GUJARAT TECHNOLOGICAL UNIVERSITY

MECHANICS OF SOLIDS
SUBJECT CODE: 2130003
B.E. 3RD SEMESTER

Type of course: Applied Physics

Prerequisite: System of units
Laws of motion
Basic idea of force
Concept of centroid
Fundamentals of stress, strain and their relationships

Rationale: Mechanics of Solids is conceptual applications of principles of mechanics in Engineering

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	10	20	150

Sr. No.	Topics	Teaching Hrs.	Module 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.	02	20
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 statically determinate pin – jointed structures. **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, Equilibrium conditions of coplanar non-concurrent force system, Application of these principles.	08	
	Module 2		
3	**Applications of fundamentals of statics**	08	15

	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 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.		
Module 3			
4	**Friction** Theory of friction, Types of friction, Static and kinetic friction, Cone of friction, Angle of repose, Coefficient of friction, Laws of friction, Application of theory of friction: Friction on inclined plane, ladder friction, wedge friction, belt and rope friction.	06	20
5	**Centroid and 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. Examples related to moment of inertia of composite geometry,	08	
Module 4			
6	**Simple stresses & strains** Basics of stress and strain: 3-D state of stress (Concept only) Normal/axial stresses: Tensile & compressive 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.	10	20
Module 5			
7	**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	25
8	**Torsion:** Derivation of equation of torsion, Assumptions, application of theory of torsion equation to solid & hollow circular shaft, torsional rigidity.	04	

9	**Principle stresses:** Two dimensional system, stress at a point on a plane, principal stresses and principal planes, Mohr's circle of stress, ellipse of stress and their applications	04	
Module –VI			
10	**Physical & Mechanical properties of materials: (laboratory hours)** Elastic, homogeneous, isotropic materials; Stress –Strain 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	05	50% (Practical) & 0% (Theory)
11	**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.	05	

Course Outcome:

After learning the course the students should be able to:

1. apply fundamental principles of mechanics & principles of equilibrium to simple and practical problems of engineering.
2. apply principles of statics to determine reactions & internal forces in statically determinate beams.
3. determine centroid and moment of inertia of a different geometrical shape and able to understand its importance.
4. know basics of friction and its importance through simple applications.
5. understand the different types of stresses and strains developed in the member subjected to axial, bending, shear, torsion & thermal loads.
6. know behaviour & properties of engineering materials.
7. know basics of simple machines and their working mechanism.

List of Experiments:

The students will have to solve atleast 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 coefficient of static friction using inclined plane
7. 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

8. Determination of hardness of metals: Brinell /Vicker/Rockwell hardness test
9. Determination of impact of metals: Izod/Charpy impact test
10. Determination of compression test on
    (a) Metals – mild steel and cast iron
    (b) Timber – along and parallel to the grains
11. Determination of tensile strength of metals
12. Determination of shear strength of metals

Design based Problems (DP): (any two)

1. For a real industrial building having roof truss arrangement, (a) take photograph & identify type of truss, (b) draw sketch of truss with all geometrical dimension, cross sections details, type of joints, type of support conditions (c) prepare a model of truss (d) identify & determine types of load acts on it (d) determine support reactions & member forces due to dead load & live load only.
2. Take a case of the Mery-Go-Round used in the fun park. Draw its sketch showing radius of wheel, no of seats, capacity of each seats and other related information. Determine the amount of resultant produced at the centre of wheel during rest position, when (i) it is fully loaded (2) it is 30% loaded with symmetric arrangement. Draw support arrangement and determine support reactions. Also determine amount of torque required to start its operation.
3. Prepare working models for various types of beams with different shape of cross section, supporting conditions and study the effect of cross section on the deflection of beams.
4. Prepare working model of simple lifting machine using different types of pulley systems and calculate various parameters like load factor, velocity ratio, law of machine, efficiency of machine etc.

Major Equipments:

1. Force table
2. Beam set up
3. Truss set up
4. Bell crank lever
5. Friction set up
6. Lifting machine
7. Hardness testing machine
8. Impact testing machine
9. Universal testing machine with shear attachment

List of Open Source Software/learning website:
www.nptel.iitm.ac.in/courses/

Active learning Assignments (AL) : Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will

allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.