



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Metallurgy

Subject Code: BE03021031

Subject Name: Metallurgical Thermodynamics

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

Prerequisite:	Nil
Rationale:	The course in Materials Engineering forms the foundation of various engineering disciplines, as materials are essential to modern life. From everyday items like pins to advanced technologies such as rocket science, materials are fundamental to the design and creation of engineered products. This course offers a strong base for understanding the properties, selection, and processing of materials, providing students with the necessary knowledge for further graduate studies in Metallurgical Engineering. It equips students with the skills to contribute to advancements in material science, critical for innovation across multiple industries. Understanding metallurgy is essential for developing sustainable methods to meet the growing demand for metals, enhancing material properties, and reducing environmental impact.

Course Outcomes:

Sr. No.	CO statement	Marks % Weightage
CO-1	Develop a comprehensive understanding of metallurgy.	35
CO-2	Understand the structure-property relationships in metals and alloys.	35
CO-3	Categorize general and special-purpose engineering materials in relation to their respective applications and manufacturing processes.	30

Teaching and Examination Scheme:

Teaching - Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
L	T	P	PBL*	TH		Theory		Tutorial / Practical			
						ESE (E)	PA (M)	PA/ (I)	PBL (I)	ESE (V)	
45	0	60	15	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

Content:

Sr. No.	Content	Total Hours	% Weightage
1	Historical aspects of metallurgy: Historical aspects and Scope of materials and metallurgy, Various fields of metallurgical engineering, Status of metallurgical industry in India.	05	12



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2	Classification of Engineering Materials: Classification, Properties and applications of Engineering Materials, Engineering requirements of materials, Structure-property relationships in materials, Criteria for selection of materials for engineering applications.	07	15
3	Crystal Geometry and Crystal Imperfection: Nature of Metallic Bonding, Crystal structure of Metals: Unit Cell, Types of Crystal Structure, Bravis lattice, atomic packing, coordination number, crystal structures of metallic elements, crystal directions and planes, Miller indices, Slip System, Imperfections in Crystals.	08	20
4	Macro and Microscopic Examination: Structure of Metals, microscopic examination, quantitative metallography, Metallurgical Microscopes: resolution, magnification, numerical aperture, spherical aberrations, and Bragg's law.	08	13
5	Metals and Alloys: Introduction, properties and applications, Classification of ferrous alloys - cast irons and wrought iron, Classification of non-ferrous alloys - aluminium, copper, magnesium, zinc.	09	20
6	Introduction to Manufacturing Processes: Foundry, Welding, Metal Forming, Powder Metallurgy.	08	20
	Total	45	100

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	30	35	15	00	00

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

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.

Reference Books:

1. Materials Science and Engineering: An Introduction: William D Callister; Wiley, 2014.
2. Materials and Design: The Art and Science of Material Selection in Product Design, Mike Ashby and Kara Johnson, 3rd Edition, Butterworth-Heinemann, 2014.
3. Materials Science and Engineering: A First Course by Raghavan V, Sixth Edition, PHI Learning.



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4. Material Science and Metallurgy by G. H. Upadhyay, Atul Prakashan.
5. Engineering Materials: Polymers, Ceramics and Composites by A. K. Bhargava, PHI Learning.
6. Engineering Materials: Properties and Applications of Metals and Alloys by C. P. Sharma, PHI Learning.
7. Elements of Materials Science, L. H. Van Vlack, Addison-Wesley.
8. Elements of Metallurgy, D. Swarup, Banaras Hindu University Press, Varanasi.

List of Experiments:

1. To review the development of metallurgical techniques over time with the industrial civilization.
2. To classify the engineering materials and correlate the relationship between material properties and engineering applications.
3. Mini Project on selection of engineering material for a given application.
 - Collection of materials for given application.
 - Aspects of selection/Alternate materials/Price/Properties/Manufacturing Processes
4. To calculate number of atoms in a Unit Cell, coordination number, relationship between atomic radii and lattice parameter, and atomic packing factor.
5. To find the Miller Indices cubic and hexagonal structures.
6. To calculate the resolution, magnification, and numerical aperture of metallurgical microscopes.
7. To compare the properties and applications of ferrous and non-ferrous alloys.
8. Virtual lab/industry/research laboratories visit for demonstration of sophisticated and state-of-art instruments related to metallurgy.
9. To classify the bulk manufacturing processes.
10. To explore the introductory overview of metal casting.
11. To explore the introductory overview of welding.
12. To explore the introductory overview of metal forming, and powder metallurgy.

Major Equipment: This is an introductory subject to discipline so equipment's available in different subject laboratories of discipline will be used for demonstration.

List of Open Source Software/learning website:

1. https://onlinecourses.nptel.ac.in/noc22_mm05/preview
2. <https://staging.capabilitydevelopment.org/Coursedesc/ioc/BASIC-METALLURGY>.

• 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.



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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	Duration = Min. 1 hr.per subject. Max. 3 hrs. per	Based on performance in group discussion, technical depth,



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	technical topics based on subject	subject	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 equipment of the laboratory	Duration 10 hrs.	Based on the performance of the 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.
