Government of Karnataka

DEPARTMENT OF COLLEGIATE AND TECHNICAL EDUCATION

Programme	Civil Engineering	**Semester**	Third Semester
Course Code	20CE31P	**Type of Course**	Programme Core
Course Name	Engineering Mechanics & Strength of Materials	**Contact Hours**	8 hours/week 104 hours/semester
Teaching Scheme	L:T:P :: 3:1:4	**Credits**	6
CIE Marks	60	**SEE Marks**	40

1. Rationale: The study of strength of materials often refers to various methods of calculating the stresses and strains in structural members such as beams, columns and shafts. The methods employed to predict the response of a structure under loading and its susceptibility to various failure modes takes into account the properties of the materials such as its yield strength, ultimate strength, Young's modulus, and Poisson's ratio. In addition, the mechanical elements, geometric properties such as its length, width, thickness, boundary constraints and abrupt changes in geometry such as holes are considered.

2. Course Outcomes/Skill Sets: At the end of this course students will be able to:

CO-01	Explain the potential impact of forces / stresses on structural elements / materials in a given condition.
CO-02	Calculate the moment of Inertia for a given symmetrical or asymmetrical geometric sections.
CO-03	Calculate shear force and bending moments for different loading conditions and support conditions, draw the SFD & BMD and validate the analysis using Ansys software.
CO-04	Calculate bending and shear stresses in beams under different load conditions and validate the analysis using any FEM analysis software.
CO-05	Calculate and validate the safety of a column for various given loads and end conditions.

3. Course Content

Week	**CO**	**PO**	**Lecture (Knowledge Criteria)**	**Tutorial (Activity Criteria)**	**Practice (Performance Criteria)**
			3 hours/week	1 hour/week	4 hours/week(2 hours/batch twice in a week)
1	1	1, 2	1.Force and characteristics of a force. Force system: Classification of force system according to plane		1 & 2. Verification of lami's Theorem.

			and line of action- Principle of transmissibility of forces, moment of a force, Resolution & composition of forces. 2. Resultant force, Law of moments, Resultant of Concurrent and non-concurrent force system. Equilibrium conditions. 3.Simple Problems on determination of resultant of con current & non concurrent force systems.	1.Determine Forces in members of a truss at the given joint. 2.Determination of resultant of forces acting on retaining wall and trapezoidal dam section.	
2	1	1, 2	1.Rigid body, plastic body Mechanical properties of metal- Rigidity, Elasticity, Plasticity. 2.Compressibility, Hardness, Toughness, Stiffness, Brittleness, Ductility 3. Malleability, Creep, Fatigue, tenacity, durability. Testing procedures and importance of each property of materials.	1. Compare the properties of Hard, soft, brittle and Ductile material.	1. Hardness test to evaluate a hardness of given material Example: Mild Steel, Stainless steel, Wood, Copper, Bronze, Brass, Aluminium, Glass. 2. Impact test to evaluate toughness of a given material Example: Mild Steel, Stainless steel, Wood, Copper, Bronze, Brass, Aluminium, Glass.
3	1	1, 2	1. Stress, strain, Hooke's law Types of stresses - Normal stress and Shear stress Types of normal stress - Tensile stress and Compressive stress 2.Types of strains- Normal strain and Shear strain Types of normal strain - Longitudinal strain, Lateral strain and volumetric strain Types of Lateral strain - Tensile strain and Compressive strain 3.Problems	1. Plot Stress/strain graph for various structural steel	1.Conduct tensile test on following materials and plot Stress-strain curve a)Mild steel b)HYSD bar Determine yield stress/ proof stress, Ultimate stress, breaking stress and percentage of elongation, Young's Modulus 2.Conduct tensile test on following materials and plot Stress-strain curve a) Plastic b) Bamboo c) Fibres Determine yield stress/ proof stress, Ultimate stress, breaking stress and percentage of elongation, Young's Modulus

4	1	1, 2	1.Elongation and Contraction - Poisson's Ratio and Modulus of Elasticity. 2.Problems 3.Problems	1. Determine Stresses and Modulus of Elasticity in Civil Engineering Building materials	1. Conduct tensile test and Measure strain using electric strain gauge on following materials and plot Stress-strain curve. a) Mild steel b) HYSD bar 2. Determine yield stress/ proof stress, Ultimate stress, breaking stress and percentage of elongation, Young's Modulus and compare the methods of finding yield stress.
5	1	1,2	1. Stresses in bars of composite section (Modular ratio). 2.Principles of superposition, Deformation of uniform bars and bars of varying cross section subjected to constant load & varying loads. 3.Volumetric strain & change in volume, Relation among elastic constants, Thermal stresses.	1. Analyse the thermal stresses in different materials using Open-source Software.	1. Problems on axially loaded composite sections. 2. Analysis of Composite Section -Interpretation of Results. (Analysis by any FEM analysis software)
6	2	1, 2,3	1 Centre of gravity & centroid, Moment of Inertia for Plane lamina: radius of gyration, elastic sectional modulus, parallel and perpendicular axes theorems. 2. Moment of Inertia for rectangle, square, circle, semi-circle, and quarter circle and triangle section. 3. M.I of symmetrical and unsymmetrical I section, Channel section.	1. Study and compare different geometrical shapes of structural elements like beams, columns, members of truss, shafts etc.	1. Calculation of Centroid and Moment of Inertia of different sections using CADD software. 2. Finding the centroid and moment of inertia of irregular sections by manual method (Open ended Experiment) Comparison of M I with manual calculation and CADD software.
7	2	1, 2,3	1. M I of T section, L section, hollow sections, built-up sections about centroidal axes and any other reference axis. 2.Problems.	1. Calculation of Moment of Inertia for other built-up sections.	1 & 2. Calculation of centroid and Moment of Inertia by Open-Source application/Ansys for a given section and Influence of MI on a strength of section.

			3.Polar moment of inertia of solid circular sections. - problems.		
8	3	1, 2,3	1. Types of beams –simply supported, cantilever, fixed continuous and overhanging beams. Types of supports: Roller support, Hinged support, Fixed support and Pinned support. 2. Determinate structures: Types of loading- Axial load, Transverse load, point load, uniformly distributed load, uniform varying load, moment, support reactions for determinate structures. 3. Concept of shear force and bending moment, sign convention. Relation between bending moment, shear force and rate of loading.	1. Differentiate between line, Surface and solid structural elements on the basis of their behaviour under loads.	1.Calculation of Bending Moment and shear force for simply supported beams with UDL and point load. 2.Draw Shear force and bending moment diagrams for simply supported beams. (UDL and point load).
9	3	1, 2,3	1. Calculation of Bending Moment and shear force for cantilever beams with UDL and point load and Draw Shear force and bending moment diagrams for cantilever beams with UDL and point load. 2. Problems. 3. Problems.	1. Calculation of Bending Moment and shear force for for fixed beams with UDL and point load. 2.Draw Shear force and bending moment diagrams for fixed beam beams. (UDL and point load).	1. Analyse simply supported beams, subjected to different types of loads, for SFD and BMD using any FEM analysis software. 2. Analyse cantilever beams, subjected to different types of loads, for SFD and BMD using any FEM analysis software.
10	3	1, 2,3	1. Calculation of Bending Moment and shear force for overhanging beams with UDL and point load Draw Shear force and bending moment diagrams for overhanging beams with UDL and point load and Locate points of contra- flexure. 2. Problems.	1.Calculation of bending moment and shear force foe an overhanging beam of bicycle stand.	1& 2. Analyse overhanging beams, subjected to different types of loads, for SFD and BMD using any FEM analysis software.

			3. Problems		
11	4	1, 2,3	1. Bending stress in beam, Assumptions in simple bending theory, bending equations. 2. Neutral axis, Modulus of rupture, section modulus, flexural rigidity, moment of resistance. 3. Bending and Shear Stresses across the cross section of the beams- rectangular and T section.	1. Determine bending stress and shear stress across a section of structural elements like RCC beam, Steel beam and purlins.	1. Problems on Bending stress and preparation of bending stress distribution diagram- variation of bending. 2. Flexure Test on materials like steel, concrete specimens - Two Point Load system.
12	5	1, 2,3	1. Slope and deflection using Moment area method for simply supported and cantilever beams subjected to symmetrical point loads and UDL. 2. Problems 3. Problems	1.Calculation of deflection for Overhanging beams 2.Limitation of deflection for various structural Elements	1.Calculation and analysis of beams for slope and deflection by Open-Source application / any FEM analysis software 2.Animations of deflection
13	5	1, 2,3	1. Introduction – Short and long columns - Euler's theory 2. Effective length, slenderness ratio - radius of gyration, buckling load, crippling load 3. Assumptions, Euler's Buckling load for different end conditions, Limitations of Euler's theory	1.Study and prepare a report on the failure modes of Column and Influence of L/D ratio on the Strength of column.	1. Problems 2. Calculation and analysis of crippling load by Open-Source application/any FEM analysis software for Axial load, eccentric load and column with different materials
Total in hours			**39**	**13**	**52**

NOTE 1: The course content shall be delivered through lectures, PowerPoint presentations, video demonstrations and field visits.

NOTE 2: The TUTORIAL (Activity criteria) shall be conducted / executed by the student (Minimum ONE suggested activity from each week) and to be submitted in portfolio evaluation of activities through rubrics to the faculty.

NOTE 3: The PRACTICE (Performance criteria) shall be conducted by the student and observations and report to be submitted at the end of each session to the faculty.

4. CIE and SEE Assessment Methodologies

Sl. No	Assessment	Test Week	Duration In minutes	Max marks	Conversion
1.	CIE-1 Written Test	5	80	30	Average of three tests 30
2.	CIE-2 Written Test	9	80	30	
3	CIE-3 Written Test	13	80	30	
4.	CIE-4 Skill Test-Practice	6	180	100	Average of two skill test reduced to 20
5	CIE-5 Skill Test-Practice	12	180	100	
6	CIE-6 Portfolio continuous evaluation of Tutorial sessions through Rubrics	1-13		10	10
Total CIE Marks					60
Semester End Examination (Practice)			180	100	40
Total Marks					**100**

5. Format for CIE written Test

Course Name	**Strength of Materials**	Test	I/II/III	Sem	III/IV
Course Code	**20CE31P**	Duration	80 Min	Marks	30

Note: Answer any one full question from each section. Each full question carries 10 marks.

Section	Assessment Questions	Cognitive Levels	Course Outcome	Marks
I	1			
	2			
II	3			
	4			
III	5			
	6			

Note for the Course coordinator: Each question may have one, two or three subdivisions. Optional questions in each section carry the same weightage of marks, Cognitive level and course outcomes.

6. Rubrics for Assessment of Activity (Qualitative Assessment)

Sl. No.	Dimension	Beginner	Intermediate	Good	Advanced	Expert	Students Score
		2	4	6	8	10	
1		Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	8
2		Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	6
3		Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	2

4		Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	2
	Average Marks= (8+6+2+2)/4=4.5						**5**

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the activities

7. Reference:

Sl. No.	Description
1	**Ramamurtham. S.,** ***"Strength of Materials",*** 14th Edition, DhanpatRai Publications
2	**SS Bhavikatti, Strength of Materials**
3	Fundamentals of strength of materials by **P N Chandramouli"** PHI New delhi
4	Relevant IS Codes

8. a. CIE Skill Test 1- Scheme of Evaluation

SL. No.	Particulars/Dimension	Marks
1	Portfolio evaluation for practice sessions -Performance criteria (Observations and report)	10
2	One Question on forces and its validation with any FEM analysis software	10
3	One Experimental Question to Conduct hardness test/tensile test/Impact test for a given specimen. Writing Observations and Tabular column, Equation with all notation-10 Conduction of Experiment-10 Calculation and result with graph-20	40
4	Manual Calculation of Centroid and Moment of Inertia of given section and validate using CADD	30
5	Viva- voce	10
	Total Marks	**100**

8. b. CIE Skill Test 2 - Scheme of Evaluation

SL. No.	Particulars/Dimension	Marks
1	Portfolio evaluation for practice sessions -Performance criteria (Observations and report)	10
2	Manual Calculation of Shear force and Bending moment - 10 marks Draw SFD & BMD for Simply supported beam / cantilever beam / overhanging beam with point load and UDL - 10 marks Validation with any FEM analysis software- 10 marks	30
3	One Experimental Question on UTM to Conduct a flexural test for a given specimen Writing Observations and Tabular column, Equation with all notation-10 marks Conduction of Experiment-10 marks Calculation and result -10 marks	30
4	One question on column deflection/bending and its validation with any FEM analysis software	20
5	Viva- voce	10
	Total Marks	**100**

8. c. SEE Scheme of Evaluation

SL. No.	Particulars/Dimension	Marks
1	One Experimental Question to Conduct hardness test/tensile test/Impact test/ flexural test for a given specimen. Writing Observations and Tabular column, Equation with all notation-10 marks Conduction of Experiment-10 marks Calculation and result with graph-10 marks	30
2	Manual Calculation of Shear force and Bending moment - 10 marks Draw SFD & BMD for Simply supported beam / cantilever beam / overhanging beam with point load and UDL - 10 marks Validation with any FEM analysis software- 10 marks	30

3	a. One question on column deflection/bending and its validation with any FEM analysis software - 20 marks **OR** b. Manual Calculation of Centroid and Moment of Inertia of given section and validate using CADD - 20 marks	20
4	Viva- voce	20
	Total Marks	**100**

Note for the External Examiner: The choice between the questions 3a and 3b shall be done by the external examiner.

9. Equipment/software list with Specification for a batch of 20 students

Sl. No.	Particulars	Specification	Quantity
1	Lami's apparatus	It Consists of a board of about 65 × 50cm, with two aluminium pulleys, on clamp, for mounting on board in any desired position. Complete with three mass hangers and 12 slotted masses, each of 50g each.	20
2	Hardness test apparatus-Rockwell	Model Number: TRSN. Test Loads: 60,100,150 kgs (Rockwell) Initial Loads: 10 (kgs) Maximum Test Height: 222 mm. Depth of Throat: 130 mm. Machine Height: 627 mm. Net weight: Approx. 65 kg. Size of base: Approx. 450 * 265 mm.	5
3	Universal Hardness test apparatus	• Screen display of hardness value and scale with 0.1-unit resolution • Built-in x50 total magnification • Variable test sequence timing from 1 to 50 s • Multiple loads available – Vickers: 3, 5, 10, 30 and 100 kgf – Brinell: 5, 10, 30, 62.5 and 187.5 kgf	2

		– Rockwell: 10, 60, 100 and 150 kgf	
4	Impact test apparatus-charpy's apparatus	Model 50 Maximum Capacity Units- J 500 Maximum Scale Graduation Units- J 0.1 Overall Size without Protection Guard (Approx.) L x W x H Units- m 1.1 x 0.45 x 1.65 Overall Size with Protection Guard (Approx.) L x W x H Units- m 2.2 x 1.2 x 2.1 Net Weight of Machine (Approx.) Units- kg 500	4
5	UTM	Force range: 10kN, 20kN, 30kN, 50kN, and 100kN. ... Crosshead speed: 0.05 to 500 mm/min. Speed accuracy: < 0.5% Load cell accuracy: ± 0.5% of reading. Software: software for tensile, compression + bending incl. Electrical supply: 220-230Vac, 50Hz, 1kVA, single phase 3 wires. Accessories: ... Weight:	1
6	Dial Gauge With magnetic stand	Clamping Force (N): 600 N Overall Height (mm): 220 mm Applicable for: For Dial Test Indicator Size (mm): 10 mm	4
7	Electric Strain gauge.	Guage Length 0.3mm to 60mm Guage Resistance Within ±0.3% of the nominal resistance	4
8	Desktop Computers / Laptops	8 GB RAM, 512GB HARD DRIVE, i5 and above 2.5 GHz PROCESSOR,	20
9	Computer Aided Drafting Software-AUTOCAD	LICENSED, Ver. 2020 and above	1 / computer
10	Any FEM analysis software	LICENSED, Ver. 2020 and above	1 / computer