GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Mining Engineering

Course / Subject Code: BE03022021

Course / Subject Name: Mechanics of Solids

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

Prerequisite:	NA
Rationale:	The branch of Applied science that deals with state of rest or the state of motion is termed as Mechanics. Starting from the analysis of rigid bodies under gravitational force and simple applied forces the mechanics has grown to the analysis of robotics, aircrafts, space crafts under dynamic force, atmospheric forces, temperatures forces etc. The principal of mechanics developed around state of rest and state of motion of the bodies by Sir Issac Newton which is termed as three laws of motion and the laws of gravitation. The mechanics based on these laws is called classical mechanics or Newtonian mechanics. Engineers are keen to use laws of mechanics to actual field problems. Application of laws of mechanics to field problems is termed as engineering mechanics. Here the students will learn the laws and principals of mechanics along with their applications to engineering problems. As a matter of fact knowledge of mechanics of solids is very essential for an engineer in planning, designing and construction of various types of structures and machines, so that the design is safe and economical.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Apply fundamental principles of mechanics, equilibrium and statics to practical problems of engineering.	R/U
02	Determine centroid and moment of inertia of a different geometrical shape and its use in engineering problem.	R/U/A
03	Determine different types of stresses and strains developed in the member subjected to axial, bending, shear, torsion & thermal loads.	R/U
04	Differentiate behaviour and properties of different engineering materials.	U/A
05	Apply the basics of simple machines and their working mechanism	R/U

**Revised Bloom's Taxonomy (RBT)*

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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

Course Content:

Sr. No.	Name of Topic	Teaching Hours	% Weightage
	MODULE 1		
1	**Introduction** Definition of space, time, particle, rigid body, deformable body. Force, types of forces, Characteristics of a force, System of forces, Composition and resolution of forces. Fundamental Principles of mechanics: Principle of transmissibility, Principle of superposition, Law of gravitation, Law of parallelogram of forces, Newton's Laws of Motion.	02	25
2	**Fundamentals of Statics** **Coplanar concurrent and non-concurrent force system:** Resultant, Equilibrant, Free body diagrams. **Coplanar concurrent forces:** Resultant of coplanar concurrent force system by analytical and graphical method, Law of triangle of forces, Law of polygon of forces, Equilibrium conditions for coplanar concurrent forces, Lami's theorem. Application of these principles. **Coplanar non-concurrent forces:** Moments & couples, Characteristics of moment and couple, Equivalent couples, Force couple system, Varignon's theorem, Resultant of non-concurrent forces by analytical method and graphical method, Equilibrium conditions of coplanar non-concurrent force system, Application of these principles. Concept of statically determinate and indeterminate problems.	10	
	MODULE 2		
3	**Applications of fundamentals of statics Statically determinate beams:** Types of loads, Types of supports, Types of beams; Determination of support reactions, Relationship between loading, shear force & bending moment, Bending moment and shear force	06	15

	diagrams for beams subjected to only three types of loads :i) concentrated loads ii) uniformly distributed loads iii) couples and their combinations; Point of contraflexure, point & magnitude of maximum bending moment, maximum shear force		
4	**Stresses in Beams:** **Flexural stresses –** Theory of simple bending, Assumptions, derivation of equation of bending, neutral axis, determination of bending stresses, section modulus of rectangular & circular (solid & hollow), I Sections **Shear stresses –** Derivation of formula, shear stress distribution across various beam sections like rectangular, circular, I sections.	06	15
	MODULE 3		
5	**Centroid and moment of inertia and mass moment of inertia** Centroid: Centroid of lines, plane, areas and volumes, Examples related to centroid of composite geometry, Moment of inertia of planar cross-sections: Derivation of equation of moment of inertia of standard lamina using first principle, Parallel & perpendicular axes theorems, polar moment of inertia, radius of gyration of areas, section modulus. Examples related to moment of inertia of composite geometry	08	20
6	**Introduction to Torsion:** Assumptions, theory of torsion equation to solid & hollow circular shaft, torsional rigidity	02	05
	MODULE 4		
7	**Simple stresses & strains** Basicsofstressandstrain:3D state of stress(Concept only) Normal/axial stresses: Tensile & compressive Tangential Stresses: Shear and complementary shear Strains: Linear, shear, lateral, thermal and volumetric. Hooke's law, Elastic Constants: Modulus of elasticity, Poisson'sratio, Modulus of rigidity and bulk modulus and relations between them with derivation. Application of normal stress & strains: Homogeneous and composite bars having uniform & stepped sections subjected to axial loads and thermal loads	08	20
	MODULE 5		
8	**Physical & Mechanical properties of materials: (laboratory hours)** Physical & Mechanical properties of materials: (laboratory hours) Elastic, homogeneous, isotropic materials; Stress –Strain	This portion to be covered in	Theory Weightage shall be 0%

	relationships for ductile and brittle materials, limits of elasticity and proportionality, yield limit, ultimate strength, strain hardening, proof stress, factor of safety, working stress, load factor, Properties related to axial, bending, and torsional & shear loading, Toughness, hardness, Ductility, Brittleness	Laboratory	
9	**Simple Machines: (laboratory hours)** Basics of Machines, Definitions: Velocity ratio, mechanical advantage, efficiency, reversibility of machines. Law of Machines, Application of law of machine to simple machines such as levers, pulley and pulley blocks, wheel and differential axle, Single purchase, double purchase crab, screw jacks. Relevant problems		

Suggested Specification Table with Marks (Theory):

R Level	U Level	A Level	N Level	E Level	C Level
35	40	25	-	-	-

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Engineering Mechanics statics by R. C. Hibbeler, McMillan Publication.
2. Engineering Mechanics by R S Khurmi
3. Engineering Mechanics by S S Bhavikatti
4. Mechanics for Engineers - Statics Fourth Edition, by F. P. Beer and E. R. Johnson
5. Engineering Mechanics, 2nd ed. — MK Harbola
6. Introduction to Mechanics — M K Verma
7. An Introduction to Mechanics — D Kleppner & R Kolenkow
8. Principles of Mechanics — JL Synge & BA Griffiths
9. Mechanics — JP Den Hartog
10. Engineering Mechanics - Dynamics, 7th ed. - JL Meriam
11. Engineering Mechanics by Shames I. H., P H I India.
12. Mechanics of Structure Vol. I S. B. Junnarkar & H. J. Shah
13. Mechanics of Materials E. P. Popov
14. Strength of Materials G. H. Ryder

15. Mechanics of Materials Timoshenko and Gere
16. Mechanics of Materials Beer and Johnston.

(b) Open source software and website:

1. http://nptel.ac.in/

Suggested Course Practical/Assignment List:

The students will have to solve at least five examples and related theory from each topic as an assignment/tutorial. Students will have to perform following experiments in laboratory and prepare the laboratory manual.

Mechanics of rigid body

1. Equilibrium of coplanar concurrent forces
2. Equilibrium of coplanar non-concurrent forces
3. Equilibrium of coplanar parallel forces: Determination of reactions of simply supported beam
4. Verification of principle of moment: Bell crank lever
5. Determination of member force in a triangular truss
6. Determination of parameters of machines (Any two)
   (a) Wheel and differential axles
   (b) Single purchase crab
   (c) Double purchase crab
   (d) System of pulleys

Mechanics of deformable body

1. Determination of hardness of metals: Brinell /Vicker/Rockwell hardness test
2. Determination of impact of metals: Izod/Charpy impact test
3. Determination of compression test on
   a. Metals – mild steel and cast iron
   b. Timber – along and parallel to the grains
4. Determination of tensile strength of metals
5. Determination of shear strength of metals

List of Laboratory/Learning Resources Required:

1. Force table
2. Beam setup
3. Bell crank lever

4. Friction setup
5. Lifting machine
6. Hardness testing machine
7. Impact testing machine
8. Universal testing machine with shear attachment

- **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 submittedassignment.
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	5 research papers = 20 hrs.	Summarize research paper and evaluation critical parameters

	subject		
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 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.

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