GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3131904
Semester III
MATERIAL SCIENCE AND METALLURGY

Type of Course:

Prerequisite: Zeal to learn the subject

Rationale: Basic principles of science are used to study the structure-properties relationships of various materials for their proper applications in this subject. Especially study of different types of ferrous and non-ferrous metals and alloys, in terms of their composition, structure, properties and applications; nondestructive testing are included in this course to understand the basic concept of selection and processing of metals and materials for their applications. Corrosion covers the mechanism, types and prevention techniques.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE Viva (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Sr. No.	Topics	Teaching Hours	% Weightage
1	**Introduction to Material Science and Metallurgy:** Basics of Engineering Materials, their Classifications and Application, Basics of Advance Engineering Materials, Engineering requirements of materials, Properties of engineering materials, Criteria for selection of materials for engineering Applications.	4	8
2	**Crystal Geometry and Crystal Imperfection:** Unit Cell, Crystal structure, Bravise lattice, atomic packing, coordination number, crystal structures of metallic elements, crystal directions and planes, Miller indices, Polymorphism or Allotropy. Crystal structure and correlated properties. diffusion processes; Crystallization: Mechanism of crystallization - nucleation and growth, factors influencing nucleation and growth. Imperfections in crystals and their effect on properties, Solute strengthening.	5	10
3	**Metallic Materials:** Types, properties and applications, Structure of Metals, Fracture, Macro-examination, Spark Test, Sculptures Print, Macro-etching, Microscopic examinations, Magnetic Testing, Chemical analysis of steel and iron for Carbon, Sulphur & Phosphorous.	5	10
4	**Solidification and Theory of Alloys:** Solidification of metals and an alloy, Nucleation and Growth during freezing of pure metal and alloy ingot/a casting Resultant macrostructures; Effects of Structure on Mechanical Properties.	6	12

	Systems, phases and phase rule, structural constituents, Gibb's free energy for thermodynamic stability of phases, Gibb's phase rule. Solid solutions and compounds, Hume-Rothery rules; Cooling curves, lever-arm principle.		
5	**Phase and Phase equilibrium:** Unary and Binary equilibrium phase diagrams, Different reactions like eutectic, eutectoid, peritectic and peritectoid; Non-equilibrium cooling.	5	10
6	**Allotropy of Iron, Iron-Iron Carbide equilibrium system:** Allotropy of iron; Iron-iron carbide equilibrium diagram: Phases present and their properties, different reactions of the Iron-Iron Carbide equilibrium system; constituents, microstructures and properties of plain carbon steels. Alloy groups (Wrought Irons, Steels and Cast Irons) of Iron-Iron Carbide equilibrium system and their characteristics in general. Equilibrium cooling of eutectoid, hypoeutectoid and hypereutectoid steels, their resultant microstructures and hence correlated properties and applications. IS and ISO Codification, Different specifications and designations of steels.	5	12
7	**TTT diagram and Heat Treatment of Steel:** Time-Temperature-Transformation Diagram, Isothermal and continuous transformations. Study of heat treatment processes such as annealing, normalizing, spherodizing, hardening, tempering, carburizing, nitriding, cyaniding, induction hardening, flame hardening and hardenability of steel. Application of above processes to machine components and mechanical equipments such as gears, shaft bearings, turbine blades, crank shafts, pistons etc.	6	14
8	**Powder Metallurgy:** Applications of powder metallurgy, advantages of powder metallurgy, manufacturing processes, production of powder, compacting, sintering, products of powder metallurgy.	3	10
9	**Non Destructive Testing:** Non Destructive testing of materials such as Radiography Testing, Dye Penetration Testing, Magnetic Particle Testing, Ultrasonic Testing. Eddy current testing with their Principle of non-destructive testing, the test methods, relative merits, demerits and applications.	4	10
10	**Corrosion of Metal And Alloys:** Mechanism of corrosion, types of corrosion, corrosion prevention techniques.	2	4
	Total	45	100

Distribution of marks weightage for cognitive level

Bloom's Taxonomy for Cognitive Domain	Marks % weightage
Recall	30

Comprehension	30
Application	25
Analysis	10
Evaluate	05
Create	00

References:

1. Callister's Material Science and Engineering, R. Balasubramaniam, Wiley India.
2. Elements of Material Science and Engineering, Lawrence H. Van Vlack, Pearson Education.
3. The Science and Engineering of Materials Donald R. Askeland and Pradeep P. Phule, Cengage Learning.
4. Principles of Materials Science and Engineering, W F Smith, McGraw Hill.
5. Materials Science and Metallurgy, K. I. Parashivamurthy, Pearson Education.
6. Physical Metallurgy, Sydney H. Avner, Tata McGraw-Hill.
7. Practical Non-Destructive Testing, Baldev Raj, T. Jayakumar and M. Thavasimuthu, Narosa Pub. House. ASM Handbook Vol.
8. Metallography and Microstructure, Ed. George F. Vander Voort, ASM International 2004.

Course Outcomes:
After learning the course the students should be able to :

Sr. No.	CO statement	Marks % weightage
CO-1	Understand the basic concept of Material Science and Metallurgy	20
CO-2	Know about the ferrous and non ferrous metals and alloys and their applications	40
CO-3	Understand different non-destructive testing methods	20
CO-4	Find the causes and prevention of metallic corrosion	10
CO-5	Judge the Scope and limitations of different materials	10

List of Practical:

1. To get acquainted with the operation, construction, use and capabilities of a metallographic microscope.
2. To study procedure of specimen preparation for microscopic examination and to carry out a specimen preparation.
3. To understand what is micro examination, importance of micro examination and to study various ferrous, non-ferrous microstructures.
4. To identify the different types of material available for design, manufacturing and processing of various components based on structure-property-performance-processing relationships.
5. To show the effect of different quenching media (Oil, Water and Brine) on the hardness of medium carbon steel.
6. To understand the concept of hardenability and its relevance to heat treatment procedure to be adopted in practice.
7. To find out the effect of varying section size on hardenability of steel and obtain hardness distribution curves of hardened steel cross-section.

8. Study of different heat treatment processes- annealing, normalizing, hardening and tempering, surface and casehardening to improve properties of steel during processes and applications.
9. To understand the procedure of testing, nature of indication, the capability and sensitivity of the liquid penetrant test and the magnetic particle test.
10. To understand the procedure of testing, nature of indication, the capability and sensitivity of the Eddy current test and the Ultrasound test.

Major Equipment:

Metallurgical microscope with computerized image analysis system, Standard specimen set of steel, cast iron and non- ferrous metals and alloys, Spectrometer, Muffle furnace, standard specimens of steels and cast iron for heat treatment, Hardness tester, Universal tensile testing machine.