GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Metallurgy
Subject Code: BE04021051
Subject Name: Plastic Deformation of Metals

w.e.f. Academic Year:	2024-25
Semester:	4
Category of the Course:	Basic Science Course

Prerequisite:	Nil
Rationale:	Plastic Deformation of Metals program is to prepare students for careers in Engineering where Principles of Mechanical Metallurgy of metals can be applied to the Industries dealing with Metal forming operations. This education at the undergraduate level will enable students to seek employment in Metal Industries upon graduation while, at the same time, provide a firm foundation for the pursuit of graduate studies in Metallurgy Engineering.

Course Outcomes:

After successful completion of the course students should be able to:

Sr. No.	CO statement	Marks % Weightage
CO-1	Know about Elastic and plastic deformation of metallic materials	35
CO-2	Understand effect of deformation behaviour of ductile & brittle material.	35
CO-3	Recognize various strengthening methods and related structural changes in metals & alloys.	30

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL*	Total no of hours per semester		ESE (E)	PA / CA (M)	PA/CA (I)	PBL (I)	ESE (V)	
45	0	30	15	90	3	70	30	20	30	50	200

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

Content:

Sr. No.	Content	Total Hours	% Weightage
1	**Elastic and Plastic Deformation:** Elastic and plastic deformation of metallic materials. Stress-strain, ductile and brittle behaviour, Yielding criterion, Von-Mises and Maximum-shear-stress/Tresca yielding criterion, Failure criteria under combined stresses,	06	13
2	**Plastic deformation of single crystals:** Lattice defects, Crystal Imperfection: Point defect, line defect & surface defects. Slip phenomena, slip systems, Slip by dislocation movement, concept of critical resolved shear stress, Twinning as mode of deformation, Stacking faults, Strain hardening of single crystal.	08	18
3	**Plastic deformation of poly crystalline material:** Grain boundaries & deformation, strengthening from grain boundaries, strain hardening of poly crystalline materials. Strengthening Mechanism of metals.	10	22
4	**Theory of dislocations:** Burger vector and dislocation loop. Dislocation in FCC (Including formation of Stacking faults) BCC & HCP, stress field of dislocations, forces on dislocation, forces between dislocation motions of dislocations, dislocation climb. Jogs in dislocations. Sources, Multiplication of dislocationsFrank-Reed source. Techniques of observation of dislocation.	08	18
5	**Recovery of deformation:** Annealing of cold worked metals, Recovery, Recrystallization and grain growth.	05	11
6	**Fracture behaviour of metals:** Types of fracture in metals, theoretical cohesive strength of metals, Griffith theory of brittle fracture. Theory of ductile brittle transition temperature. Concept of Fracture Mechanics	08	18
	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. Mechanical Metallurgy by -G. E. Dieter, Publisher: Mc Graw Hill Co,
2. Mechanical Behaviour and testing of Materials by A.K.Bhargava & C.P.Sharma, Publisher: PHI
3. Dislocations and Mechanical Behaviour of Metals by M.N.Shetty, Publisher: PHI
4. Deformation and Fracture Mechanics of Engineering Materials by R. W. Hertzberb, Publisher: John Wiley & Sons.
5. Physical Metallurgy Principles-Robert E. Reed Hill, Publisher: Cengage Learning

List of Experiments:

1. To calculate yield strength, ultimate tensile strength, % Elongation using a universal testing machine (UTM) from the given material test data.
2. To Compare hardness values before and after deformation or heat treatment.
3. Use optical microscopy to observe grain structure changes due to cold work and annealing.
4. To Reveal slip lines in cold-worked austenitic stainless-steel samples via etching and optical microscopy.
5. To Study recovery, recrystallization, and grain growth post cold work.
6. To review energy absorbed in fracture and determine ductile-to-brittle transition from the given impact test data of a sample.
7. To Conduct compression or rolling operations on a specimen to demonstrate increase in strength.
8. Study fracture surfaces to differentiate between ductile and brittle fractures (Case-Study)
9. To calculate Numerical based on Plastic deformation theories.
10. To calculate Numericals based on Fracture Toughness phenomena.
11. Chart Preparation of various dislocation interactions.
12. To write Industrial visit report / Lab visit report / Expert talk report

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.

- **Activities suggested under Problem Based Learning:**

Sl. No.	Name of the activity	No. of hours	Evaluation Criteria
1.	Industry/Research laboratory visit	Visit = 5h, Report preparation = 5h Total = 10h	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 = 5h Report preparation = 5h Total = 10h	Report /presentation based on the video learning outcomes.
3.	Assignment writing. Numericals based assignment is preferable.	5 assignments of 2h each. Total = 10h	Based on the assignment submitted.
4.	Expert Lecture/session	Lecture 2 hr Report 1 hr	Report should contain observation and learning.
5.	Self learning on-line course	Minimum duration of the course should be 10h.	Examination based assessment at the end of course. Based on the certificate produced.
6.	Complex problem solving	Maximum 2 problem. Study of the problem and solution finding, Total = 10h	Based on the depth of the solution submitted.
7	Videos on Industrial safety aspects based on subject	Duration of video = 5h Report preparation = 5h Total = 10h	Based on quiz/report submitted
8	Discussion on research paper based on relevant subject	5 research paper = 20 h	Summarize research paper and evaluation critical parameters
9.	Poster/chart/power point preparation on technical topics	Duration = 6 h	Based on poster/chart preparation and presentation skills
10	Working/non-working model on technical topics	Working = 12 h Non- working = 8 h	Based on inter department/external evaluation
11	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/any other issue	Duration = 15 h for industrial exposure Problem identification and tentative solution = 10 h Total = 20 h	Based on evaluation of critical problems and solutions
12	Group Discussion on emerging/trending technical topics based on subject	Duration = 1 h each	Based on performance in group discussion, technical depth, knowledge etc.

13.	Real world case studies-based learning	Duration of data collection/study = 5h Report preparation = 5h Total = 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.

Note:
1. All the suggested activity should be related to the subject.
2. 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.
3. Rubrics for the evaluation can be prepared by the faculty.

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