GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Subject Code : BE03001011

Subject Name : Aeronautical Mechanics of Solids

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

Prerequisite:	Basic understanding of Physics and Mathematics
Rationale:	Mechanics is the branch of applied science that studies the motion and rest of bodies under forces, founded on Newton's laws of motion and gravitation. It has evolved to include complex applications like robotics and aerospace engineering. Engineering mechanics applies these principles to solve real-world engineering problems, ensuring safety and efficiency in design and construction.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT level
1	Apply fundamental principles of mechanics, equilibrium and statics to practical problems of engineering.	25
2	Determine centroid and moment of inertia of a different geometrical shape and its use in engineering problem.	10
3	Determine different types of stresses and strains developed in the member subjected to axial, bending, shear, torsion & thermal loads.	25
4	Determine principal stresses and strains for two dimensional system using analytical and graphical methods.	10
5	Differentiate behaviour and properties of different engineering materials.	20
6	Apply the basics of simple machines and their working mechanism	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.**

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
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	11	25
	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.		
2.	**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,T,Angle, channel sections Shear stresses – Derivation of formula, shear stress distribution across various beam sections like rectangular, circular, triangular, I, T, angle sections.	06	15
3.	**Centroid, moment of inertia and mass moment of inertia** Centroid: Centroid of lines, plane areas and volumes, Examples related to centroid of composite geometry, Pappus – Guldinus first and second theorems. 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	14	30
	Torsion: Derivation of equation of torsion, Assumptions, application of theory of torsion equation to solid & hollow circular shaft, torsional rigidity		

4.	**Simple stresses & strains** Basics of stress and strain: 3-D 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's Ratio, 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, analysis of homogeneous prismatic bars under multidirectional stresses	14	30
	Principal stresses: 2-d system, stress at a point on a plane, principal stresses and principal planes, Mohr's circle of stress, ellipse of stress and their applications		
	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**
-	**30**	**70**	-	-	-

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. Hibbeler, R.C. *Engineering Mechanics: Statics*, 15th ed., Pearson, 2021.
2. Khurmi, R.S. *A Textbook of Engineering Mechanics*, 37th ed., S. Chand Publishing, 2022.
3. Bhavikatti, S.S. *Engineering Mechanics*, 9th ed., New Age International Pvt Ltd Publishers, 2024.
4. Beer, F.P., and Johnson, E.R. *Mechanics for Engineers: Statics*, 7th ed., McGraw-Hill Education, 2016.
5. Harbola, M.K. *Engineering Mechanics*, 2nd ed., Cengage India, 2013.

(b) Open source software and website:

1. https://nptel.ac.in/courses/112107146
2. https://ocw.mit.edu/courses/1-050-solid-mechanics-fall-2004/
3. www.vlab.co.in

Suggested Course Practical List:

Mechanics of Rigid Bodies

1. **Equilibrium of Coplanar Concurrent Forces**
2. **Equilibrium of Coplanar Non-Concurrent Forces**
3. **Equilibrium of Coplanar Parallel Forces**
   - Determination of reactions of a simply supported beam
4. **Verification of the Principle of Moment**
   - Bell crank lever
5. **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 Bodies

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:**
   - Metals – mild steel and cast iron
   - Timber – along and parallel to the grains
4. **Determination of Tensile Strength of Metals**
5. **Determination of Shear Strength of Metals**

Students must be given at least 4 assignments targeting applications based on the above course content.
List of Laboratory/Learning Resources Required:
Force table, Beam set up, Bell crank lever, Friction set up, Lifting machine, Hardness testing machine, Impact testing machine, 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	Duration of video = 5hrs.	Report /presentation based on

	related to the subject	Report preparation = 5hrs. Total = 10hrs.	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 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 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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