Course code	Course Name	L-T-P - Credits	Year of Introduction
ME209	**MECHANICAL PROPERTIES OF STRUCTURAL MATERIALS**	**3-1-0-4**	**2016**

Prerequisite : Nil

Course Objectives

- To know about different materials, their structure and property relationships
- To study about crystalline and amorphous materials, crystal defects, grain size, strengthening mechanisms, alloying, phase diagrams and heat treatment of metals
- To enable students to understand about the behavior of materials for engineering applications and select the materials for various engineering applications.
- To understand the causes behind fracture and various failure mechanisms

Syllabus:

Crystallography- imperfections- Mechanical properties- plastic deformation- fracture- fatigue- creep- crystallization- diffusion- phase diagrams- heat treatment – strengthening mechanisms- hot and cold working –ferrous and non ferrous alloys.

Expected outcome .

The students will

i. understand crystal structure and various imperfections in materials.
ii. acquire a knowledge about alloying and phase diagrams
iii. know the relationship between structure, properties, processing and performance of metals.
iv. study about various fracture and failure mechanisms in structural components.
v. be able to select materials for specific applications.

Text Books:

- Raghavan V, Material Science and Engineering, Prentice Hall,2004

References:

1. Avner H Sidney, Introduction to Physical Metallurgy, Tata McGraw Hill,2009
2. Callister William. D., Material Science and Engineering, John Wiley,2014
3. Dieter George E, Mechanical Metallurgy, Tata McGraw Hill,1976
4. Higgins R.A. - Engineering Metallurgy part - I – ELBS,1998
5. Myers Marc and Krishna Kumar Chawla, Mechanical behavior of materials, Cambridge University press,2008
6. Van Vlack -Elements of Material Science - Addison Wesley,1989
7. Askland and Phule- The Science and Engineering of Materials, Thompson publishers, 2007
8. Anderson J.C. *et.al*., Material Science for Engineers, Chapman and Hall,1990
9. Clark and Varney,Physical metallurgy for Engineers, Van Nostrand,1964
10. Reed Hill E. Robert, Physical metallurgy principles, 4th Edn. Cengage Learning,2009
11. http://nptel.ac.in/courses/113106032/1
12. http://www.myopencourses.com/subject/principles-of-physical-metallurgy-2
13. http://ocw.mit.edu/courses/materials-science-and-engineering/3-091sc-introduction-to-solid-state-chemistry-fall-2010/syllabus/
14. http://www.msm.cam.ac.uk/teaching/partIA.php

Course Plan			
Module	**Contents**	**Hours**	**Sem. Exam Marks**
I	**Introduction**: Material science. Materials ad types of materials: metals, polymers, ceramics, composites, and electronic materials. **Crystal structures and geometry**: Crystal lattices and the unit cell. Principal metallic crystal structures: the body-centered cubic, the face-centered cubic, and the hexagonal close-packed structures. Miller's indices of planes and directions in the cubic system. Atomic packing. Density calculation. Planar and linear atomic densities. Polymorphism. **Crystal imperfections**: Point defects, solid solutions, vacancies and interstitialcies, line defects (dislocations), Burger's vector, edge and screw dislocations. Grain boundaries and grain size.	9	15%
II	**Stresses, strains and Mechanical testing**: Normal and shear stresses. Elastic and plastic deformation. The tensile test and the engineering stress-strain diagrams. Young's modulus, the yield strength, the ultimate tensile strength, the percent elongation and percent reduction in area. True stress and true strain. Compression testing, Hardness and hardness testing. Plastic deformation in single crystals. The slip mechanism and dislocations. Slip systems and the critical resolved shear stress. Schmidt's law. Twinning. Effects of plastic deformation on the microstructure and mechanical properties of metals. Cold work and strain hardening. **Mechanism of crystallization:** Homogeneous and heterogeneous nuclei formation, under cooling, dendritic growth, grain boundary irregularity. Effects of grain size, grain size distribution, grain shape, grain orientation on dislocation/strength and creep resistance - Hall - Petch theory, simple problems.	9	15%
FIRST INTERNAL EXAMINATION			
III	Strengthening by solid solutions, cold-working. Recovery, recrystallization and grain growth. **Fracture of metals**. Ductile and brittle fracture. Toughness and impact testing. Fracture toughness. Ductile to brittle transition temperature **(DBTT)** in steels and structural changes during DBTT. **Fatigue of metals**. The S/N diagram. Mechanisms of fatigue. Stress raisers and stress concentration. Initiation and growth of fatigue cracks. Factors affecting fatigue behavior of metals. **Creep and stress rupture in metals**. Stages of creep. Effect of stress and temperature on creep behavior. Creep mechanisms, The Larsen-Miller parameter. Stress relaxation.	9	15%

	Diffusion : Atomic diffusion and diffusion mechanisms. Substitutional and interstitial diffusion. Steady state diffusion and Fick's first law. Transient diffusion and Fick's second law. Effect of temperature on diffusion rate. Industrial applications of diffusion.		
IV	**Phase diagrams of pure substances** (Unary systems). Gibb's phase rule of heterogeneous equilibrium. Binary Systems: Systems with unlimited solid solubility (isomorphous). The lever rule. Binary eutectic systems with no solid solubility and eutectic systems with limited solid solubility. Systems with compound and intermediate phases. Systems with peritectics. The invariant reactions, eutectics (and eutectoids) and peritectics (and peritectoids). Applications to typical binary phase diagrams. Copper-Zinc diagram and the Aluminum-Copper diagram. The Iron-iron carbide equilibrium diagram	11	15%
SECOND INTERNAL EXAMINATION			
V	**Heat treatment of eutectoid steel**: The eutectoid reaction in the iron-iron carbide system. The isothermal decomposition of austenite. The T.T.T. diagram. Formation pearlite and bainite. Decomposition of austenite on continuous cooling. Formation of martensite and the martensite lines. The structure of martensite. Annealing, quench hardening, and austempering. The hardness of martensite. Tempering of martensite. Heat treatment of noneutectoid plain carbon steel. T.T.T. diagrams of alloy steels. Hardenability of steel and the end-quench test. The process of precipitation (or Age) hardening and its application to the aluminum-copper alloys. Solution treatment, quenching and aging. Artificial (or forced) aging and over-aging. S**urface hardening methods**:- no change in surface composition methods :- Flame, induction, laser and electron beam hardening processes- change in surface composition methods :carburizing and Nitriding; applications.	11	20%
VI	**Alloy steels**:- Effects of alloying elements on steel: dislocation movement, polymorphic transformation temperature, alpha and beta stabilizers, formation and stability of carbides, grain growth, displacement of the eutectoid point, retardation of the transformation rates, improvement in corrosion resistance, mechanical properties Nickel steels, Chromium steels etc. - Enhancement of **steel properties** by **adding alloying elements: -** Molybdenum, Nickel, Chromium, Vanadium, Tungsten, Cobalt, Silicon, Copper and Lead. **High speed steels:-** Mo and W types, effect of different alloying elements in HSS	7	20%

	Cast irons: Classifications; grey, white, malleable and spheroidal graphite cast iron etc, composition, microstructure, properties and applications. **Principal Non ferrous Alloys: -** Aluminum, Copper, Magnesium, Nickel, study of composition, properties, applications, reference shall be made to the phase diagrams whenever necessary.		
END SEMESTER EXAM			

Question Paper Pattern

Maximum marks: 100 Time: 3 hours

The question paper should consist of three parts

Part A
4 questions uniformly covering modules I and II. Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part B
4 questions uniformly covering modules III and IV. Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part C
6 questions uniformly covering modules V and VI. Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: In all parts, each question can have a maximum of four sub questions, if needed.