ME301: METALLURGY
CREDITS = 5 (L=3, T=0, P=2)

Course Objective:

To understand the behavior of metals and alloys through macro and microstructure- property-performance relationships.

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				
L	T	P	C	Theory		Practical		Total Marks
				ESE	CE	ESE	CE	
3	0	2	5	70	30	30	20	150

Course Contents:

Unit No.	Topics	Teaching Hours
1	**Introduction:** Definition and role of metals and alloys, Classification of Metallurgy, Overview of Physical Metallurgy, Metallurgy in industry and its scope for mechanical engineers, Revision of significance of free energy, phase equilibrium, phase rule and phase diagrams, Forms of product- rolled and cast, Overview of Mechanisms to control structure and properties namely, Grain size strengthening, Solid solution strengthening, Strain hardening, Dispersion strengthening, Age hardening and Phase transformation, Applications of these methods in industrial practices.	02
2	**Solidification of Metals and Alloys:** Nucleation, homogeneous and heterogeneous nucleation, factors influencing nucleation, Growth, mechanisms of growth- planar and dendritic, conditions for planar and dendritic growth, factors controlling nucleation and growth. Freezing of a pure metal and an alloy ingot/casting, resultant macro structure with different cases, Methods to control grain size in castings, Solidification defects like gas and shrinkage porosities, macro and micro segregations, their causes of formation and remedies, Industrial practices to control solidification defects.	08
3	**Iron-Iron-Carbide Equilibrium Diagram:** Allotropy of Iron, Phases of the Iron-Iron Carbide equilibrium diagram and their properties, Reactions of the Iron-Iron Carbide equilibrium system, Alloy groups (Wrought Irons, Steels and cast Irons) of Iron-Iron Carbide equilibrium system and their characteristics in general, Transformation studies of eutectoid, hypoeutectoid and hypereutectoid steels, their resultant microstructures and hence correlated properties and applications. Effect of presence of small quantity of alloying elements on properties of plain carbon steels, Classification of Plain Carbon steels IS and ISO Codification, Different specifications and designations of steels. **Wrought Irons**- microstructures, properties and applications. **Cast Irons**: Iron-Iron Carbide and Iron-Carbon diagrams, Graphitization, factors influencing graphitization, Transformations resulting into White Cast Irons, Grey Cast Irons, Malleable Cast Irons, S. G. Irons, Alloy Cast Irons. Their microstructures and correlated properties and applications. IS Codification.	08

Unit No.	Topics	Teaching Hours
4	**Heat Treatment of Plain Carbon Steels:** Time-Temperature transformations- isothermal and continuous, Austenitization, factors governing austenitization. Annealing: Objectives of different types of annealing like, Full, Process, Stress relief, Spherodizing etc, with Thermal cycle, resultant structures and hence applications. Normalizing: Aim, Thermal cycle and Time-temperature transformations, resultant structure and hence applications. Hardening and Tempering: Aim, features of martensitic transformation, need for tempering, different types of tempering operations, resultant structures and hence applications, Hardenability, methods of hardening with thermal cycles, Causes of residual stresses during hardening and its effects, remedies. Surface Hardening Methods: Carburizing, Nitriding, Cyaniding, Induction, Flame-Thermal cycles, aim, process parameters, advantages, disadvantages and applications.	08
5	**Alloy Steels:** Purpose of alloying, Effect of alloying elements upon ferrite and carbide, Influence of alloying elements on the Iron-Iron Carbide diagram, Different types of alloy steels like Manganese, Silicon, Stainless, Duplex, etc.; their specifications and designations, properties and applications. Overview of tool steels. **Non-ferrous alloys:** Phase diagrams of widely used alloy systems like Cu-Zn, Cu-Ni, Al-Cu, Al-Mg, properties of their alloys and applications, Other alloys of lead, tin, zinc, nickel, manganese, titanium white metals and bearing alloys- structure-property relationships and applications.	08
6	**Non Destructive testing of materials:** Definition of non-destructive testing, Non-destructive testing methods like Dye Penetrant, Radiography, Magnetic Particle, Ultrasonic, Eddy Current with their Principle of non-destructive testing, Characteristic features, variables of the test, sensitivity, relative merits, demerits and applications.	08
7	**Metallography:** Structure of Metals, Macro-examination: Macro-etching; Microscopic examinations: Specimen Preparation, etching, grain size measurement; Chemical analysis of steel and Iron for Carbon, Sulphur & Phosphorous.	*
	TOTAL	**42**

List of References:

1. Donald R. Askeland, Donald R, Phule, Pradeep P," *The Science and Engineering of Materials"*, Cengage Learning.
2. Avner, Sidney H., "*Introduction to Physical Metallurgy*", 2nd Edition, Tata-McGraw Hill.
3. William D. Callister, Jr., David G. Rethwisch.," *Materials Science and Engineering-An Introduction*", 8th Edition John Wiley & Sons.
4. Yu Lakhtin," *Engineering Physical Metallurgy*", MIR Publishers.
5. Engineering Materials and their Applications, Richard A. Flinn and Paul K. Trojan, Jaico
   Publishing House.
6. Smith, W. F." *Principles of Materials Science and Engineering*", McGraw Hill.
7. Baldev Raj, T. Jayakumar and M. Thavasimuthu: "*Practical Non-Destructive Testing*", Narosa Pub. House,
8. George F. Vander Voort (editor): ASM Handbook Vol. 9: "*Metallography and*

Microstructure," ASM International 2004.
9. Robert E.Reed-Hill: "*Physical Metallurgy Principles*", Affiliated East West Press New Delhi.

Course Outcomes (COs):

*(**Note:** Number of COs should be about 6. Each statement should start with an action verb. Attached herewith (in Annex-1) are example action verbs that can be used to address different levels of Bloom's taxonomy. You should prefer 3rd or higher level action verbs from this list.)*

At the end of this course students will be able to …

1. Illustrate methods of strengthening of metals and their applications.
2. Analyze solidification of metals and alloys and methods of control for resultant macro structure.
3. Infer microstructure-property correlationships of wrought irons, plain carbon steels and cast irons.
4. Apply the knowledge of heat treatment of plain carbon steels to get the desired properties for given application.
5. Discover the structure-property relationships and hence applications for alloy steels and non-ferrous alloy systems.
6. Outline principle of non-destructive testing methods and choose appropriate non-destructive testing method for given application.