis and processing of materials and other domains of engineering.

e. Create, select, learn and apply appropriate fabrication techniques, resources, modern characterization techniques and software-tools for prediction and modelling of process parameters for synthesis and processing of various types of materials 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 synthesis and processing of materials 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

PEO \ PO	a	b	c	d	E	f	g	h	i	j	K
I	✓	✓	✓		✓		✓				
II	✓	✓	✓	✓	✓	✓	✓				
III	✓	✓	✓	✓	✓	✓					
IV				✓	✓				✓	✓	✓
V							✓		✓	✓	✓
VI	✓	✓	✓					✓			

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			Credits
				L	T	P	
1.	PSMC	MPR-19001	Heat and Mass Transfer	3	1	0	4
2.	PSBC	MPR-19002	Concepts in Materials Science	3	0	0	3
3.	DEC	 MPR(DE)-19001 MPR(DE)-19002 MPR(DE)-19003	Department Elective –I a) Powder Metallurgy b) Electronic and Magnetic Materials c) Heat Treatment Technology	3	0	0	3
4.	PCC	MPR-19003	Solidification Processing & Material Joining	3	0	0	3
5.	PCC	MPR-19004	Advanced Composites	3	0	0	3
6.	PCC	MPR-19005	Advances In Iron and Steel making	3	1	0	4
7.	LC	MPR-19006	Lab Practice I	0	0	2	1
8.	LC	MPR-19007	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			Credits
				L	T	P	
1.	IOC		Interdisciplinary Open Course	3	0	0	3
2.	DEC	 MPR(DE)-19004 MPR(DE)-19005 MPR(DE)-19006 MPR(DE)-19007	Department Elective –II a) Nuclear Materials b) Light Metals and Alloys c) High Pressure Die Casting d) Surface Processing of Materials	3	0	0	3
3.	DEC	 MPR(DE)-19008 MPR(DE)-19009 MPR(DE)-19010 MPR(DE)-19011	Department Elective –III a) High Temperature Corrosion b) Laser Materials Processing c) Modeling of Engineering Materials d) Advances in Metal working	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	MPR-19008	Characterization Techniques	3	0	0	3
8.	PCC	MPR-19009	Thermodynamics of Materials	3	0	0	3
9.	PCC	MPR-19010	Mechanical Behavior of Materials	3	0	0	3
10.	LC	MPR-19011	Lab Practice II	0	0	4	2
11.	LC	MPR-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	MPR-20001	Dissertation Phase-I	--	--	18	9
2.	SLC	MPR(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	MPR-20002	Dissertation Phase-II	--	--	18	9
2.	SLC	MPR(OC)-20002	Massive Open Online Course -II (To be decided in consultation with the faculty advisor)	3	--	--	3
			Total	3	--	18	12

SEMESTER- I

(MPR-19001) Heat and Mass Transfer

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

Examination scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 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 mass transfer.
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 heat conduction 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, 1976.

(MPR-19002) Concepts in Materials Science

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 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 & CCT diagrams.
- 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 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.

(MPR(DE)-19001) Powder Metallurgy

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:
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, and Materials, Universities Press, 2011.
2. Randall German, Powder Metallurgy Science, Metal Powder Industry; 2 Sub edition, 1994.
3. Randall German, Powder Metallurgy & Particulate Materials Processing, Metal Powder Industry, 2005.

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.

(MPR(DE)-19002) Electronic and Magnetic 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 be able to:
1. Understand physical basis of electrical, electronic and magnetic properties.
2. Understand structure of advanced electrical engineering materials.

3. Suggest the materials for electrical, electronic and magnetic applications.
4. Use solid state principles for design of electrical, electronic and magnetic materials.

Syllabus Contents:

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

Text Books:

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

Reference Books:

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

(MPR(DE)-19003) Heat Treatment Technology

Teaching Scheme:	Examination Scheme:
Lectures: 3 hrs/week	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 basic principles of various heat treatments.

2. Analyse 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, tool steel 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 behind defects 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, New Delhi.
2. R.A. Higgins, Engineering Metallurgy, Part I, App. Physical Met, ELBS, 5th ed., 1983.

Reference Books:

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

(MPR-19003) Solidification Processing and Material Joining

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. Establish correlation between process parameters to resultant structure and properties of the joints.
2. Solve numerical problems related to casting design and weld metal profile.
3. Understand concepts and process capabilities of casting and welding of various engineering materials.
4. Know materials and process selection for manufacturing of different components by casting and welding.
5. Know pre-treatment and post heat treatment of castings and welded joints in relation to metallurgical 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, continuous casting, die casting, semi-solid processing,
- Fusion and solid state welding processes involving solidification, Heat Flow during Welding, Chemical Reactions in the Welding Zone, Weld Pool Convection and Evaporation,
- Weld Residual Stresses, Distortion and Fatigue, different weld zones, Fusion Zone,Partially Melted Zone, Heat Affected Zone.
- Weldability tests, defects and their remedies.

Textbooks:

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

(MPR-19004) 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.

(MPR-19005) Advances in Iron and Steel Making

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs/week	T1 and T2/assignments: 20 Marks each
Tutorials: 1 Hrs/Week	End-Sem Exam: 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 the steel 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 necessary ingredients 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.

(MPR-19006) Lab Practice I

Teaching Scheme: Lectures: 2 Hrs/week

Examination Scheme: Term work/oral – 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 areas will be conducted.

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

(MPR-19007) Seminar I

Teaching Scheme: Lectures: 2 Hrs/week

Examination Scheme: Term work/presentation Marks - 100

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

(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:

1. Michael F. Ashby, Materials Selection in Mechanical Design, third edition, Butterworth Heinemann, 2005

2. J. Charles, F.A.A. Crane, J. A.G. Furness, Selection and Use of Engineering Materials, third edition, 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, ISBN 0-471-35924-6.

(MPR(DE)-19004) Nuclear 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 be able to:

1. Understand the use of nuclear energy as a major source of energy of the future.
2. Understand nuclear reactions, design & working of nuclear reactors and about various materials required for its major components.
3. Understand the manufacturing processes & the fabrication methods employed for the Production of various materials used in the reactor.

Syllabus Contents:

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

Text/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 Vols 1-2 Chapman & Hall 4th Edition, 1994.
4. 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.
5. Nuttall, W.J., Nuclear Renaissance: Technologies and Policies For The Future of Nuclear Power, IOP, 2005.

(MPR(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.

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

Wrought Aluminium Alloys: Production of wrought alloys, Designation of alloys and tempers, Work hardening of aluminium and its alloys, Heat treatable and Non heat treatable alloys, Defect in wrought alloys, Joining methods, Special products-aircraft, automotive, packaging 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 McGraw Hilledition1976.
4. Semisolid Processing of Alloys edited by Kirkwood.

(MPR(DE)-19006) High Pressure Die-casting Technology

Teaching scheme:	**Examination scheme:**
Lectures: 3 Hrs/week	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. 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 in Manufacturing (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 in Materials, 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 Die Casting Operations (PDF)*, Ohio State University.*
3. *North American Die Casting Association, Arlington Heights, Illinois IL 60004, USA.: Publications and Handbooks, 2015*

(MPR(DE)-19007) Surface Processing of Materials

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs/week	T1 and T2/assignments: 20 Marks each
	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, ASM International, 2001.
2. George J. Rudzki -Surface Finishing Systems. metal and non-metal finishing handbook-guide Metals 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.

(MPR(DE)-19008) High Temperature Corrosion

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 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 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: 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.

(MPR(DE)-19009) Laser Material Processing

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 the course, students will able 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 laboratoryteams, 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
- Heat flow theory: one-dimensional model, stationary point source models, movingpoint 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. Lasercutting, Laser welding, Laser Surface treatment, rapid prototyping, laser bending, andlaser cleaning.
- Process automation, online control Laser safety, standards, safety limits, laserclassification**.**

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

(MPR(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 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, 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.

(MPR(DE)-19011) Advances in Metal Working

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

(ML-19011) Research Methodology and Intellectual Property Rights

Teaching Scheme:
Lectures: 2 hrs/week

Examination Scheme:
Continuous evaluation
Assignments/Presentation/Quiz/Test

Course Outcomes:

a. At the end of the course, students will demonstrate the ability to:
b. Understand research problem formulation and approaches of investigation of solutions for research problems
c. Learn ethical practices to be followed in research
d. Apply research methodology in case studies
e. Acquire skills required for presentation of research outcomes (report and technical paper

writing, presentation etc.)

f. Infer that tomorrow's world will be ruled by ideas, concept, and creativity
g. 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
h. Discover how IPR is regarded as a source of national wealth and mark of an economic leadership in context of global market scenario
i. Study the national & International IP system
j. 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 Hrs/week

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

Course Outcomes:
At the end of the course, students will be able 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 5 questions (20 marks)

• **T2:** Identify and meet an expert (in or outside college) in your choice of topic and give a write up about their ideas regarding your topic (video /audio recording of your conversation permitted (20 marks)

• **ESE:** Presentation in the form of PPT, demonstration, performance, charts, etc. in front of Everyone involved in your sub area and one external expert (60 marks)

Resources:

1. Expert (s), Books, Texts, Newspaper, Magazines, Research Papers, Journal, Discussion with peers orfaculty, Internet, etc.

(MPR-19008) Characterization Techniques

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs/week	T1 and T2/assignments: 20 Marks each
	End-Sem Exam: 60 Marks

Course Outcomes: At the end of the course, students will be able 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 & its applications. Indexing of planes. Reciprocal lattice. Relation of reciprocal & Bravais lattice. Diffraction in terms of reciprocal lattice. Application to diffraction in electron microscopy. Use of x-rays in; textures& preferred orientation.

- **Transmission Electron Microscopy (TEM):** Types of Electron sources. Focusing systems for parallel beams & probes. Image contrast & interpretation of images. Specimen preparation techniques, Contrast theory for electron microscopes. Kikuchi lines.
- **Scanning Electron Microscope (SEM):** Working, detectors, Back Scattered & secondary electron imaging. Channeling patterns. Specimen preparation techniques, Microanalysis(EDS, WDS).
- **Introduction to Modern Techniques**: scanning transmission electron microscope. High voltage Electron microscopy, EELS, FIM. Techniques of surface analysis such as XPS, AES,SIMS, Tunneling & related methods (SPM and AFM),
- **Thermal analysis**: TG/DTA/DSC/ dilatometer and related techniques.

Textbooks/Reference Books:

1. B. D. Cullity- Elements of X-ray diffraction- Addison Wesley Publications 3rd edition
2. P.J. Goodhew, J. Humphreys, R. Beanland, Electron Microscopy and Analysis, 3rd edition,Taylor and Francis, London (England)
3. Edited by E. Metcalfe- Microstructure Characterization – The Institute of Metals, USAASM 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. Metals and Material Science, Process, Applications – Smallman and Bishop.

(MPR-19009) Thermodynamics of Materials

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs/week	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.
6. C. Wagnev, Thermodynamics of alloys, Addison Wesley, Cambridge, 1952.
7. F. D. Richardson, Physical Chemistry of Melts in Metallurgy, Academic, N. Y., 1974.

(MPR-19010) Mechanical Behavior 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 be able 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, and martensitic strengthening. Fracture mechanics and fracture toughness evaluation: Strain energy release rate, stress intensity factor, fracture toughness and design, KIC 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 BookCo Ltd , U.K.
2. Mechanical Behaviour of Materials, Marc Andre Meyers and Kishan Kumar Chawala,Second Edition, 2009 , Cambridge University Press, U.K.

Reference Books:

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

(MPR-19011) Lab Practice – II

Teaching Scheme:	**Examination Scheme:**
Lectures: 4 Hrs/weeK	Oral/term work Marks 100

Course Outcomes:

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

List of Experiments/Assignments:

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

- XRD studies of Cubic metals
- Residual stress analysis in cast, wrought, welded and heat treated components by X-ray diffraction techniques
- X-ray radiography of various finished components
- Quantification of retained austenite in hardened components by X-ray diffraction techniques
- Studies of fracture by SEM
- Wear testing of surface treated components by Pin On- Disc techniques
- Low cycle fatigue test and fracture toughness measurement
- Selection of materials and processes, failure analysis – case studies

- Study of Oxidation: weight gain after oxidation as a function of temperature
- Time and gaseous atmosphere, data analysis, find possible mechanisms.
- A short project where every student will take up one modeling problem and do a small project on his own. For this they may spend 4-6 weeks of the time on their own and submit a short report.

(MPR-19012) Seminar II

Teaching Scheme:
Practical: 2 hrs/ 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. Subsequently, student will do a presentation of fifteen minutes followed by question answer session.

Semester III

(MPR-20001) Dissertation Phase – I

Teaching Scheme: Nil

Examination Scheme: Term work: 100 Marks

Course Outcomes:

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

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. At the end of the Dissertation Phase-I, student shall submit a write-up in prescribed format. Evaluation will be on the basis of the attendance, literature survey and objectives, experimental planning (and work done), set up created if any, and presentation- viva voce(understanding of the concepts) of the student.

(MPR(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 IV

(MPR-20002) Dissertation Phase – II

Teaching Scheme:
Nil

Examination Scheme:
Term work: 100 Marks
External viva/oral: 100 mark

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

(MPR(OC)-20002) Massive Open Online Course -II

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