SEMESTER S3

MATERIAL SCIENCE AND METALLURGY

Course Code	**PBAUT304**	**CIE Marks**	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	**ESE Marks**	40
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. **Understand Atomic and Crystalline Structures**: Students will learn the characteristics of different atomic bonds and crystal structures and how these influence material properties and applications.
2. **Analyse Material Microstructures and Defects**: Students will explore various modes of deformation, crystallization effects and the role of crystal imperfections in determining the mechanical properties of materials.
3. **Apply Principles of Phase Transformations and Alloy Design**: Students will gain knowledge of phase diagrams, heat treatment processes, alloying principles and the behaviour of advanced materials under different conditions.

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SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals of Materials:** Atomic structure and bonding characteristics of covalent, ionic and metallic bonds. Properties based on atomic bonding (Briefly), secondary bonds, classification and applications. **Crystallography:** Crystal structures: SC, BCC, FCC, HCP (brief description). Atomic packing factor (APF), Miller Indices: crystal plane and direction. **Analysis of Microstructure:** X-ray diffraction (XRD) with simple	**9**

	problems, Scanning electron microscopy (SEM) and Transmission electron microscopy (TEM). *Suggestion - Problem Project - Students can choose their focus areas, such as investigating different crystal structures, analyzing atomic packing factors, or exploring the applications of X-ray diffraction, SEM, and TEM in material science.*	
2	**Deformation and Crystallization:** Deformation and crystallization, modes of plastic deformation, slip and twinning, Schmid's law, crystallization, effects of grain size, Hall-Petch theory (simple problems), crystal imperfections, classification of crystal imperfections (point, line, surface). **Dislocations:** Burgers vector, Frank-read source, correlation of dislocation density with strength and the concept of nanomaterials, grain boundaries, high and low angle boundaries, driving force for grain growth, applications, characterization techniques, polishing and etching. *Suggestion - Discipline Project- Allowing students to explore specific aspects of microstructure and defects, such as slip, twinning, grain size effects, or dislocation density, within a defined overall theme.*	**9**
3	**Phase Transformations:** Constitution of alloys, solid solutions, substitutional and interstitial phase diagrams, isomorphous, eutectic, eutectoid, peritectic and peritectoid reactions, Iron-carbon equilibrium diagram. Classification of steel and cast iron microstructure, properties and application. **Heat Treatment:** Time-temperature-transformation (TTT) and Continuous cooling transformation (CCT) diagrams with applications**,** tempering, hardenability and Jominy end quench test**,** surface hardening methods.	**9**

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	Suggestion - Problem Project - independently explore phase transformations, heat treatment processes, and the practical applications of TTT and CCT diagrams.	
4	**Alloys**: Need for alloying, classification of alloys, Hume-rothery rules. Equilibrium diagrams of common binary systems (five types), coring, lever rule, and Gibbs' phase rule. Strengthening mechanisms**,** cold working and hot working**.** **Fatigue**: Mechanism, factors affecting fatigue life, fatigue test, S-N curve, endurance limit, methods to improve fatigue life and thermal fatigue. **Advanced Materials:** Composite materials, bio-materials, super alloys, smart materials and nano materials. *Suggestion - Problem Project - independently explore alloy classifications, strengthening mechanisms, and advanced materials such as composites, biomaterials, and nanomaterials.*	**9**

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Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Examination-1	Internal Examination- 2	Total
5	**30**	**12.5**	**12.5**	**60**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 2 marks **(8x2 =16 marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 sub divisions. • Each question carries 6 marks. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the characteristics of covalent, ionic, and metallic bonds, and their influence on material properties.	**K2**
CO2	Apply Schmid's Law to analyse the deformation behaviour of crystalline materials under different stress conditions.	**K3**
CO3	Understand the Fe-C phase diagram and the principles of phase transformations in alloys.	**K2**
CO4	Apply the lever rule and Gibbs' phase rule to interpret equilibrium diagrams of common binary systems and predict phase compositions.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3											
CO2		3	3									
CO3	3											
CO4		3	3									

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

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Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Material Science and Metallurgy	Name of the Author: O.P. Khanna	Dhanpat Rai Publications	17th Edition, 2015
2	Materials Science and Engineering: A First Course	V. Raghavan	Prentice Hall India Learning Private Limited	5th Edition, 2004
3	Introduction to Physical Metallurgy	Sidney H. Avner	Tata McGraw-Hill Education	2nd Edition, 1997
4	Mechanical Metallurgy	George E. Dieter	Tata McGraw-Hill Education	3rd Edition, 2013
5	Heat Treatment: Principles and Techniques	T. V. Rajan, C. P. Sharma, and Ashok Sharma	Prentice Hall India Learning Private Limited	2nd Edition, 2012
6	Phase Transformations in Metals and Alloys	David A. Porter, Kenneth E. Easterling, M. Y. Sherif	CRC Press	3rd Edition, 2009

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles of Materials Science and Engineering	William F. Smith, Javad Hashemi	McGraw-Hill Education	5th Edition, 2021
2	Physical Metallurgy: Principles and Practice	Raghavan	PHI Learning Private Limited	2nd Edition, 2006
3	Engineering Physical Metallurgy and Heat Treatment	Y. Lakhtin and V. Livshits	Mir Publishers	3rd Edition, 1989
4	Fundamentals of Creep in Metals and Alloys	Michael E. Kassner	Elsevier Science	3rd Edition, 2015

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Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	Material Science and Engineering, IIT Roorkee,Dr. Vivek Pancholi https://nptel.ac.in/courses/113107078
2	Introduction to Materials Science and Engineering, IIT Delhi,Prof. Rajesh Prasad https://archive.nptel.ac.in/courses/113/102/113102080/
3	Heat Treatment and Surface Hardening – II,IIT Kanpur, prof. Kallol Mondal, prof.sandeep sangal https://archive.nptel.ac.in/courses/112/104/112104219/
4	

PBL Course Elements

L: Lecture (3 Hrs.)	R: Project (1 Hr.), 2 Faculty Members		
	Tutorial	**Practical**	**Presentation**
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

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Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		**30**

1. **Project Planning and Proposal (5 Marks)**

    - Clarity and feasibility of the project plan
    - Research and background understanding
    - Defined objectives and methodology

2. **Contribution in Progress Presentation and Question Answer Sessions (4 Marks)**

    - Individual contribution to the presentation
    - Effectiveness in answering questions and handling feedback

3. **Involvement in the Project Work and Team Work (3 Marks)**

    - Active participation and individual contribution
    - Teamwork and collaboration

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4. **Execution and Implementation (10 Marks)**

    - Adherence to the project timeline and milestones
    - Application of theoretical knowledge and problem-solving
    - Final Result

5. **Final Presentation (5 Marks)**

    - Quality and clarity of the overall presentation
    - Individual contribution to the presentation
    - Effectiveness in answering questions

6. **Project Quality, Innovation, and Creativity (3 Marks)**

    - Overall quality and technical excellence of the project
    - Innovation and originality in the project
    - Creativity in solutions and approaches