GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-III

Course Title: Strength of Materials
(Course Code: 4331904)

Diploma programme in which this course is offered	Semester in which offered
Mechanical Engineering, Mechatronics Engineering, Marine Engineering	Third Semester

1. RATIONALE

After learning Mechanics of rigid bodies in second semester as course Engineering Mechanics, students will now learn the fundamentals of Mechanics of deformable bodies in this course as Strength of Materials. This course deals with this behavior of solid materials by studying the distribution of internal forces, the stability and deformation of the materials under the applied loads or forces. To choose proper material by keeping its strength and suitability in mind is very important stage in production and design level in the field of Mechanical Engineering. Hence the course is prerequisite for understanding principles of machine design at various levels.

2. COMPETENCY

The purpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use the principle of Mechanics of deformable bodies to solve broad-based engineering related problems.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

a) Analyse structural behaviour of various materials under axial loading.
b) Determine moment of inertia of a symmetrical and asymmetrical section about a given axis.
c) Draw and Interpret shear force and bending moment diagrams and determine the bending and shear stresses in beams for various types and loading conditions.
d) Determine slope and deflection in cantilever and simply supported beams.
e) Determine stresses in the shaft and springs under twisting moments.
f) Select suitable material(s) for given purposes in engineering**.**

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	

3	0	2	4	30*	70	25	25	150

(*):Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** -End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the subcomponents of the COs. *Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'*.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Conduct tension test on a given sample of mild steel and draw stress-strain curve.	I	04*
2	Determine Young's Modulus of wire of given material.	I	02*
3	Find out Compressive Strength of Cast Iron, Mild Steel, Wooden specimen with parallel & perpendicular to grains.	I	04*
4	Compute Polar Moment of Inertia of Fly Wheel.	II	02*
5	Conduct flexural test on wooden beam and find out ultimate bending stress.	III,IV	02*
6	Conduct shear test (Single and Double shear) on mild steel and cast iron specimen.	III,IV	02*
7	Find out deflection of cantilever beam for end point load and simply supported beam for central point load	V	02*
8	Conduct Torsion test on cast iron, mild steel specimen.	VI	02*
9	Verify stiffness of springs in series and parallel	VI	02*
10	Determine Izod impact value and Charpy impact value of given materials.	VII	04*
11	Determine Brinell and Rockwell hardness of given materials.	VII	02*
	Total hours		**28 Hrs.**

Note

i. *More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

ii. *The following are some **sample** 'Process' and 'Product' related skills(more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Identify components	10
2	Prepare experimental setup.	20
3	Operate the equipment setup.	20
4	Follow safe practices .	10

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
5	Record observations correctly.	20
6	Interpret the result and conclude.	20
	Total	**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to use in uniformity of practicals in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Universal Testing Machine with beam and shear attachment.	1,5&6
2	Searl's apparatus to find Young's modulus of wire	2
3	Compression Testing Machine.	3
5	Fly Wheel for polar moment of inertia	4
6	Deflection of beam apparatus	7
7	Torsion Testing Machine	8
8	Spring stiffness testing apparatus.	9
4	Izod & Charpy Impact Test Apparatus	10
7	Brinell Hardness Testing Machine	11
8	Rockwell Hardness Testing Machine	11

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a leader/a team member.
b) Follow safety practices while using equipment.
c) Realize importance of green energy. (Environment related)

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit – I Direct Stress & Strain	1a. Evaluate Material properties Under Longitudinal and Lateral Loads. 1b. Calculate stress and strain under thermal variation. 1c. Interpret stress strain curve for various material. 1d. Analyse composite & compound section for stress and strain. 1e. Compute Strain Energy under different types of loading on elements.	1.1 Direct stress, Linear strain, Elasticity, Elastic limit, Hook's law, Modulus of Elasticity or Young's modulus, Stress Strain curve for mild steel bar under tension with numerical problems. 1.2 Lateral stress and strain, Poisson's ratio, Volumetric strain, Bulk modulus, relation between three moduli and numericals. 1.3 Basics Concepts of Shear Stress , Shear Strain & Modulus of rigidity. 1.4 Concept of composite and compound section, modular ratio and numericals. 1.5 Concept of Thermal stress and strain, Thermal stresses for non-yielding and yielding condition with numericals. 1.6 Stresses due to gradual, sudden and impact load, corresponding deformation, Strain energy, Resilience, Proof resilience and Modulus of resilience with numericals.
Unit – II Moment of Inertia	2a. Locate the axis of symmetry & Centroidal axis in symmetrical & asymmetrical solid and hollow sections 2b. Apply Parallel axis theorem to determine moment of inertia, for symmetrical & asymmetrical sections about centroidal axis and any other reference axis. 2c. Apply Perpendicular axis theorem to determine Polar Moment of Inertia of a section.	2.1. Importance of Moment of Inertia. 2.2. Axis of symmetry, Centroidal axis and axis of reference. 2.3. Parallel Axis Theorem & Perpendicular Axis Theorem 2.4. Formulas to calculate Moment of Inertia of solid and hollow rectangle, square, circle, triangle shapes (without derivations). 2.5. Moment of Inertia of symmetrical and asymmetrical I-section, Channel section, T-section, Angle section, Hollow sections and Built up sections about Centroidal axis and any other reference axis using Parallel axis theorem. 2.6. Polar Moment of Inertia of solid & hollow circular sections.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit– III **S.F. & B. M. in Beam**	3a. Identify statically determinate and statically indeterminate beams. 3b. Analyse statically determinate beam for Bending Moment and Shear Force. 3c. Draw Shear Force and Bending Moment diagram for statically determinate beams. 3d. Interpret Shear Force and Bending Moment diagram of statically determinate beams.	3.1 Statically Determinate and statically indeterminate beam examples. 3.2 Concept of Bending Moment and Shear Force in beam. 3.3 Sagging and Hogging Bending Moment. Positive and Negative Shear Force. 3.4 Calculation of Bending Moment and Shear Force at various sections of beam for cantilever simply supported and overhang beam subjected to point load and/ or u.d.l. 3.5 S.F. & B.M. Diagram for above beams 3.6 Point of Contra-flexure & its importance.
Unit– IV Bending & Shear Stress in Beam	4a. Determine Bending stress at a particular section of beam using the bending equation. 4b. Draw a Bending stress distribution diagram for a particular beam section. 4c. Determine Shear stress at a particular section of beam using the shear equation. 4d. Draw a Shear stress distribution diagram for a particular beam section. 4e. Identify factors affecting Bending and Shear stress.	4.1 Concept and theory of pure bending, assumptions, Bending equation (without derivation), Section Modulus, Bending stresses and their nature, Bending stress distribution diagram. 4.2 Concept of moment of resistance and simple numerical problems using bending equation. 4.3 Shear stress equation (without derivation), relation between maximum and average, Shear stress for rectangular and circular section. 4.4 Shear stress distribution for square, rectangular, circle, hollow square, rectangular, circular, angle sections, channel section, I-section, T section. Simple numerical problems based on Shear equation.
Unit– V Slope and Deflection	5a. Differentiate between strength and stiffness of structural member. 5b. Calculate maximum slope and deflection in cantilever and simply supported beams under symmetrical loads. 5c. Identify factors affecting slope and deflection.	5.1 Concept of Slope & Deflection of beams. 5.2 Flexural rigidity and its significance. 5.3 Formulas (without derivation) of maximum slope & deflection for cantilever beams subjected to point load at free end and u.d.l. over the entire span. 5.4 Formulas (without derivation) of maximum slope & deflection for simply supported beams subjected to point load at center and u.d.l. over the entire span.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit– VI Torsion & Springs	6a. Calculate torque and power transmitted by a shaft in the given situation. 6b. Compute shear stress and angle of twist in a shaft for the given power to be transmitted. 6c. Determine the diameter of shaft for the given shear stress and angle of twist for maximum transmission of power. 6d. Analyse the Closed Coiled Helical spring spring for stresses.	6.1 Torque or turning moment or twisting moment, Angle of twist, Shear stress in shaft, strength of shafts, Polar moment of inertia, Torsional rigidity, assumptions in the theory of torsion. 6.2 Equation of Torsion (without derivation) and related numericals. 6.3 Relationship of H.P. , Torsion and RPM and related numericals 6.4 Springs: Stiffness of a spring(s)- Individual, in series and in parallel, Uses of springs, Types of springs. 6.5 Calculation of main dimensions of Closed Coiled Helical spring.
Unit– VII Mechanical Properties of Material	7a. Identify various materials used in Mechanical Engineering 7b. Evaluate different mechanical properties of materials used. 7c. Compare and select the material for their utility point of view.	7.1. Classification of engineering materials. 7.2. Physical properties of material:- Elasticity, Plasticity, Ductility, Brittleness, Malleability, Fatigue, Creep, Toughness, Hardness etc. 7.3. Testing of materials for impact value (Izod impact and charpy impact test) and hardness (Brinell and Rockwell hardness test) 7.4. Factors affecting selection of materials.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	**Direct Stress & Strain**	**10**	**2**	**4**	**8**	**14**
II	**Moment of Inertia**	**04**	**2**	**2**	**4**	**08**
III	**S.F. & B. M. in Beam**	**08**	**2**	**4**	**8**	**14**
IV	**Bending & Shear Stress in Beam**	**06**	**2**	**2**	**6**	**10**
V	**Slope and Deflection**	**04**	**2**	**2**	**4**	**08**
VI	**Torsion & Springs**	**06**	**2**	**2**	**6**	**10**
VII	**Mechanical Properties of Material**	**04**	**2**	**2**	**2**	**06**
Total		**42**	**14**	**18**	**38**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test*

items/questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may slightly vary from above table.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Collect different situations with photographs of machine components where axial force is predominant.
b) Collect the photographs of machine component made of I-section, angle section, channel section and built-up section.
c) Collect different situations with photographs of machine components where bending moment and shear force are predominant.
d) Collect the information with photographs of machine component where check for deflection is important.
e) Collect different situations with photographs of machine components where torsion is predominant.
f) Collect different situations with photographs of machine components where impact force is predominant.
g) Collect the information of machine components where hardness and important and also collect required hardness for that.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Guide students on how to address issues on environment and sustainability.
g) Guide students for using data manuals.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the micro-project should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Prepare spreadsheet or computer program to calculate the stresses in the composite section.
b) Compare tensile strength and cost of three locally available steel bars.
c) Compare modulus of elasticity of wires of three different materials using Searle's apparatus.
d) Prepare spreadsheet or computer program to calculate the support reactions of statically determinate beams.
e) Prepare spreadsheet or computer program to calculate the bending stress and shear stress in a beam having a rectangular or circular section.
f) Prepare spreadsheet or computer program to calculate slope and deflection of simply supported beam and cantilever beam for various load cases.
g) Calculate modulus of elasticity of a material by measuring deflection of beam.
h) Prepare spreadsheet or computer program to calculate dia. of shaft for given data.
i) Measure dia. of shaft in at least three power transmitting machines and justify it.
j) Compare chart for any 5 material regarding their Mechanical properties.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Strength of Materials (Mechanics of Solids)	R.S.Khurmi N. Khurmi	S Chand Publishing (2019) ISBN: 97-893-528-339-79
2	Strength of Materials	Dr. R.K.Bansal	Laxmi Publications (P) Ltd. New Delhi (2005) ISBN: 97-881-700-814-70
3	Strength of Materials	S. Ramamrutham & R.Narayanan	Dhanpat Rai Publishing Company (2011) ISBN:97-881-874-335-45
4	Strength of Materials (Mechanics of Materials)	R.S. Laheri A.S. Laheri	S.K. Karatia & Sons, Delhi. (2010) ISBN: 97-881-857-494-40

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
5	Strength of Materials	Dr. Sadhu Singh	Khanna Publishers , New Delhi.(2018) ISBN: 97-893-810-686-18

14. SOFTWARE/LEARNING WEBSITES

a) https://nptel.ac.in/courses/105104160 (NPTEL Course :- Mechanics of Solids by IIT, Kanpur)

b) https://www.youtube.com/watch?v=GkFgysZC4Vc&list=PL27C4A6AEA552F9E6 (NPTEL Video Lectures by IIT, Kharagpur)

c) www.vlab.co.in (Virtual Lab by Ministry of Education, Government of India)

15. PO-COMPETENCY-CO MAPPING

Semester III	Strength of Materials (Course Code: 4331905)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	Use the principle of Mechanics of deformable bodies to solve broad-based engineering related problems.						
Course Outcomes COa) Analyse structural behaviour of various materials under axial loading.	2	3	-	3	2	2	2
COb) Determine moment of inertia of a symmetrical and asymmetrical section about a given axis.	2	3	-	2	2	2	2
COc) Draw and Interpret shear force and bending moment	2	3	-	-	2	2	2

diagrams and determine the bending and shear stresses in beams for various types and loading conditions.							
COd) Determine slope and deflection in cantilever and simply supported beams.	2	3	-	3	2	2	2
COe) Determine stresses in the shaft and springs under twisting moments.	2	3	-	3	2	2	2
COf) Select suitable material(s) for given purposes in engineering.	2	3	-	2	2	2	2

*Legend: '**3**' for high, '**2**' for medium, '**1**' for low and '**-**' for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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