GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Subject Code : BE03000221

Subject Name : Material Science and Metallurgy

w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	PCC

Prerequisite:	**Knowledge of basic science**
Rationale:	The course will provide an over view of the study of basic knowledge of various materials and their properties, commonly used for engineering applications applications. It also includes the various heat treatment processes and their practical applications. This course covers the importance of non-destructive testing methods to evaluate the properties and integrity of materials without causing any damage or altering their usefulness. It also involves the study of corrosion, including its principle, types and prevention techniques.

Course Outcomes:

Sr. No.	CO statement	Marks % Weightage
CO-1	Understand the different types of engineering materials and their structure –property relationships.	20
CO-2	Examine the microstructure of metallic materials through phase diagrams and alter their microstructure and properties by applying various heat treatments.	50
CO-3	Understand the scope of different non-destructive testing methods and powder metallurgy.	20
CO-4	Interpret the causes of metallic corrosion and identify the methods for its prevention.	10

Teaching and Examination Scheme:

Teaching - Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL*	TH		ESE (E)	PA (M)	PA/ (I)	PBL (I)	ESE (V)	
45	0	30	45	120	04	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End-Semester Examination, PA = Progressive Assessment

* Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.

Content:

Sr. No.	Content	Total Hrs	% 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**	**9**
2	**Crystal Geometry and Crystal Imperfection:** Unit cell, Crystal structure, Bravise lattice, atomic packing factor, coordination number, Metallic crystal structures- SC, BCC, FCC and HCP, crystal directions and planes, Miller indices, Imperfections in crystals and their effect on properties, Solute strengthening.	**6**	**14**
3	**Solidification and Theory of Alloys:** Solidification of metals and an alloy, Crystallization: Mechanism of crystallization - nucleation and growth, factors influencing nucleation and growth, Solid solutions and compounds, Hume-Rothery rules; Cooling curves, lever-arm principle.	**4**	**9**
4	**Phase Diagrams:** Systems, phases and phase rule, structural constituents, Gibb's phase rule. Binary equilibrium phase diagrams, Allotropy of iron; Iron-iron carbide equilibrium diagram with different reactions like eutectic, eutectoid and peritectic. Constituents, microstructures and properties of plain carbon steels. Alloy groups (Pig Iron, 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.	**8**	**17**
5	**Non-ferrous Metal and Alloys:** Introduction, properties and application of aluminium, copper, magnesium, titanium, nickel and their alloys.	**4**	**9**
6	**TTT diagram and Heat Treatment of Steel:** Time-Temperature-Transformation Diagram, Isothermal and continuous transformations. Study of heat treatment processes such as annealing, normalizing, hardening, tempering, carburizing, nitriding, cyaniding, induction hardening and flame hardening. Hardenability of	**7**	**15**

	steel. Application of above processes to machine components and mechanical equipments such as gears, shaft bearings, turbine blades, crank shafts, pistons etc.		
7	**Powder Metallurgy:** Introduction, advantages, disadvantages and applications of powder metallurgy, production of powder, compacting, sintering.	**3**	**7**
8	**Non Destructive Testing:** Non Destructive testing of materials such as Visual inspection, Dye Penetration Testing, Magnetic Particle Testing, Ultrasonic Testing, Radiography Testing, Eddy current testing with their principles, relative merits, demerits and applications.	**4**	**9**
9	**Corrosion of Metal And Alloys:** Principle of corrosion, types of corrosion, corrosion prevention techniques.	**3**	**7**
10	**Metallography:** Structure of Metals, Macro-examination: Macro-etching; Microscopic examinations: Specimen Preparation, etching, Spark Test, Sculptures Print, Magnetic Testing, Chemical analysis of steel and iron for Carbon, Sulphur & Phosphorous.	*	**4**
	Total	**42**	**100**

* Topic should be cover during laboratory session only.

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
Recall	**Comprehension**	**Application**	**Analysis**	**Evaluate**	**Create**
30	**30**	**25**	**10**	**05**	**00**

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

References:

1. Materials Science and Engineering: An Introduction: William D Callister and David G. Rethwisch, 10th edition, 2020.
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. Material Science and Metallurgy by G. H. Upadhyay, Atul Prakashan.
5. Introduction to Physical Metallurgy, Sydney H. Avner, Tata McGraw-Hill.
6. Practical Non-Destructive Testing, Baldev Raj, T. Jayakumar and M. Thavasimuthu, Narosa Pub. House.
7. Corrosion Engineering, Mars G. Fontana, McGraw Hill Education India.
8. ASM Handbook Vol. 9: Metallography and Microstructure, Ed. George F. Vander Voort, ASM International 2004.

List of Experiments:

1. To understand the concept of crystal planes and directions: a) To determine the coordination number (CN), Atomic Packing Factor (APF) and Effective number of atoms per unit cell for SC, BCC, FCC, and HCP structures.

   b) To draw the crystal planes and directions in a unit cell.
2. To get acquainted with the operation, construction, use and capabilities of a metallurgical microscope.
3. To perform specimen preparation for microscopic examination and gain a deeper understanding of the specimen preparation process.
4. To examine different ferrous microstructures and identify the micro-constituents and phase present in a specimen.
5. To examine different non-ferrous microstructures and identify the micro-constituents and phase present in a specimen.
6. To learn different heat treatment processes- annealing, normalizing, hardening and tempering to improve properties of steel during processes and applications.
7. To observe the effect of different quenching media (Oil, Water and Brine) on the hardness of medium/high carbon steel specimen.
8. To determine the effect of varying section size on hardenability of steel and obtain hardness distribution curves of hardened steel cross-section.
9. To understand the procedure of testing, nature of indication, the capability and sensitivity of the liquid penetrant test.
10. To understand the procedure of testing, nature of indication, the capability and sensitivity of the magnetic particle test.

11. To understand the procedure of testing, nature of indication, the capability and sensitivity of Ultrasound test.
12. To identify the different types of material through spark test.

Major Equipment:

Metallurgical microscope with computerized image analysis system, Standard specimen set of steel, cast iron and non- ferrous metals and alloys, Muffle furnace, Hardness tester, Jominy-end quench set-up.

List of Open Source Software/learning website:

https://archive.nptel.ac.in/courses/113/106/113106032/
https://archive.nptel.ac.in/courses/113/102/113102080/
https://archive.nptel.ac.in/courses/113/107/113107078/

- **List of suggested activities for Problem Based Learning:**

Sl. No.	Name of the activity	No. of hours	Evaluation Criteria
1.	Industry/Research laboratory visit	Visit = 5hrs., Report preparation = 5hrs. Total = 10hrs.	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
2.	Technical Video based learning related to the subject	Duration of video = 5hrs. Report preparation = 5hrs. Total = 10hrs.	Report /presentation based on the video learning outcomes.
3.	Assignment writing. Numericals based assignment is preferable.	5 assignments of 4hrs. each. Total = 20hrs.	Based on the correctness of submitted assignment.
4.	Problem solving/Coding using C, C++, MATLAB, Python, SCILAB,modeling and Analysis software or any other software	5 small coding-based assignment of 2hrs. each. Total = 10hrs.	Based on the coding solution submitted.
5.	Self-learning online course	Minimum duration of the course should be 10hrs.	Examination based assessment at the end of course. Based on

			the certificate produced.
6.	Identification and solution of Complex problem	Maximum 2 problems. Study of the problem and solution finding, Total = 10hrs.	Based on the depth of the solution submitted.
7	Videos on Industrial safety/Disaster Management aspects based on subject	Duration of video = 5hrs. Report preparation = 5hrs. Total = 10hrs.	Based on quiz/report submitted
8	Technical paper reading and summarization of research papers based on relevant subject	5 research papers = 20 hrs.	Summarize research paper and evaluation critical parameters
9.	Poster/chart/power point preparation on technical topics	Duration = 6 hrs.	Based on poster/chart preparation and presentation skills
10	Working/non-working model on technical topics	Working = 12 hrs. Non- working = 8 hrs.	Based on inter department/external evaluation
11	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/sustainability/any other issue	Duration = 15 hrs. for industrial exposure Problem identification and tentative solution = 10 hrs. Total = 20 hrs.	Based on evaluation of critical problems and solutions
12	Group Discussion on emerging/trending technical topics based on subject	Duration = Min. 1 hr.per subject. Max. 3 hrs. per subject	Based on performance in group discussion, technical depth, knowledge etc.
13.	Real world case studies-based learning	Duration of data collection/study = 5hrs. Report preparation = 5hrs. Total = 10hrs.	Based on in-depth study, technical depth, data collected, fact finding, etc.
14.	Application/Software development	Duration = 10 hrs.	Depending on the complexity of the Application/Software
15.	Research paper publication	Duration = 10 hrs.	Based on submission of proof of publication
16.	Upgradation/Reverse engineering studies of existing	Duration 10 hrs.	Based on the performance of the

	equipment of the laboratory		equipment
17.	Expert lecture/session	Duration 3 hrs. For attending the lecture/session– 2 hrs. and for report writing 1 hr.	Based on the proof of attendance and report submitted
18.	Annotated Video Explanation of Concept/Problem	10h (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
19.	Patent Search and Innovation Gap Identification	10h (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.

Note:

- All the suggested activity should be related to the subject.
- The number of hours are suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
- Rubrics for the evaluation can be prepared by the faculty.
- Subject teacher can add the relevant activities other than those listed above, with the consent of head of the department and DQAC.
- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.

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