

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE MODULE

Faculty Name/s: Prof. Devaraj M R			Academic Year: 2026 - 2027				
Department: Mechanical Engineering							
Course Code	Course Title	Core/Elective	Prerequisite	Contact Hours			Total Hrs/ Sessions
				L	T	P	
1BME302	Material Science & Metallurgy	IPCC	Engg. Materials & Crystal Structure	3	-	2	L: T : P : SL : TW 42 : 0 : 28 : 25 : 25

Syllabus

Module 1

Introduction, Crystalline Solids, Defects in Crystals: Classification of Materials: Metals, composites, ceramics, polymers. Advanced materials: Semiconductors, biomaterials, smart materials, nanomaterials, modern material's needs. Structure of Crystalline Solids: Fundamental concepts, arrangement of atoms and packing density in unit cells-BCC, FCC, HCP, density computations, numerical problems. Determination of crystal structures through X-ray diffraction techniques (principles only). Defects in Crystals: Classification of crystal imperfections, point defects, line defects, volume defects. Microscopic examination: Basic concepts in microscopy, microscopic techniques - Optical microscopy, Scanning electron microscopy, Transmission electron microscopy.

Number of Hours: 9

Module 2

Diffusion: Introduction, diffusion mechanisms, Fick's laws for steady state and non-steady state diffusion. Factors affecting diffusion. Numerical problems on determining the depth of diffusion, time of diffusion and diffusion cycles. Diffusion in semiconducting materials.

Number of Hours: 8

Module 3

Mechanical Properties of Metals: Stress, strain, Concepts of loading: tensile, compressive, shear and torsion. Elastic deformation: Stress-strain behaviour, elastic properties of materials, numerical problems. Plastic deformation, tensile properties, tensile strength, ductility, Resilience, Toughness, numerical problems. True stress and true strain. Hardness, Hardness tests. Dislocations and strengthening mechanisms. Fatigue properties and tests. factors affecting the fatigue behaviour. Creep properties and tests, factors affecting the creep behaviour.

Number of Hours: 8

Module 4

Phase Diagrams and Phase Transformations: Concept of solid solution formations and fundamentals of phase diagrams, unary and binary phase systems, rules governing formation of iso-morphous phase systems, Construction, development of microstructures and interpretation of Cu-Ni, Pb-Sn and Cu-Ag phase systems, discussion on mechanical properties. Iron-Iron carbide phase diagram: Eutectic, eutectoid and peritectic phase reactions in Fe-Fe₃C system, Development of microstructures, interpretation and numerical problems in Fe-Fe₃C system. Properties and Designations for steels and cast irons. Basic concepts of phase transformations, homogeneous nucleation, derivation of critical radius and change in free energy. Iso-thermal transformation diagram and Continuous cooling transformation diagrams: Construction, interpretation, microstructures formed, properties of Iron-carbon alloys. Heat treatment: Objectives, annealing, hardening concepts.

Number of Hours: 9

Module 5

Composites, Ceramics and Polymers: Classification, particle reinforced composites, fibre reinforced composites, structural composites. Expressions for elastic modulus of composites with axial and transverse loading. Ceramics basics, types and applications of glasses, clay products, refractories, abrasives, cements. Polymers: Factors influencing melting and glass transition temperatures, plastics, elastomers, Fibers.

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Number of Hours: 8

PRACTICAL COMPONENTS OF IPCC

PART – A: FIXED SET OF EXPERIMENTS

1. Specimen preparation for macro and micro structural examinations and study the macrostructure and microstructure of a sample metal/ alloy
2. Study the heat treatment processes (Hardening and tempering) of steel/Aluminium specimens.
3. To determine the hardness values of Mild Steel/ Aluminium by Rockwell hardness/Vickers Hardness.
4. To determine the hardness values of Copper/ Brass by Brinell's Hardness testing machine.
5. To study the creep behaviour of a given Cast Iron or Aluminium specimen.
6. To study the fatigue behaviour of EN8 bars.
7. To study of microstructure of welding Mild Steel components and Heat Affected Zone (HAZ) macro and micro examinations
8. To determine the tensile strength, modulus of elasticity, yield stress, % of elongation and % of reduction in area of Cast Iron, Mild Steel/Brass/ Aluminium and to observe the necking.
9. To conduct a wear test on Mild steel/ Cast Iron/Aluminium/ Copper to find the volumetric wear rate and coefficient of friction.
10. Study the chemical corrosion and its protection. Demonstration
11. Study the properties of various types of plastics. Demonstration
12. Computer Aided Selection of Materials: Application of GRANTA Edupack for material selection: Case studies based on material properties. Demonstration.

Suggested Learning Resources:

Textbooks:

1. William D. Callister, "Materials Science & Engineering - An Introduction", John Wiley & Sons Inc, 2010.
2. William F. Smith, "Principles of Materials Science and Engineering", 3rd International Edition, McGraw Hill Publishing Co.1996
3. V Raghavan, "Materials Science & Engineering", 4th Edition, Prentice Hall of India, 2002.

Reference Books / Manuals:

1. Donald R. Askeland, Pradeep P. Fulay and Wendelin J. Wright, "The Science and Engineering of Materials", Cengage Learning, 2010.
2. Michael F. Ashby and David R. H. Jones, "Engineering Materials 2 - An Introduction to Microstructures, Processing and Design", 3rd Edition, Butterworth-Heinemann.

Web links and Video Lectures (e-Resources):

1. <https://nptel.ac.in/courses/112106293>
2. <https://nptel.ac.in/courses/113102080>
3. <https://nptel.ac.in/courses/112102319>

Teaching-Learning Process (Innovative Delivery Methods):

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching learning process and facilitate the achievement of course outcomes.

- Flipped Classroom
- Simulation and Virtual Labs
- ICT-Enabled Teaching

Assessment Structure:

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying 50% weightage (i.e., 50 marks each).

The CIE Theory component will be 25 marks and CIE Practical component will be 25 marks.

The CIE Theory component consists of IA tests for 25 marks. **The CIE Practical component for continuous**

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assessments will be for 15 marks through rubrics and for lab tests will be for 10 marks.

- To qualify and become eligible to appear for SEE, in the CIE theory component, a student must score at least 40% of 25 marks, i.e., 10 marks.
- To qualify and become eligible to appear for SEE, in the CIE Practical component, a student must secure a minimum of 40% of 25 marks, i.e., 10 marks.
- To pass the SEE, a student must secure a minimum of 35% of 50 marks, i.e., 18 marks.
- A student is deemed to have successfully completed the course if the combined total of CIE and SEE is at least 40 out of 100 marks.

CIE Practical component:

The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. The summation of all the experiments marks to be scaled down to 15 marks.

The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 10 marks. For laboratory test, the student is required to conduct one experiment.

Continuous Internal Evaluation (CIE)

(i) Theory component

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

(ii) Laboratory component

Out of 25 marks, 15 marks shall be assigned for assessment as per the rubrics listed in the course syllabus.

The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for regular class work and practical test as indicated in the Table – ICs/IPCCs 1.

(i) To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 40 % of 25 marks, i.e., 10 marks, in the CIE theory component, and at least 40 % of 25 marks, i.e., 10 marks in the CIE Practical component.

Passing requirement in SEE

For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

Course Outcome (Course Skill Set):

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

1. Summarize the atomic arrangements in the crystal structures with computation of crystal parameters, packing factor and theoretical density.
2. Apply the mechanics of diffusion to enhance the desirable properties on the metal surfaces.
3. Examine the significance of various mechanical properties and testing of metals.
4. Assess the amounts of phases, constituents in the alloys and kinetics of phase transformations.
5. Describe the application of composites, ceramics and polymers.

The Correlation of Course Outcomes (CO's) and Program Outcomes (PO's)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO-1	3	2	-	-	-	-	-	-	-	-	2
CO-2	3	2	-	-	-	-	-	-	-	-	2
CO-3	3	2	-	-	-	-	-	-	-	-	2
CO-4	3	2	-	-	-	-	-	-	-	-	2
CO-5	3	-	-	-	-	-	-	-	-	-	2

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The Correlation of Course Outcomes (CO's) and Program Specific Outcomes (PSO's)

List of Course Outcomes	Program Specific Outcomes	
	PSO1	PSO2
CO-1	2	-
CO-2	2	-
CO-3	2	-
CO-4	2	-
CO-5	2	-

Note: 3 = Strong Contribution 2 = Average Contribution 1 = Weak Contribution - = No Contribution

