ANDHRA UNIVERSITY

DEPARTMENT OF METALLURGICAL ENGINEERING

PROGRAM : M.Tech. (Industrial Metallurgy)

REGULATIONS AND SYLLABUS EFFECTIVE

FROM 2019-2020 BATCH

ANDHRA UNIVERSITY
DEPARTMENT OF METALLURGICAL ENGINEERING

Program Outcomes:

At the end of the Programme the student will be able to:

PO1. The industrial metallurgy graduates are capable of applying knowledge of basic sciences, mathematics and engineering in their fields.

PO2.The industrial metallurgy graduates are capable of testing and conduct experiments related to their work as well as to analyze and interpret the results

PO3.The industrial metallurgy graduates are capable of doing design and development of processes or system keeping in view of socio-economic aspects.

PO4.The industrial metallurgy graduates are capable of involving and work together in a team.

PO5. The industrial metallurgy graduates are able to apply their knowledge and skills in solving industrial problems effectively.

Program Specific Outcomes:

PSO1.The industrial metallurgy graduates are capable to utilize the recent cutting edge technologies, innovative practices to develop new technologies

PSO2.The industrial metallurgy graduates will undergo technical training programs and management skill development programs periodically

PSO3.The industrial metallurgy graduates will develop eco-friendly technologies.

PSO4.The industrial metallurgy graduates are capable of developing need basic technologies pertaining to the current industrial requirements of the country

DEPARTMENT OF METALLURGICAL ENGINEERING

M.TECH. (INDUSTRIAL METALLURGY)
(with effect from 2019-2020 academic year)

I – SEMESTER

Code No	Course Title	Scheme of Instruction			Scheme of Examination			Total	Credits
		Lec.	Tut.	Total	Exam. Duration	Theory/Lab./Viva	Sess.		
IMT 11	Core subject 1 Advances in iron and steel making	4	-	4	3	70	30	100	3
IMT 12	Core subject 2 Metal Casting	4	-	4	3	70	30	100	3
IMT 13	Core subject 3 Metal Joining	4	-	4	3	70	30	100	3
IMT 14	Programme Elective 1 a. Composite Materials b. Polymer Technology c. Ceramic Technology	4	-	4	3	70	30	100	3
IMT 15	Programme Elective 2 a. Corrosion Engineering b. Alloy Steels c. Surface Engineering	4	-	4	3	70	30	100	3
IMT 16	Research Methodology and IPR	3	-	3	-	70	30	100	2
IMT 17	Audit Course-1	3	-	3	-	-	-	-	0
IMT 18	Casting Lab	--	3	3	Viva-voce	50	50	100	2
IMT 19	Welding Lab	--	3	3	Viva-voce	50	50	100	2
TOTAL		***26***	***6***	***32***	***15***	***520***	***280***	***800***	***21***

Note: The viva-voce for the labs/seminars shall be held with the course instructor/faculty member and an external examiner nominated by the university from any academic institution/industry/R&D organization.

II - SEMESTER

Code No	Course Title	Scheme of Instruction			Scheme of Examination			Total	Credits
		Lec.	Tut.	Total	Exam. Duration	Theory/Lab/Viva	Sess.		
IMT 21	Core subject 3 Failure Analysis	4	-	4	3	70	30	100	3
IMT 22	Core subject 4 Strengthening Mechanisms	4	-	4	3	70	30	100	3
IMT 23	Core subject 5 1ndustrial Heat Treatment	4	-	4	3	70	30	100	3
IMT 24	Programme Elective 3 a. Powder Metallurgy b. Energy materials c. Electronic Materials	4	-	4	3	70	30	100	3
IMT 25	Programme Elective 4 a. Non Destructive Testing b. Metal forming c. Fracture Mechanics	4	-	4	3	70	30	100	3
IMT 26	Audit Course-2	3	-	3	-	-	-	-	0
IMT 27	Physical Metallurgy Lab	--	3	3	Viva-voce	50	50	100	2
IMT 28	Testing of materials Lab	--	3	3	Viva-voce	50	50	100	2
IMT 29	Mini project with Seminar	--	3	3	Viva-voce	-	100	100	2
TOTAL		***23***	***9***	***32***	***15***	***450***	***350***	***800***	***21***

Note: The viva-voce for the labs/seminars shall be held with the course instructor/faculty member and an external examiner nominated by the university from any academic institution/industry/R&D organization.

III – SEMESTER

Code No	Course Title	Scheme of Instruction			Scheme of Examination			Total	Credits
		Lec.	Tut.	Total	Exam. Duration	Theory/Lab/Viva	Sess.		
IMT 31	Programme Elective 5 a. Nano Composites b. Functional materials c. Bio materials	4	-	4	3	70	30	100	3
IMT 32	Open Elective a. Materials Characterization b. Solidification Processing c. Phase Transformations	4	-	4	3	70	30	100	3
IMT 33	Dissertation-I	--	-	-	-	-	100	100	6
TOTAL		***8***	***-***	***8***	***6***	***140***	***160***	***300***	***12***

Note: The Dissertation shall be evaluated through Viva-voce examination by a committee with HOD, Chairman, Board of studies and Research Guide as members. The marks shall be awarded in the ratio of 30,30 and 40 percent by the members respectively.

IV - SEMESTER

Code No	Subject	Scheme of Examination	Total Marks	Credits
IMT 41	Dissertation –II	Viva-voce	100	14

Note: The Dissertation shall be evaluated through Defence and Viva-voce examination by a committee with an External Examiner nominated by University, HOD, Chairman, Board of studies and Research Guide as members. The marks shall be awarded in the ratio of 20, 20, 20 and 40 percent by the members respectively.

Audit course 1 & 2

1. English for Research Paper Writing (Research Papers Methodology)
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

Total Credits: 68

Year	I Semester	II Semester	Total
First	21	21	42
Second	12	14	26
Total Credits			**68**

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I SEMESTER

IMT 11- ADVANCES IN IRON & STEEL MAKING

Periods / week: 4 Credits: 3 Sessionals:30 Exam: 70

Course Objectives:

- This course introduces the principles of sponge iron making
- To know the various smelting reduction processes
- To gain a thorough knowledge about thermodynamics and phase relations in the production of iron and ferroalloys.
- To understand the production methodology for a particular type of iron/ferroalloy from given ore, other raw materials and set of conditions.
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Course Outcomes:

- Describe the physical and chemical processes that take place during sponge iron making
- To familirize with recent developments in iron making
- Describe various methods of smelting and reduction
- To identify and choose a production methodology for a particular type of iron/ferroalloy from given ore, other raw materials and set of conditions
- To perform basic calculations like mass and energy balance relating to production of iron and ferroalloys, taking into consideration the thermodynamic limitations and kinetics.

SYLLABUS

Sponge Iron making: Coal based processes: Rotary kiln process, Rotary hearth furnace process (Fastmet process, ITmk3 process). Gas based processes –Finmet process, Midrex process, HYL processes (HYL -III & HYL –IVM processes).

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the principles and classification of sponge iron processes.
- Describe the various sponge iron production processes with process flow sheets.

Smelting Reduction (SR): Fundamental of SR, Classification and important SR processes: COREX process, Finex process, Hismelt process, Romelt process.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Gain the knowledge of different smelting operations and fundamentals of SR practices.
- Explain about various SR processes in detail with process, equipment and schematic diagrams

Hybrid Steel making processes, Continuous steel making processes: WOCRA, IRSID, Spray steel making. Secondary steel making processes, Inert Gas Purging, decarburization techniques, vacuum treatments, Ladle Furnace (LF).

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the fundamentals and classification of hybrid steel making processes.
- Describe the equipment required for different hybrid steel making processes along with process flow sheets.
- Study the fundamentals and different types of continuous steel making processes.
- Explain about the equipment required for different continuous steel making processes and advancement in steel making processes.

- Describe the fundamentals of secondary steel making processes and the process requirements.
- Gain the knowledge about secondary refining operations involved with iron making and their process in detail.

Text books:

1. Iron making & Steel Making- Theory and Practice- Ahindra Ghosh, Amit Chattterjee
2. Sponge Iron Production by Direct reduction of Iron Oxide – Amit Chatterjee
3. Hot metal production by Smelting Reduction of Iron Oxide - Amit Chatterjee
4. Modern Steel Making- R.H. Tupkary, V.R. Tupkary

IMT 12-METAL CASTING

Periods / week: 4 Credits: 3 Sessionals: 30 xam: 70

Course Objectives:

- To study the science and engineering of casting.
- To study the various moulding materials and emerging techniques
- To study various types of patterns and materials
- To gain knowledge of designing of moulds.

Course Outcomes:

After completing this course the student have:

- Knowledge of technical procedures of making patterns and moulds.
- The ability to design gating system for the castings.

SYLLABUS

New and emerging casting techniques: Counter gravity low pressure casting, squeeze casting, semi solid metal casting and forging, plaster molding, ceramic molding, replicast process.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the fundamentals, principles of emerging casting techniques.
- Gain the knowledge of process, equipment and applications of different casting techniques.

Design consideration: Risers, gating, casting, dimensional tolerances and allowances.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study about design consideration for risers in gating system and casting moulds.
- Describe the dimensional tolerances and allowances for pattern making.

References:

1. Principles of Metal Casting – Richard Heine, Carl Loper, Philip Rosenthal
2. Foundry Technology-Bailey
3. Casting Technology – Vol 4 ASM Metals Hand book

IMT 13 - METAL JOINING

Periods / week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course objectives:

- To develop understanding fundamentals of welding
- To know the requirements of Joining a material
- To know the various types of joining processes

Course outcomes:
At the end of this chapter the student will be able to:

- Select welding process for the given application.
- Identify different material joining technique and analyze the concept, mechanism, parameters associated with the processes.
- Demonstrate weld design procedures and also describe influence of metal joining technique on dissimilar metals convincingly.

SYLLABUS

Flux assisted GTAW process, lead free soldering, friction welding processes, friction stir welding and friction surfacing, micro joining, microwave Joining and hybrid welding.

Learning Outcomes:
At the end of the chapter the student will be able to:

- Understand the fundamentals, classification of different types advanced metal joining techniques.
- Gain the knowledge of advantages and disadvantages of emerging technologies in material joining.

Heat flow and temperature distribution in and around weld metal., calculation of heat input and heat affected zone width.

Learning Outcomes:
At the end of the chapter the student will be able to:

- Study the heat flow and temperature distribution in and around weld metal in different welding techniques.
- Understand the calculation of heat input and heat affected zone width and weld joint efficiency.

Problems during welding of carbon steels, welding of stainless steels. Schaffler diagram.
Learning Outcomes:
At the end of the chapter the student will be able to:

- Describe the problems during welding of carbon steels, welding of stainless steels.
- Explain the Schaffler diagram and its role in welding metallurgy.

Welding of aluminum alloys, welding of titanium alloys and welding of dissimilar metals.
Learning Outcomes:
At the end of the chapter the student will be able to:

- Study the welding of various light alloys and dissimilar metals.
- Gain the knowledge of challenges during welding of light alloys, dissimilar metals and remedies.

Reference:
ASM Metal hand book

IMT 14– (Elective - 1)

(a). COMPOSITE MATERIALS

Periods/week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- To obtain knowledge on classification, processing, characterization and applications of composite materials.
- To obtain knowledge on mechanical properties and failure mechanisms of composites under loading conditions for engineering applications.

Course Outcomes:

- Knowledge on classification, processing, characterization and applications of various composite materials
- Ability to select proper method of fabrication for the given type of composite material

SYLLABUS

Introduction: Definition, classification, properties, applications, advantages and limitations of composites, Types of matrix and reinforcements, and their properties. Mechanics of Composites, Iso-strain and Iso stress conditions, Role of fibers, Critical fiber length.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the fundamentals, classification of composites and their properties.
- Gain the knowledge of various types of matrix and reinforcements, mechanics involved with it.

Fabrication of Polymer Matrix Composites (PMCs): Properties, Applications and Limitations of PMCs; Various fabrications methods- Hand Layup technique, Spray Up Technique, Filament welding, Pultrusion, Autoclave based methods, Injection moulding, Extrusion.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the different fabrication techniques of PMCs and their properties.
- Explain the applications and limitations of PMCs.

Fabrication of Metal Matrix Composites (MMCs): Properties, Applications of MMCs; Fabrications methods: Liquid methods- Duralcan process, Spray forming, Squeeze casting, Stir casting; Solid state process- Diffusion bonding.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Describe the different fabrication techniques of MMCs and their properties.
- Explain the applications and process limitations of MMCs.

Fabrication of Ceramic Matrix Composites (CMCs): Properties, Applications and limitations of CMCs; Various fabrications methods: Cold pressing and sintering, Hot pressing, Liquid infiltration, Lanxide process.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the different fabrication techniques of CMCs and their properties.
- Gain the knowledge of applications and process limitations of CMCs.

Fabrication of Carbon-Carbon Composites (CCCs): Properties, Applications and limitations of CCCs; Processing of CCC- Solid, Liquid and Gas phase pyrolysis processes.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the different fabrication techniques of CCCs and their properties.
- Explain the applications and process limitations of CCCs.

Text books:

1. *Materials Science and Engineering: An Introduction - William D Callister Jr*
2. Composite Materials-Krishma K Chawla

Reference books:

1. ASM Handbook Volume 21: Composites

(b). POLYMER TECHNOLOGY

Periods/week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- To impart knowledge about the significance of polymers
- Explain the uses and applications of types of polymers ceramics
- Describe about the characteristics of polymers

Course Outcomes:

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

- Appreciate the importance of polymers and their classification and apply the knowledge for the practical applications
- Describe the properties of polymers and choose a particular polymer for a given application.

- Correlate the structure, property and applications of polymers.

SYLLABUS

Polymer Structures: Polymer molecules chemistry, shape, weight, structure, and configurations. Classification, properties and applications, Thermoset and Thermo plastic polymers, Polymerization, Copolymers, Polymer crystallinity, Polymer crystals, Defects in polymers, Diffusion in Polymeric materials.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the structural aspects of polymers and fundamentals involved with it.
- Understand the processing techniques for polymers and their applications.

Characteristics and Processing of Polymers: Mechanical Behaviour of Polymers, Deformation Mechanisms and strengthening of Polymers, Glass transition phenomenon in polymers, Polymer synthesis and Processing.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Gain the knowledge of mechanical behaviour of polymers, deformation mechanisms and strengthening of polymers
- Understand the glass transition phenomenon in polymers, in detail.

Text books:

1. *Materials Science and Engineering: An Introduction - William D Callister Jr*

(c). CERAMIC TECHNOLOGY

Periods/week: **4** Credits: **3** Sessionals: **30** Exam: **70**

Course Objectives:

- To impart knowledge about the significance of ceramics
- Explain the uses and applications of various ceramics

Course Outcomes:

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

- Appreciate the importance of ceramics and their classification and apply the knowledge for the practical applications
- Describe the properties of ceramics and choose a particular ceramic for a given application.
- Correlate the structure, property and applications of ceramics

SYLLABUS.

Introduction: Definition- Classification of Ceramics- Traditional Ceramics – Structural Ceramics, Fine Ceramics, Bio Ceramics. Structure of Ceramic Crystals: Oxide structures, Silicate structures, Glass formation, Types of Glasses.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Gain the knowledge on classification and mechanical properties of ceramics.
- Describe the various processing techniques for manufacturing of ceramics and their application.

Ceramic Phase diagrams: Two component systems- Al_2O_3-SiO_2, BaO-TiO_2; Three component systems- MgO-Al_2O_3-SiO_2.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Gain the knowledge on ceramic phase diagrams: Two component systems- Al_2O_3-SiO_2, BaO-TiO_2; Three component systems- MgO- Al_2O_3-SiO_2.
- Understand the applications of different ceramic phase diagrams.

Powder preparation techniques: Sol-gel technology, Precipitation, Coprecipitation, Hydrothermal precipitation.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Study the process of different powder preparation techniques: Sol-gel technology, precipitation, coprecipitation, hydrothermal precipitation in detail.

Ceramic processing techniques: Die compaction, Hot pressing, Cold Isostatic Pressing (CIP), Hot Isostatic Pressing (HIP), Sintering: Principles and processes. Slip casting, Tape Casting.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Study the process of various ceramic processing techniques in detail.
- Understand the advantages and disadvantages involved with it.

Text Books:

1. *Introduction to Ceramics: W.D. Kingery et al- John Wiley*
2. *Materials Science and Engineering: An Introduction - William D Callister Jr*

IMT 15- (Elective 2)

(a). CORROSION ENGINEERING

Periods / week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- To Know the electrochemical and thermodynamic aspects of corrosion.
- To Know the various forms of corrosion.
- To know the preventive methods of corrosion

Course Outcomes:

- Explain the importance of studying corrosion
- Describe the thermodynamic aspects of corrosion
- Describe the kinetic aspects of corrosion
- Indicate the various forms of corrosion
- Explain the measurement and control of corrosion.

SYLLABUS

Introduction, Polarization and passivity, Pourbaix diagrams.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the electrochemical, thermodynamic aspects of corrosion and fundamentals involved with it.
- Define polarization, different polarization techniques, significance of Pourbiax diagrams in detail.

Forms of corrosion, Characterization and remedial measures of uniform corrosion, Galvanic corrosion, pitting corrosion, crevice corrosion, intergranular corrosion, erosion corrosion and stress corrosion cracking.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the fundamentals and mechanisms involved with various forms of corrosion,
- Describe possible reasons for corrosion occurrence in detail.

Corrosion prevention methods: Alteration of Environment (Inhibitors), Design, Coatings, Cathodic and anodic protection, Material selection, Metallurgical aspects, Corrosion fatigue, Hydrogen damage (hydrogen blistering, hydrogen embrittlement, prevention).Corrosion of welds.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Explain the various preventive measures for corrosion.
- Describe the protection techniques against corrosion in detail.

Text books:

An introduction to Electrometallurgy, Sharan and Narain, Standard Publishers
Corrosion Engineering, MG Fontana, Mc-Graw Hill Book Company
Electro Beam Analysis of Materials, Loretto.

(b). ALLOY STEELS

Periods / week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- To understand the importance of various materials used in engineering and obtain a qualitative analysis of their behavior and applications

Course Outcomes:

- Understands various types of steels their properties in various conditions.
- Understands various types of steels with their structure- property relation in various applications.

Low-carbon steels: Introduction, Conventional low carbon steels, cold forming characteristics, Dual phase steels, Mild steel, HSLA steels, Formability of HSLA steels, Strengthening Mechanisms, Structure property relationships.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the characteristics of different types of Carbon steels and their properties.
- Describe the manufacturing process of various carbon steels and their applications.

Medium and High carbon ferrite- pearlite steels – structure property relationships, Ferrite – Pearlite steels, Bainitic steels, requirements and developments. Rail structurals, Spring steels and High strength structural steels – heat treatment, structure, properties and applications.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Explain the characteristics of different types of alloy steels and their making process.
- Gain the knowledge on properties of alloy steels and their applications.

Ultra – high strength steels: Thermomechanical treatments (TMT), Maraging steels, Ausforming steels, Strengthening mechanisms, structure-property relationships. Mechanical properties and applications.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the structure-property relationships of alloy steels and their making process.
- Gain the knowledge on properties of alloy steels and their applications.

Heat and corrosion resistant steels – Basic Principals, Low chromium heat resistant steels, Stainless steels: Classification, Composition, Heat Treatment, Microstructure properties and applications.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the basic principles of heat and corrosion resistant steels, low chromium heat resistant steels.
- Gain the knowledge on properties of heat and corrosion resistant steels, low chromium heat resistant steels and their applications.

Tool steels Classification and property requirements, Composition – Heat Treatment Microstructure – properties and applications of various groups of alloy tool and die steels.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Explain the basic principles of tool steels, classification and property requirements
- Gain the knowledge on properties of tool steels and their applications.

Text Books:

Physical Metallurgy and the design of steels: F.B. Pickering
Physical Metallurgy of Steels: W.C. Leslie.

(c) SURFACE ENGINEERING

Periods / week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- To understand the need for Surface Engineering and to become familiar with the techniques associated with Surface Engineering.

Course Outcomes:

- Indicate the need for surface engineering.
- Indicate the different methods of surface engineering.
- Differentiatebetweenthemethodsusedandindicatetheirrelativemerits.
- Understandaspectsassociatedwithindustrialapplicationsofsurfaceengineering.

SYLLABUS

Need for engineered surface, Conventional surface hardening methods, definition and principles,

Learning Outcomes:

At the end of the chapter the student will be able to:

- Gain the knowledge about significance of engineered surface and applications

- Describe the various conventional surface hardening techniques and principles.

Methods involving no change in the chemical composition of the surface, Methods involving change in chemical composition of the surface.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the different surface hardening techniques based on with and without modification in the chemical composition.
- Explain about process and applications of above surface hardening techniques.

Application of advanced techniques such as ion and electron beam towards creating newengineered surface.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the fabricating surface hardened material using ion and electron beam.
- Describe the advantages, limitations of above process and their applications.

Controlled high quality surface modification by techniques such as CVD, PVD, Plasma, laser, ion bombardment.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Gain the knowledge of high quality surface modification by techniques such as CVD, PVD, Plasma, laser, ion bombardment.
- Study about their process, equipment required and their applications.

Effect of process variables and structure- property correlations, thermo- chemical, thermo- mechanical and thermal processes Treatments for industrial components, Case studies.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the influence of process variables on material properties.
- Describe the different types processes and their significance.
- Explain about various treatments used for industrial components along with case studies.

Text Books:

Advanced Thermally Assisted surface engineering processes, Ramanarayan Chattopadhyay, Kluwer Academy Publishers.
Surface Engineering of metals: Principles, Equipment and Techniques, Tadeusz Burakowski, Tadeusz Wierzchon, CRC Press.
Laser Material Processing, W. Steen, Springer.

IMT 16- RESEARCH METHODOLOGY AND IPR

Periods / week: 3 **Credits: 2** **Sessionals: 30** **Exam: 70**

IMT 17- AUDIT COURSE-1

Periods / week: 3 **Credits: 0** **Sessionals: 30** **Exam: 70**

IMT 18-CASTING LAB

Periods / week: 3 Credits: 2 Sessionals: 50 Exam: 50

A laboratory project on any one of these topics.

1. Sand Testing
2. CO_2 Molding,
3. Shell Molding,
4. Design of Gating systems,
5. Vacuum Molding,
6. NDT of castings

IMT 19- WELDING LAB

Periods / week: 3 Credits: 2 Sessionals: 50 Exam: 50

1. Study on microstructure of different zones of aluminium and steel welds.

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II SEMESTER

IMT 21-FAILURE ANALYSIS

Periods / week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- To highlight factors governing the failure of materials and types of failure
- To evaluate the mechanisms and environmental effects associated with failure
- To identify various failures in heat treatments, and deformation processing, andmethods to prevent them

Course Outcomes:

After completing this course the student will have:

- The ability to identify the types of failures in engineering components under service
- Knowledge of the tools and techniques to perform failure analysis
- The skill set to perform fractographic analysis after various failures
- The ability to identify different failure mechanisms resulting from manufacturing processes
- Sources of Failures, Steps in Failure Analysis,

Sources of Failures, Steps in Failure Analysis,
Characteristics of ductile and brittle fracture, ductile to brittle transition. High temperature failures,

Learning Outcomes:

At the end of this chapter the student will be able to:

- Understand the characteristics of ductile and brittle fracture, ductile to brittle transition and influencing factors.
- Gain the knowledge on high temperature failures and the causes with the help of case studies.

Fatigue failures

Learning Outcomes:

At the end of this chapter the student will be able to:

- Study the fatigue failures, stages involved with it and the reasons for the failure in detail.
- Gain the knowledge on different types of fatigue failures and methods to improve fatigue life with the help of case studies.

Corrosion failures and their identification

Learning Outcomes:

At the end of this chapter the student will be able to:

- Explain about various corrosion failures and type of corrosion associated with failure by studying the different case studies.
- Describe the reasons for corrosion failures and preventive measures to resist corrosion failure

Failures of industrial components like casting and welding. Some case studies in failure analysis.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Study about various failures of industrial components like casted and welded components.
- Gain the knowledge on failure of components with the help of case studies and causes for the failure.

Text Books/Reference:

Analysis of Metallurgical failures-VJ Collangelo and PA Heiser

IMT 22- STRENGTHENING MECHANISMS

Periods/week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- To explain and describe various strengthening mechanisms involved in the development of existing alloys and new alloys.

Course Outcomes:

- Explain the process of strengthening by grain / grain boundary in materials.
- Explain and illustrate how alloying can improve strength in metals
- Choose cold working and annealing cycles for improving strength and ductility in materials for suitable applications.
- Compare and contrast the different means of strengthening by small second phase particles.
- Distinguish composite strengthening by various methods of orientation of fibers in materials.
- Choose a particular strengthening mechanisms for design of high strength metals and alloys.

Strengthening from grain boundaries, Hall-Petch relation, ASTM grain size measurement, yield-point phenomenon, strain aging.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Describe the grain boundary strengthening and solve the problems related to grain size.
- Define Hall-Petch relation, yield- point phenomenon and strain aging.

Solid solution strengthening: Elastic interaction, modulus interaction, stacking fault interaction, electrical interaction, short range order interaction, long range order interaction.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the solid solution strengthening and its influence.
- Explain different types of interactions involved with solid solution strengthening.

Cold working: Strain hardening of single crystals, annealing of cold worked metal, recovery, recrystallization and grain growth.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the cold working and mechanism of strain hardening.
- Describe the various stages in formation of strain free grains and the process of annealing.

Strengthening from fine particles: Principle, mechanisms and examples of Precipitation hardening (age hardening), Dispersion hardening. Fiber strengthening, strength and moduli of composites (Iso-strain and Iso-stress condition), influence of fiber length, orientation and concentration

Learning Outcomes:

At the end of the chapter the student will be able to:

- Gain the knowledge on precipitation hardening and dispersion hardening mechanisms.
- Study the fiber strengthening and its influencing factors.

Strengthening by phase transformations, Martensite strengthening.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Explain the strengthening resulted from various heat treatment processes.
- Describe the transformations and mechanisms involved with the heat treatment processes

Text Books:

1. Mechanical Metallurgy - George E Dieter
2. Mechanical Behaviour of Materials - Thomas H Courtany
3. Materials Science and Engineering an Introduction - William D Callister Jr
4. Materials Science and Engineering – V Raghavan

IMT 23-INDUSTRIAL HEAT TREATMENT

Periods / week: 4 Credits: 3 Sessionals: 30 Exam: 70

- To gain knowledge related to working principles of furnaces used in metallurgical industries.
- To explain construction, salient features and heat transfer aspects of various furnaces.

Course Objectives:

- Classify and explain construction and working of different furnaces. Analyze causes of Heat losses in furnaces and suggest methods of minimization it and Waste heat recovery.
- Explain various manufacturing and testing processes of refractories. Link
- Inherent properties of the refractory mineral and how it affects the production technology

and the application.

Furnaces, salt bath equipment, fluidized bed equipment, vacuum furnaces. Heat treatment of Cast iron, tool steels, stainless steel and heat resistant alloys, non-ferrous alloys: Al, Cu, Mg, Ti. Thermo mechanical processing of steels.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Define Heat treatment furnace and the primary parts of furnace and draw different Heat treatment furnaces.
- Classify Heat treatment furnaces based on the fuels used, design, and use.
- Explain the working principle of the furnaces – Muffle furnace, Salt bath furnace, Bogie, Pit, Rotary hearth.
- Explain about the necessity of maintaining controlled atmosphere in furnaces, and the mixtures of gases which were used for controlled atmospheres.
- Describe the different reactions that takes place in furnaces and state different atmospheres that are available commercially.

- Understand the influence of alloying elements and factors affecting hardenability.
- Study the different thermo-mechanical treatments for steels.

- Study the various surface hardening techniques like surface hardening, carburizing, nitriding, cyaniding, carbonitriding. induction and flame hardening.

Text books:
1. Heat treatment, Rajan
2. Heat treatment of metals, Zakharov

References:
1. Physical Metallurgy, V Raghavan
2. Introduction to Physical Metallurgy, SH Avner
3. Physical Metallurgy Principles, RE Reed-Hill.
4. Physical Metallurgy for Engineers, Clark and Varney

IMT 24- (Elective - 3)

(a) POWDER METALLURGY

Periods/week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course objectives:

- This course introduces the particulate technology to create components from powder route.
- To build the necessary back ground of emergence and importance of powder metallurgy scope and limitations.
- Obtain a necessary knowledge about various powder production techniques and characteristics.
- Obtain a working knowledge of compaction and sintering techniques.
- Gain an effective knowledge of applications of powder metallurgy products.

Course Outcomes:

- Appreciate the importance of powder metallurgy technology for production of materials

and components in comparison with other fabrication techniques.

- List out the advantages, limitations and applications of powder metallurgy technique.
- Able to choose the production method to get the required size and shape of the powders.
- Knowledge of various characterization methods to control the properties of the powders.
- Describes the consolidation and sintering processes in powder metallurgy route.
- Can develop and design powder metallurgical components for specific applications and needs of various industries.

Introduction: Advantages and limitations of powder metallurgy. Applications of powder metallurgy.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Study the significance of powder metallurgy and applications of powder metallurgy.
- Gain the knowledge on advantages and limitations of powder metallurgy.

Powder production methods:

Mechanical, Chemical, Electrolytic and atomization Methods. Commercial production of metallic powders.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Understand the various powder metallurgy techniques and their process in detail.
- Describe the commercial production of metallic powders and process limitations in detail.

Powder characteristics:

Composition and structure, particle size, shape, specific surface, surface topography, flow rate, apparent and tap density, pressing properties.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Study the powder characteristics produced by various powder metallurgy techniques and their properties.
- Explain the influencing factors of powder characteristics in their production.

Compaction of metal powders:

Pressure and Pressure-less compaction techniques: Die compaction, Cold Iso-static pressing, Powder rolling, Powder forging, Explosive forming; High Temperature Compaction methods: Hot Pressing, Hot Extrusion, Spark Plasma Sintering, H I P.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Describe the various pressure and pressure less compaction techniques and their process in detail.
- Understand the advantages and disadvantages of compaction methods and applications.

Principles and practice of sintering:

Sintering mechanisms, stages of sintering, Driving forces for sintering, sintering atmospheres, Liquid phase sintering, Post sintering operations.

Learning Outcomes:
At the end of this chapter the student will be able to:

- Describe the fundamentals, principles of sintering and its mechanism.
- Study the influencing factors of sintering and different type of sintering techniques.

Text Books

1. Powder Metallurgy Science, Technology and Applications – P.C. Angelo & R. Subramanian
2. Powder Metallurgy – J.S. Hirschhorn
3. Treatise on Powder Metallurgy – C. Goetzel, vol. 1&2.
4. Powder Metallurgy Practice and Applications – R.L. Sands & C.R. Shakespeare.
5. Handbook of Powder Metallurgy – H. H. Hausner & M.Mal- 2nd Ed.

(b) ENERGY MATERIALS

Periods/week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- To learn the operating principle of several environmentally friendly energy technologies. To identify the material issues relevant to these technologies and to evaluate various operational aspects associated with these technologies.

Course Outcomes:

- Evaluate an energy technology for environmental friendliness.
- Explain the operating principle of several energy technologies.
- Indicate the material requirements for these energy technologies.
- Demonstrate the ability to understand the characterization, performance, and failure datarelated to these technologies.

SYLLABUS

Energy requirements in a global scale and in the Indian context.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the significance of energy materials and their properties.
- Gain the knowledge on manufacturing of energy materials and their applications in India, world-wide.

Evolution of energy sources from the perspective of clean energy. Carbon equivalent.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Describe the evolution of energy materials with respect to clean energy.
- Define carbon equivalent and its influence on environment.

Introduction to different types of energy storage and conversion devices and technologies. Synthesis and characterization of materials used for these technologies, Properties desired in the materials, Techniques

to evaluate the properties and performance, failure modes and analysis, environmental impact of the following technologies:

I. Fuel cells
II. Batteries
III. Super capacitors
IV. Solar energy conversion devices
V. Wind Energy
VI. Mechanical Energy storage

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the different types of energy materials and their properties.
- Gain the knowledge on synthesis of energy materials and their applications.
- Explain about various revolutionary technologies of energy materials and their impact on the environment.

Text books

1. Renewable Energy: Power for a Sustainable Future, Godfrey Boyle, Oxford University Press, 2004

(c) ELECTRONIC MATERIALS

Periods/week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- To become familiar with the science, synthesis, evaluation, and applications of electronic materials. To know the manufacturing processes associated with use of electronic materials for devices.

Course Outcomes:

- Indicate and explain important scientific parameters associated with electronic materials.
- Describe different semiconductors and their properties with examples.
- Explain the features and functioning of several electronic devices.
- Describe the manufacturing processes associated with electronic materials and devices.

SYLLABUS

Intrinsic semiconductors. Electron and hole (carrier)

concentrations.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the significance of electronic materials and their properties.
- Gain the knowledge on manufacturing of intrinsic semiconductors and their applications.

Fermi energy level, effect of temperature on Fermi energy.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Define fermi energy level and effect of temperature on fermi energy.
- Gain the knowledge on influence of fermi energy level on thermal, electrical, optical, magnetic properties.

Carrier mobility. Direct vs. indirect band gap materials.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the carrier mobility and its significance.
- Explain about the direct, indirect band gap materials and their properties.

Elemental vs. compound semiconductors. Extrinsic semiconductors. Doping – p and n type semiconductors.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the elemental and compound semiconductors and their properties.
- Describe about the extrinsic, p and n-type of semiconductors and their applications.

carrier concentration and Fermi level as a function of temperature. Drift mobility. Light and heavydoping.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Gain the knowledge on carrier concentration and fermi level as a function of temperature.
- Define drift mobility, light and heavy doping, and their applications.

Semiconductor diodes p-n junctions at equilibrium. Forward and reverse bias. I- V characteristics. Band diagram. Diode breakdown mechanisms.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study about semiconductor diodes, forward and reverse bias and their significance in detail.
- Describe various diode breakdown mechanisms.

LEDs and solar cell materials. Transistors – MOSFETs. Band diagram and channel formation. Threshold voltage. I-V characteristics.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand about LEDs and solar cell materials, transistors- MOSFETs and their applications.
- Define Band diagram, channel formation and threshold voltage and their significance.

Introduction to semiconductor manufacturing – history, process flow, manufacturing goals. Bulk Sicrystal growth.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Gain the knowledge on manufacturing of semiconductors for their various applications
- Explain about process steps with flow sheet and limitations.

Overview of manufacturing technology – oxidation, photolithography, etching, doping, deposition, planarization. Clean room classifications.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Describe about various manufacturing techniques, oxidation, photolithography, etching, doping, deposition, planarization and their process in detail.

CMOS manufacturing steps. Process monitoring – blank and patterned thin film measurement. Defect inspection. Electrical testing. Yield monitoring & statistical process control. Definitions of yield, process control, defect density. Process integration. Assembly and packaging.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the steps in manufacturing of CMOS and defect inspection.
- Define yield, process control, defect density.

Text books

1. Semiconductor Materials, Devices and Fabrication, Parasuraman Swaminathan, Wiley 2017

Reference books

1. Principles of Electronic Materials and Devices, S. O. Kasap, McGraw Hill Education, 2017

IMT 25- (Elective - 4)

(a). NON-DESTRUCTIVE TESTING

Periods / week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- To gain and understanding of the response of various metals under the application of stress and/or temperature.
- Obtain a working knowledge of various hardness testing machines BHN, VHN, RHN
- Obtain a working knowledge of creep and fatigue testing methods and analysis of data.
- To get an exposure to NDT techniques for detection of various types of flaws.

Course Outcomes:

- Understand and interpret the results of various hardness tests and impact tests.
- Evaluate various tensile properties of ferrous and Non Ferrous Metals and solve problems related to the tensile tests.
- Analyse the modes of failure occurring due to fatigue and suggest remedial measures.
- Analyse the methods of failure of materials at high temperature by creep and stress rupture and the mechanisms responsible for fracture
- Determine appropriate tests to be employed to determine the given mechanical properties using both destructive and non-destructive techniques

- Knowledge of various testing methods for based on Destructive Techniques &Non destructive Techniques and their importance in enhancing service / component life.

Visual examination. Leakage Testing.
Penetrant methods: Principles, equipment, applications and limitations.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the significance of visual inspection methods and their principles.
- Gain the knowledge of precise operations involved to determine the surface cracks by liquid penetrant test by using cleaner, penetrator and developer.
- Know about various equipment used for visual inspection methods, and their limitations.

Magnetic methods: Principles of magnetism and magnetization. Principles of magnetic particle inspection. The magna flux machine. The process. The magnetic bath. Methods for the application of magnetic bath. Demagnetization. Application of the method. Salient features of the process.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Learn about the significance of magnetic methods of NDT and their principles.
- Gain the knowledge of precise operations involved and their principles.
- Know about various equipment used for magnetic methods, and their applications.

Ultrasonic testing: Types of ultrasonic waves. Flow detection and ultrasonic energy. Interpretation of results and limitations.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the importance of Ultrasonic testing and their principle.
- Gain the knowledge of precise operations involved and their principles.
- Know about various equipment used for magnetic methods, and their applications.

X-ray radiography: Production of X-rays. X-ray tube. The Radiograph. Optical factors which effect the radiograph. X-ray films. Filters and screens. Sensitivity of a radiograph.
Gamma ray radiography : Production of gamms-rays, interpretation of the radiograph. Safety precautions.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Gain the knowledge on X-ray radiography, influencing factors and data interpretation.
- Understand in detail about production of gamma rays, its analysis and safety measures.

Electrical methods: Thermoelectric methods. Eddy current methods. Detection of the eddy currents. Eddy current instruments. Continuous inspection and testing.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the electrical methods involved in non-destructive testing and the instruments used, in detail.

Text Books:

1. Metals Hand book Vol.11 (Non-Destructive Testing)
2. Non-Destructive Testing-WJ Mc Gonnangle

(b) METAL FORMING

Periods / week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- To Know the mechanical and metallurgical fundamentals for metal forming processes.
- To Know the processes parameters, forming loads, process design and tool design in different processes.
- To Analyze the behavior of metals during plastic deformation.

Course Outcomes:

- Compare and classify different forming processes.
- Analyze the behaviour of materials during forming processes.
- Determine forming processes controlling parameters.
- Estimate required forming loads, powers of different forming equipment and processes.
- Determine the cause of the defects that may take place during forming processes.
- Integrate knowledge gained in this course to select and design a complete metal forming system.

SYLLABUS

Fundamentals of metal working. Classification of forming processes, Temperature in metal working, Strain-rate effects, Metallurgical Structure, Friction and Lubrication.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the fundamentals and classification of metal forming operations.
- Gain knowledge on temperature, strain rate effects, friction and lubrication

Forging: Classification, forging equipment, Open die and closed die forging, Calculation of forgingloads in closed die forging and Forging defects.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the fundamentals and classification of metal forging operations.
- Explain about different types of forging processes and defects.

Rolling classification. Rolling mills and accessories. Hot and cold rolling. Forces and geometric relationships in rolling. Rolling variables. Problems and defects in rolled products.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Describe the classification of rolling, rolling mills and accessories involved.
- Gain knowledge on rolling variables, defects and problems involved with rolled products.

Extrusion: Classification, Extrusion equipment, Hot extrusion, lubrication and defects in extrusion. Extrusion of tubing.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the fundamentals and classification of extrusion operations.
- Describe the equipment required for extrusion and defects involved with extrusion.

Drawing of rods wires and tubes. Sheet metal forming.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Gain knowledge on drawing operation of rods, wires, tubes and equipment involved with it.
- Explain fundamentals of sheet metal forming and equipment required.

Text Books:

1. Mechanical Metallurgy- GE Dieter
2. Principles of Metal Working- Surendar Kumar
3. Principles of Metal working-GW Rowe

Reference: 1. ASM Metals Handbook

(c). FRACTURE MECHANICS

Periods / week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- To study the different types of fatigue failures and their mechanisms in the engineeringapplications.
- To study the basic theory of fracture mechanics and its relationship with fatigue and creepfailure mechanisms.
- To understand the damage tolerance approach in the life estimation of structures.

Course Outcomes:

- The ability to identify the characteristic fatigue failures in the engineering structures.
- Knowledge of connecting fracture mechanics concepts to fatigue failure.
- Knowledge of fatigue failure mechanisms in non-metallic materials.

SYLLABUS

Introduction, Fracture Criteria, Theoretical strength, stress concentration factor, Griffith crack theory, strain-energy release rate.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the Fracture Criteria, Theoretical strength, stress concentration factor, Griffith crack theory, strain-energy release rate.

Mechanism of fracture: Introduction, cleavage fracture, ductile fracture, fatigue cracking, environment assisted cracking, evaluation of fracture toughness. Introduction to LEFM: Concept, Analysis of simple crack problems, nucleation and propagation of cracks, correlation between microstructure and fracture behaviour in different materials.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the fundamentals and mechanism of fracture.
- Describe the concept, analysis of simple crack problems, nucleation and propagation of cracks and correlation between microstructure and fracture behaviour.

Crack behaviour in elastic-plastic materials, effect of strain rate, environment, temperature and irradiation on fracture behaviour of materials, Application of fracture mechanicsis to material selections, alloy design and design of structures.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the crack behaviour in elastic-plastic materials, effect of strain rate, environment, temperature and irradiation on fracture behaviour of materials
- Understand the Application of fracture mechanicsis to material selections, alloy design and design of structures.

Conventional approach to fatigue crack growth in reactive environment, static and cyclic loading.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the conventional approach to fatigue crack growth in reactive environment and static, cyclic loading.

Text Books:

Fracture Mechanics: Fundamentals and Applications, T.L. Anderson,crc press Inc., 1995.
ASM Handbook: Fatigue and Fracture, S.R. Lampman, (Rechnical Ed), ASM Internationsl, 1996.

IMT 26- AUDIT COURSE-2

Periods / week: 3 **Credits: 0** **Sessionals: 30** **Exam: 70**

IMT 27- PHYSICAL METALLURGY LAB

Periods / week: 3 Credits: 2 Sessionals: 50 Exam: 50

Metallographic studies of:

- Plain Carbon steels,
- Cast Irons,
- Stainless steels,
- copper, brass
- Aluminium and bearing materials

IMT 28- TESTING OF MATERIALS LAB

Periods / week: 3 Credits: 2 Sessionals: 50 Exam: 50

1. Rolling of Copper, brass, stainless steel and plain carbon steel using laboratory mills.
2. Determination of tensile properties, n & K
3. Mechanical properties studies in cold worked Aluminium, copper, and steels etc.
4. Ericsen ductility test

IMT 29- MINI PROJECT WITH SEMINAR

Periods / week: 3 Credits: 2 Sessionals: 50 Exam: 50

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III SEMESTER

IMT 31- (Elective - 5)

(a). NANO COMPOSITES

Periods/week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- To recognize the differences between nanomaterials and conventional materials and to become familiar with a wide range of nanomaterials, their synthesis, characterization, properties and applications.

Course Outcomes:

- Indicate the differences between nanomaterials and conventional materials.
- Indicate how specific synthesis techniques can result in nanomaterials.
- Give examples of specific nanomaterial and explain the scientific reasons for theProperties displayed by them.

SYLLABUS

Synthesis of Nano Materials: Bottom-Up and Top–down approaches, Mechanical grinding method, Sol-Gel process, Gas Phase synthesis, Gas Condensation Processing (GPC) and Chemical Vapour Condensation (CVC).

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the significance of nano technology and its evolution.

- Describe the synthesizing processes used for nano technology and the challenges in the process.
- Explain the synthesis of one- dimensional nano particles through different techniques

Classification of Nano composites: Metal Matrix Nano composites (MMNC), Polymer Matrix Nano composites (PMNC) and Ceramic Matrix Nano composites (CMNC), Matrix and reinforcements, Properties and Applications.

Learning Outcomes:

At the end of the chapter the student will be able to:.

- Understand the Classification of Nano composites: Metal Matrix Nano composites (MMNC), Polymer Matrix Nano composites (PMNC) and Ceramic Matrix Nano composites (CMNC), Matrix and reinforcements, Properties and Applications.
- Gain the knowledge of characteristics of zero- dimensional nano particles and their applications.

Processing of Metal matrix nano composites (MMNCs): Liquid processes- Stir Casting route, Ultrasonic method, Solid process- Mechanical Alloying method. Compaction techniques- Hot Pressing, Spark Plasma Sintering and Microwave sintering.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the Processing of Metal matrix nano composites (MMNCs)
- Gain the knowledge of characteristics and their applications.

Processing of polymer matrix nano composites: nano tubes, nano layered (clay) and nano particles reinforced polymer matrix nano composites (PMNCs); processing of ceramic matrix nano composites (CMNCs).

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the Processing of polymer matrix nano composites: nano tubes, nano layered (clay) and nano particles reinforced polymer matrix nano composites (PMNCs); processing of ceramic matrix nano composites (CMNCs).
- Gain the knowledge of characteristics and their applications.

Text books:

1. *Challenges and Advantages in Nano composite processing techniques, V. Viswanathan, T. Laha, K. Balani, A. Agarwal and S. Seal., 2006*
2. *Nano composites: Synthesis, Structure, Properties and New Application Opportunities, Pedro Henrique Cury Camargo, Kestur Gundappa Satyanarayana, Fernando Wypych., 2009*
3. *Introduction to Nano composite Materials, Properties, Processing, Characterization, Thomas E. Twardowski, DesTech Publications, April 2007*
4. *Nano composite Science and Technology, Pulickel M. Ajayan, Linda S. Schadler, Paul V. Braun, 2006, Wiley-VCH.*

(b). FUNCTIONAL MATERIALS

Periods / week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- To introduce the student to functional materials and the science behind the performance of the functional material. To enable the student to understand the applications of functional materials.

Course outcomes:

- Indicate the various type of functional materials
- Explain the principle of operation of the functional material
- Indicate the applications of the functional materials

SYLLABUS

Characteristics and types of functional materials. Crystal structure and Properties. Effect of size on properties, effect of interfaces on properties.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the fundamentals of functional materials and their properties.
- Describe the characteristics of functional materials and their applications.

Band structure, Semiconductor devices: Theory, examples and applications of Optically active materials.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Explain the basics of semiconductor materials and their properties.
- Understand the characteristics of functional materials, mechanism involved with them and their applications.

Dielectrics: piezo- and ferro electric materials

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the fundamentals of piezo- and ferro electric materials and their properties.
- Describe the manufacturing of piezo- and ferro electric materials and their applications.

Magnetic materials: storage applications, Smart materials

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the significance of magnetic materials and their properties.
- Gain the knowledge on manufacturing of magnetic materials and their applications.

Applications in electronic, communication, aerospace, automotive, energy industries

Learning Outcomes:

At the end of the chapter the student will be able to:

- Describe the various applications of functional materials in electronic, communication, aerospace, automotive, energy industries.

Text books

1. Functional Materials: Electrical, Dielectric, Electromagnetic, Optical and Magnetic applications; Deborah D L Chung, World Scientific Publishing, 2010

(c). BIO MATERIALS

Periods / week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- To introduce the student to the range of biomaterials and the science and engineering of biomaterials. To understand constraints associated with the use of biomaterials.

Course Outcomes:

- Explain the types of Biomaterials and their relative advantages and disadvantages.
- Indicate the constraints placed on the use of materials in biological environments.
- Explain the characterization of materials from the perspective of application as a biomaterial.

SYLLABUS

Types of biomaterials, biological environment

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the significance of bio materials and their properties under biological environment.
- Gain the knowledge on manufacturing of bio materials and their applications.

Mechanical and physio-chemical properties of biomaterials, Resorbability, biodegradation, biological responses, compatibility, cytotoxicity, cell bio-material interactions, associated characterization.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the mechanical and physio-chemical properties of biomaterials and influence on applications.
- Define resorbability, biodegradation, biological responses, compatibility, cytotoxicity, cell bio-material interactions.

Metals, Polymers, Ceramics, Natural biomaterials Blends, composites, biopolymers, Hydrogels, drug delivery systems.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Explain about various bio materials in material classification and their properties.
- Understand the fabrication of bio materials according to the application.

Text books

1. Introduction to Biomaterials: Basic Theory with Engineering Applications; C.L Agrawal, J.L. Ong, Mark R Appleford, Gopinath Mani, Canbridge University Press, 2013

IMT 32- Open Elective

(a). MATERIALS CHARACTERIZATION

Periods / week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course objectives:

- To obtain knowledge on various structural and microstructural characterization techniques of materials.

- To study the principles, theory and practice of various characterization techniques

Course Outcomes:

- Determine crystal structure of materials
- Analyze microstructure of materials at different length scales
- To use XRD to study grain size, phase diagram and residual stresses
- To use XRD to determine chemical composition and order-disorder transformation

Production and properties of X-rays, Electromagnetic radiation, continuous and characteristics spectrum, absorption. Fillers. Diffraction. Bragg's law, scattering by atom, electron, unit cell, structure factor calculation.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Study the principles in the production of X-rays and their characteristics.
- Define electromagnetic radiation, continuous and characteristics spectrum, absorption, filters, Bragg's law, scattering by atom and also calculate the structure factor.

Diffraction Methods: Laue's method, rotating crystal, Debye scherrer – Specimen preparation, film loading, powder method, Determination of crystal structure, determination of precision lattice parameter, sources of error in measurements.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Gain the knowledge on different diffraction methods, their data interpretation and limitations.
- Understand the determination of crystal structure, precision lattice parameter, sources of error in measurements.

Applications – Effect of plastic deformation. Determination of particle size, grain size, residual stresses, determination of phase diagrams, order-disorder transformation.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Study about the determination of effect of plastic deformation and its data interpretation, analysis.
- Describe the determination of particle size, grain size, residual stresses, phase diagrams, order-disorder transformation through XRD.

Principles of construction of electron microscopes.SEM and TEM. Specimen preparation and technique for transmission electron microscopy.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Study the principles of construction of different types of electron microscopes.
- Explain about specimen preparation techniques for optical, scanning electron microscopy and transmission electron microscopy.

Principles of Thermo gravimetry - TGA and DTA

Learning Outcomes:

At the end of this chapter the student will be able to:

- Study the different types of principles of thermo-gravimetric analysis and data interpretation.

Text Books:
1. X-ray diffraction – B.D.Cullity
2. Transmission Electro Microsopy-G.Thomas.
3. Materials Charecterization - P.R.Khangaonkar

(b). Solidification Processing

Periods / week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- The prime objective of this course is to make the student gain an understanding of the relation between microstructural characteristics and properties of metals and alloys.
- The course also critically focuses on the crystallography, phase transformations that occur in several ferrous and nonferrous metallurgical systems as a function of temperature and composition through phase equilibrium diagrams.

Course Outcomes:

At the end of the course the student will be able to:

- Explain the solidification of metals and alloys, mechanisms.
- Explain the necessity of alloys, will identify the different types of alloy phases.
- Explain the construction and identification of phase diagrams and reactions.

SYLLABUS

Properties of metals and alloys before and during solidification. Surface phenomena. Basic terms, surface energy, surface tension, wetting angle. Wetting speed. Classification and influence of wetting.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Study the various properties of metals and alloys before and during solidification in detail.
- Define the fundamentals of solidification, surface energy, surface tension, wetting angle, wetting speed.

Homogeneous and heterogeneous nucleation, with plane front, cellular and dendritic pattern, columnar and equiaxed grain growth. Phenomena affecting the quality of castings such as micro-segregation, constituent under-cooling, macro-segregation and porosity formation.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Understand the solidification of various pure metals and alloys and the mechanism involved with it.
- Define the fundamental concepts of solidification like nucleation and growth, homogenous and heterogeneous, constitutional super cooling, coring, segregation and porosity formation.

Text Books:
Solidification processing M. Flemings, McGraw-Hill, 1974
Fundamentals of Solidification, Trans. Tech. Publications, Switzerland, 1992

(c). Phase Transformations

Periods / week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- To introduce the student to key concepts in Phase transformations and enable an understanding of the steps involved in several important phase transformations.

Course Outcomes:

- Classify phase transformations
- Indicate important steps in different types of phase transformations
- Explain phase transformations from the perspective of thermodynamics and kinetics
- Describe a few well known and studied phase transformations

Theory of Nucleation, Homogeneous and Heterogeneous Nucleation, Nucleation Kinetics, Growth Kinetics, Different types of Diffusion Growth. Nucleation and Grain size, Super Cooling, Directional Solidifications, and Segregations.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Understand the solidification of various pure metals and alloys and the mechanism involved with it.
- Define the fundamental concepts of solidification like nucleation and growth, homogenous and heterogeneous, constitutional super cooling, coring and segregation.

Study of Fe-Fe3C Phase Diagram, Phase Transformation in Steel on heating and cooling, Austenitic Grain Growth on heating, Determination of Grain Size, Isothermal Transformation Diagrams, Perlite, Bainite and Martensitic Transformations, Transformation of Austenite on Continuous Cooling. Annealing, Normalizing, Hardening and Tempering of steel, Hardenability, Mechanism of Heat removal during Quenching, Quenching media, Residual stresses and Quench Cracks, Martempering and Austempering,

Learning Outcomes:

At the end of this chapter the student will be able to:

- Study of Fe-Fe3C Phase Diagram, Phase Transformation in Steel on heating and cooling, Austenitic Grain Growth on heating,
- Determine the Grain Size, Isothermal Transformation Diagrams, Perlite, Bainite and Martensitic Transformations in detail.

Purpose of alloying, Effect of alloying on Fe-Fe3C Phase Diagram, Temperature Time Transformation (TTT) and Continuous Cooling Transformation (CCT) Plots, Secondary Hardening, Temper embrittlement. Classification of alloys steel, high strength low alloys steel, corrosion resistant steel, tool steel, Hadfield Mn steel, Different types of cast irons, White cast iron, grey cast iron, malleable cast iron, S.G iron and alloy cast iron.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Understand the Temperature Time Transformation (TTT) and Continuous Cooling Transformation (CCT) Plots, Secondary Hardening, Temper embrittlement.
- Study the Classification of alloys steel, high strength low alloys steel, corrosion resistant steel, tool steel and classification of cast iron.

Flame and Induction Hardening, Laser beam Hardening (LBM), Carburizing (solid, liquid and gas), Nitriding, Cyaniding, Boronizing. Solution Treatment, Ageing treatment, Nucleation of Precipitates, Theory of Precipitation Hardening, Effect of variables on Precipitation Hardening.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Understand the various hardening techniques and their application.
- Study the effect of variables on Precipitation Hardening in detail.

Text Books:

Phase Transformation in Metals and Alloys, VNR International, 1992 – D. A. Porter and K. E. Easterling.
Engineering Physical Metallurgy, Mir Publishers, 1997 – Y. Lakhtin.
Phase Transformation, Prentice Hall of India, 1992 – V. Raghavan.

IMT 33- DISSERTATION -I

Periods / week: 4 Credits: 6 Exam: 100

The student has to give a review presentation of comprehensive Design/Experimental project on a selected topic.

IV SEMESTER

IMT 41- DISSERTATION -II

Periods /week: Semester Credits: 14 Exam: 100
The student has to submit a comprehensive Design/Experimental project thesis and give a final viva presentation.

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MATERIALS CHARACTERIZATION

Periods / week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course objectives:

- To obtain knowledge on various structural and microstructural characterization techniques of materials.
- To study the principles, theory and practice of various characterization techniques

Course Outcomes:

- Determine crystal structure of materials
- Analyze microstructure of materials at different length scales
- To use XRD to study grain size, phase diagram and residual stresses
- To use XRD to determine chemical composition and order-disorder transformation

Production and properties of X-rays, Electromagnetic radiation, continuous and characteristics spectrum, absorption. Fillers. Diffraction. Bragg's law, scattering by atom, electron, unit cell, structure factor calculation.

Learning Outcomes:
At the end of this chapter the student will be able to:

- Study the principles in the production of X-rays and their characteristics.
- Define electromagnetic radiation, continuous and characteristics spectrum, absorption, filters, Bragg's law, scattering by atom and also calculate the structure factor.

Diffraction Methods: Laue's method, rotating crystal, Debye scherrer – Specimen preparation, film loading, powder method, Determination of crystal structure, determination of precision lattice parameter, sources of error in measurements.

Learning Outcomes:
At the end of this chapter the student will be able to:

- Gain the knowledge on different diffraction methods, their data interpretation and limitations.

- Understand the determination of crystal structure, precision lattice parameter, sources of error in measurements.

Applications – Effect of plastic deformation. Determination of particle size, grain size, residual stresses, determination of phase diagrams, order-disorder transformation.

Learning Outcomes:

At the end of this chapter the student will be able to:

- Study about the determination of effect of plastic deformation and its data interpretation, analysis.
- Describe the determination of particle size, grain size, residual stresses, phase diagrams, order-disorder transformation through XRD.

Principles of construction of electron microscopes. SEM and TEM. Specimen preparation and technique for transmission electron microscopy. Principles of Thermo gravimetry - TGA and DTA

Learning Outcomes:

At the end of this chapter the student will be able to:

- Study the different types of principles of thermo-gravimetric analysis and data interpretation.

Text Books:

1. X-ray diffraction – B.D.Cullity
2. Transmission Electro Microsopy-G.Thomas.

Text Books:

1. X-ray diffraction – B.D.Cullity
2. Transmission Electro Microsopy-G.Thomas.
3. Materials Charecterization - P.R.Khangaonkar

IMT 13 - METAL JOINING

Periods / week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course objectives:

- To develop understanding fundamentals of welding
- To know the requirements of Joining a material
- To know the various types of joining processes

Course outcomes:

At the end of this chapter the student will be able to:

- Select welding process for the given application.
- Identify different material joining technique and analyze the concept, mechanism, parameters associated with the processes.
- Demonstrate weld design procedures and also describe influence of metal joining technique on dissimilar metals convincingly.

SYLLABUS

Flux assisted GTAW process, lead free soldering, friction welding processes, friction stir welding and friction surfacing, micro joining, microwave Joining and hybrid welding.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Understand the fundamentals, classification of different types advanced metal joining techniques.

- Gain the knowledge of advantages and disadvantages of emerging technologies in material joining.

Heat flow and temperature distribution in and around weld metal., calculation of heat input and heat affected zone width.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the heat flow and temperature distribution in and around weld metal in different welding techniques.
- Understand the calculation of heat input and heat affected zone width and weld joint efficiency.

Problems during welding of carbon steels, welding of stainless steels. Schaffler diagram.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Describe the problems during welding of carbon steels, welding of stainless steels.
- Explain the Schaffler diagram and its role in welding metallurgy.

Welding of aluminum alloys, welding of titanium alloys and welding of dissimilar metals.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the welding of various light alloys and dissimilar metals.
- Gain the knowledge of challenges during welding of light alloys, dissimilar metals and remedies.

Reference:

ASM Metal hand book

IMT 15- (Elective 2)

(a). CORROSION ENGINEERING

Periods / week: 4 Credits: 3 Sessionals: 30 Exam: 70

Course Objectives:

- To Know the electrochemical and thermodynamic aspects of corrosion.
- To Know the various forms of corrosion.
- To know the preventive methods of corrosion

Course Outcomes:

At the end of the course the student will be able to:

- Explain the importance of studying corrosion
- Describe the thermodynamic aspects of corrosion
- Describe the kinetic aspects of corrosion
- Indicate the various forms of corrosion
- Explain the measurement and control of corrosion.

SYLLABUS

Introduction, Polarization and passivity, Forms of corrosion, Characterization and remedial measures of uniform corrosion, Galvanic corrosion, pitting corrosion, crevice corrosion, intergranular corrosion, erosion corrosion and stress corrosion cracking, Pourbaix diagrams.

Learning Outcomes:

At the end of the chapter the student will be able to:

- Study the electrochemical, thermodynamic aspects of corrosion and fundamentals involved with it.
- Define polarization, different polarization techniques, significance of Pourbiax diagrams in detail.
- Understand the fundamentals and mechanisms involved with various forms of corrosion,
- Describe possible reasons for corrosion occurrence in detail.

Corrosion prevention methods: Alteration of Environment (Inhibitors), Design, Coatings, Cathodic and anodic protection, Material selection, Metallurgical aspects, Corrosion fatigue, Hydrogen damage (hydrogen blistering, hydrogen embrittlement, prevention).

Learning Outcomes:

At the end of the chapter the student will be able to:

- Explain the various preventive measures for corrosion.
- Describe the protection techniques against corrosion in detail.

Text books:

1. An introduction to Electrometallurgy, Sharan and Narain, Standard Publishers
2. Corrosion Engineering, MG Fountana, Mc-Graw Hill Book Company