

STRUCTURAL MECHANICS

Course Title	Structural Mechanics	Course Code	CE-104
Semester	I year	Course Group	Core
Teaching Scheme in Periods(L:T:P)	120:30:0	Credits	3.0
Methodology	Lecture+Tutorials	Total Contact Periods	150 Periods
CIE	60 Marks	SEE	40 Marks

Pre requisites

Knowledge of Fundamentals of Engineering Physics and Engineering Mathematics

Course Outcomes

Upon completion of the course, the student shall be able to

CO1	Calculate the Resultant of force system and explain the concepts of Equilibrium.
CO2	Discuss Moments of Forces, Types of Beams, loads and Supports.
CO3	Illustrate the concept of centre of gravity and centroids for various shapes and its calculation.
CO4	Calculate Moment of Inertia of standard and Built-up sections.
CO5	Discuss geometrical properties of beam to calculate strength parameters like flexural stress in beams for different loading conditions and determine the shear stress distribution in beams of specified sections.
CO6	Analyze and design circular power-transmission shafts and thin-walled pressure vessels by applying torsional and pressurized stress formulas, while evaluating material performance through the principles of strain energy and resilience.

Course Content and Blue Print of Marks for SEE

Course Contents

Unit No	Unit Name	Periods	Questions to be set for SEE			
			R		U	A
I	Fundamentals of Engineering Mechanics and Beams with Supports	20	Q 4	Q1	Q9(a)	Q13(a)
II	Shear Force and Bending Moment	30				
III	Centroid and Moment of Inertia	25		Q2	Q10(a)	Q14(a)
IV	Simple Stresses and Strains	25				
V	Bending and shear stresses in beams	30	Q3	Q5,Q6	Q9(b),Q11(a), Q11(b)	Q13(b),Q15(a), Q15(b)
VI	Torsion, Thin cylinders and Mechanical properties of materials	20		Q7,Q8	Q10(b),Q12(a), Q12(b)	Q14(b),Q16(a), Q16(b)
Total		150	8		8	8

UNIT - 1: Fundamentals of Engineering Mechanics and Beams with Supports

Duration: 20 Periods (L: 16 – T:4)

Mechanics - Engineering Mechanics - Applications and branches of Engineering Mechanics – Statics, Dynamics, Kinetics and Kinematics — S.I and M.K.S units of physical quantities used in Civil Engineering-Definition of force — systems of forces – co-planar forces - Resultant of co-planar forces at a point – Parallelogram Law and Triangle Law of forces — Polygon law of forces – Resolution of forces - Parallel forces – like and unlike forces.

Lami's theorem – Moment of force –couple- Conditions of equilibrium of a rigid body subjected to a number of co-planar forces.

Types of supports –Simple support, fixed support, hinged support, roller support Types of beams –simply supported beams, cantilever, fixed beams, overhanging beams, continuous beams and propped cantilevers.

Types of loading - vertical point load, uniformly distributed load, uniformly varying loads, Calculation of Reactions.

UNIT – 2: Shear Force and Bending Moment

Duration: 30 Periods (L: 25 – T:5)

Concepts of S.F. and B.M.-Sign Convention - Relation between Rate of Loading, S.F. and B.M- S.F. and B.M. diagrams for Cantilevers, Simply Supported beams, Overhanging beams subjected to point loads and uniformly distributed loads - Maximum B.M and maximum S.F in beams for various loads- position and significance of point of contra flexure.

UNIT - 3: Centroid and Moment of Inertia

Duration: 25 Periods (L: 20 – T:5)

Definitions – Centroid, Centre of gravity – Differentiation between Centroid and Centre of gravity, Position of Centroid of standard figures like rectangle, triangle, circle, semi-circle, parallelogram and trapezium - Determination of location of Centroid of standard steel sections – T, L, I, Channel section, Z section and unsymmetrical I section - built up sections and plane figures having hollow portion.

Definition of Moment of Inertia (Mass moment of inertia and Area moment of inertia) - Perpendicular and parallel axes theorems - Moment of Inertia of standard sections like rectangle, triangle, circle and hollow circular sections - Moment of Inertia of standard steel sections – T, L, I, Channel section, Z sections and unsymmetrical I section and Unsymmetrical Channel sections using parallel axis theorem - Moment of Inertia and radius of gyration of built-up sections - Polar Moment of Inertia of solid and hollow circular sections using perpendicular axis theorem

UNIT - 4: Simple Stresses and Strains

Duration: 25 Periods (L: 20 – T:5)

Stress and strain – type of stresses and strains - Stress strain curves for ductile materials (like mild steel)–Hooke's law – Young's modulus – deformation under axial load - shear stress

and Shear Strain – Modulus of rigidity - Longitudinal and lateral strain – Poisson's ratio, Bulk Modulus – relationship between elastic constants (proof not required, only problems). Stress due to gradually applied load, sudden loads and impact loads.

Composite sections – effect of axial loads - Temperature stresses and strains – hoop stress – Temperature stresses in composite sections

UNIT - 5: Bending and shear stresses in beams

Duration: 30 Periods (L: 25 – T:5)

Bending stress: Introduction – Simple Bending Stress in beams – Assumptions - Bending Equation (Derivation not required) – Neutral Axis - Section Modulus, Flexural Rigidity, Modulus of Section, Radius of curvature, Moment of Resistance – Calculation of bending stresses in Symmetrical and Unsymmetrical sections-practical applications.

Shear stress: Shear Stress distribution diagrams for various symmetrical beam sections such as rectangular, solid circular, I & T sections - Calculation of shear stress in different layers of a beam for rectangular and I section (Derivation of formula not required) – Calculation of Maximum shear stress in rectangular, circular and I sections problems from fundamental equation.

UNIT – 6: Torsion, Thin cylinders and Mechanical properties of materials

Duration: 20 Periods (L: 16 – T:4)

Torsion: Introduction – Theory of torsion – Assumptions – Torsion formula (Derivation not required) – Solid and hollow circular shafts subjected to pure torsion – Simple problems – Power transmitted by circular shafts – Problems.

Thin Cylinders: Introduction - Thin cylinders - Failures of thin cylinders - Longitudinal and Hoop stresses in thin cylinders (Derivations not required) – Calculation of thickness of thin cylinder under internal pressure – Problems - strains and change in dimensions (δd , δl , δv) of thin cylinders – Problems.

Mechanical properties of materials, Resilience, Strain Energy, Proof resilience and Modulus of Resilience

Reference Books

1. Engineering Mechanics – S Timoshenko (Tata Mc Graw Hill)
2. Engineering Mechanics Statics and Dynamics – Ferdinand L. Singer
3. Engineering Mechanics – N.H. Dubey (Tata Mc Graw Hill)
4. Engineering Mechanics – R.S. Khurmi
5. Engineering Mechanics – P.K. AbdulLatheef
6. Engineering Mechanics & Statics – Dayaratnam
7. Engineering Mechanics – S.S. Bavikatti
8. Engineering Mechanics – A.K. Tayal

Suggested E-learning references

1. www.elearning.com/survey
2. <http://nptel.ac.in>

Suggested Learning Outcomes

Upon completion of the course, the student shall be able to

CO1 - Calculate the Resultant of force system and explain the concepts of Equilibrium

1. Define Mechanics and Engineering Mechanics
2. State the applications of Engineering Mechanics
3. State the branches of Engineering Mechanics
4. Define the terms 1. Statics 2. Dynamics 3. Kinetics 4. Kinematics
5. State S.I and M.K.S units of physical quantities used in Civil Engineering
6. Define the following terms
 - a) Force
 - b) Resultant
7. Distinguish between
 - a) Co-planar and Non co-planar forces
 - b) Concurrent and Non Concurrent forces
 - c) Collinear and Non Collinear forces
 - d) Parallel and non-parallel forces
 - e) Like and unlike parallel forces

8. Compute the resultant of two co-planar forces acting at a point by
 - a) Law of parallelogram of forces
 - b) Triangle law of forces
9. Solve problems on computation of the resultant of a system of coplanar concurrent forces by
 - a) Law of polygon of forces
 - b) Resolution of forces
10. Determine resultant of co-planar concurrent forces by analytical methods.
11. Define the following a) Moment b) Equilibrium of forces c) Equilibrant and d) Moment of a couple
12. State Lami's Theorem, solve simple problems using Lami's Theorem
13. Solve problems on computation of the resultant of a system of coplanar parallel forces
14. Define couple and Explain the properties of a couple
15. State the conditions of equilibrium of rigid body subjected to a number of co-planar force
16. List and describe various types of supports (Simple support, fixed support, hinged support, roller support)
17. List and sketch various types of beams (simply supported beams, cantilever, fixed beams, overhanging beams, continuous beams and propped cantilever beams)
18. List various types of loading (point load, uniformly distributed load, uniformly varying load)
19. To determine support reactions for cantilever, simply supported and overhanging beams with vertical point loads and uniformly distributed loads

CO2 - Develop Shear Force and Bending Moment Diagrams for different types of beams

1. Explain terms: a) Shear Force b) Bending Moment
2. Explain the sign conventions used to calculate Shear Force and Bending Moment
3. Explain the relationship between the rate of loading, shear force and bending moment
4. Determine Shear Force and Bending Moment on Cantilevers, Simply Supported Beams and Overhanging beams for simple cases of loading (Point Load, uniformly distributed load) analytically
5. Determine maximum SF and maximum BM for various loading conditions in Cantilevers, Simply Supported Beams and Overhanging beams.
6. Describe the procedures for sketching the Shear Force Diagrams (SFD) and Bending Moment Diagrams (BMD)
7. Sketch Shear Force Diagrams (SFD) and Bending Moment Diagrams (BMD) for Cantilever, Simply Supported Beams and Overhanging Beams

8. Determine point of contraflexure and explain its significance

CO3 - Illustrate the concept of centroid and centroids for various shapes and its calculation and Calculate Moment of Inertia of standard and Built-up sections.

1. Define Centroid and Centre of gravity.
2. Distinguish between Centroid and Centre of gravity.
3. State the need for finding the Centroid and Centre of gravity for various engineering applications.
4. Determine the position of Centroid of standard sections-T, L, I, Channel section, Z section, unsymmetrical I section, unsymmetrical channel sections.
5. Determine the position of Centroid of built up sections consisting of RSJs, flange plates and Plane figures having hollow portions.
6. Define Moment of Inertia (MI), Mass moment of inertia, Polar Moment of Inertia, Radius of gyration.
7. State the necessity of finding Moment of Inertia for various engineering applications.
8. Determine Moment of Inertia and Radius of gyration for regular geometrical sections like T, L, I, Channel section, Z section, unsymmetrical I section, unsymmetrical channel section.
9. State 1. Parallel axes theorem 2. Perpendicular axes theorem.
10. Determine MI of standard sections by applying Parallel axes theorem.
11. Determine MI of built-up sections by applying Parallel axes theorem.
12. Calculate least radius of gyration of standard sections and built-up sections.
13. Determine the polar M.I for solid and hollow circular section applying Perpendicular axes theorem.

CO4 Explain Simple stresses and strains and its effect on simple sections and Interpret mechanical properties of materials and Explain Composite sections

1. Define the following terms
 - a) Stress
 - b) Strain
 - c) Modulus of Elasticity
 - d) Longitudinal Strain
 - e) Lateral Strain
 - f) Poisson's ratio
 - g) Modulus of rigidity
 - h) Bulk Modulus
2. Distinguish between different kinds of stresses and strains.
3. Draw the stress-strain curve for ductile materials (Mild steel) and explain the

salient points in the curve.

4. State Hooke's law and limit of proportionality.
5. Solve problems on relationship between simple stress and simple strain under axial loading on uniform bars and stepped bars.
6. State the relationship among the elastic constants.
7. Solve problems on relationship between elastic constants.
8. Stress due to gradually applied load, suddenly applied load and impact loads.
9. Calculate stresses in simple and composite members under axial loading.
10. Explain and calculate temperature stress, strain, hoop stress, temperature stresses in composite sections.
11. Explain the mechanical properties of materials
12. Elasticity, plasticity, ductility, brittleness, malleability, stiffness, hardness, toughness, creep, fatigue – examples of materials which exhibit the above properties.
13. Define the following a) Resilience b) Strain Energy c) Proof resilience
d) Modulus of Resilience

CO5 - Discuss geometrical properties of beam to calculate strength parameters like flexural stress in beams for different loading conditions.

1. Explain simple / pure bending
2. Define terms a) Neutral layer b) Neutral axis c) Radius of curvature d) Moment of Resistance e) Modulus of section f) Flexural rigidity
3. State the assumptions made in the theory of simple bending.
4. Sketch and explain bending stress distribution across the depth of the beam for any cross section
5. Obtain the formula for section modulus of (solid and hollow sections): a) Square Section b) Rectangular Section c) Circular Section
6. Calculate section modulus based on above formulae
7. Solve problems on theory of simple bending for symmetrical and unsymmetrical sections to calculate Moment of Resistance, Design of cross section.
8. State formula for calculation of Shear Stress in any layer of a cross section
9. Draw shear distribution diagram across:
 - i) Rectangular section
 - ii) Solid circular section
 - iii) Symmetrical I – section
 - iv) T – section

10. Determine shear stress at any layer from fundamental equation and draw shear stress distribution diagram across:
 - i) Rectangular section
 - ii) Symmetrical I - section
11. Determine the maximum shear stress in circular, rectangular and square and I-sections

CO6 - Analyze bending, shear, torsion, and thin cylinder behavior for practical structural applications.

1. State pure Torsion
2. State the assumptions made in the pure Torsion
3. State and explain the terms in the formula for pure Torsion of a circular shaft
4. Solve the problems on Torsion applying Torsion formula
5. Explain terms: i) Polar modulus ii) Torsional rigidity
6. State and explain the terms in the formula for power transmitted by the circular shaft
7. Solve the problems on power transmitted by the solid and hollow circular shafts
8. Computes the dimensions of a solid / hollow circular shaft based on strength.
9. Define thin cylinder
10. Explain failures of thin cylinders
11. Explain longitudinal and hoop stresses in the cylinder under internal pressure
12. State the formulae for longitudinal and hoop stresses in thin cylinders.
13. Calculate the longitudinal and hoop stresses in the cylinder under internal pressure, given the dimensions of thin cylinders
14. Calculate the thickness of a thin cylinder
15. State the formulae for strains and changes in dimensions of a thin cylinder
16. Calculate the changes in dimensions of a thin cylinder under internal pressure
17. Problems based on joint efficiency.

Suggested Student Activities

1. Prepare a program in MS Excel to find centre of gravity; I_{xx} and I_{yy} of I, L, T and channel sections.
2. Prepare a report on calculation of tensile stress induced in the rope made with any material
3. Demonstrate the stresses developed in composite sections using AUTO CAD

CO-PO Mapping Matrix

	Basic and Discipline Specific Knowledge	Problem Analysis	Design/Development of Solutions	Engineering Tools, Experimentation and Testing	Engineering Practices for Society, Sustainability and Environment	Project Management	Lifelong Learning	Linked PO
CO	PO1	PO2	PO3	PO4	PO5	PO6	PO 7	
CO1	3	2	1	-	1	1	2	1,2,3,5,6,7
CO2	3	2-	1	-	1	1	2	1,2,3,5,6,7
CO3	3	2	1	-	1	1	2	1,2,3,5,6,7
CO4	3	2	2	-	1	1	2	1,2,3,5,6,7
CO5	3	3	1	-	1	1	2	1,2,3,5,6,7
C06	3	2	1	-	1	1	2	1,2,3,5,6,7

QUESTION PAPER PATTERN FOR MID SEMESTER EXAMS

Sl.No	Description	Level	No of Questions	Marks for each question	Choice	Total Marks
01	Part-A	Remembering(R)	4	1	Nil	4 Marks
02	Part-B	Understanding(U)	4	3	2	6 Marks
03	Part-C	Application(A)	4	5	2	10 Marks
Total Marks						20 Marks

MID SEM-I EXAM

S. No	Unit No	R	U	A	Remarks
1	Unit-I	1,2	5(a)	7(a)	
			5(b)	7(b)	
2	Unit-II	3,4	6(a)	8(a)	
			6(b)	8(b)	
Total Questions		4	4	4	

MID SEM-II EXAM

S.No	Unit No	R	U	A	Remarks
1	Unit-III	1,2	5(a)	7(a)	
			5(b)	7(b)	
2	Unit-IV	3,4	6(a)	8(a)	
			6(b)	8(b)	
Total Questions		4	4	4	

The length of answer for each question framed in respect of Part-A, B & C shall not exceed $\frac{1}{4}$ of a page, 1 page and 2 pages respectively

QUESTION PAPER PATTERN FOR SEMESTER END EXAM

Sl.No	Description	Level	No of Questions	Marks for each question	Choice	Total Marks
01	Part-A	Remembering(R)	8	1	Nil	8 Marks
02	Part-B	Understanding(U)	8	3	4	12 Marks
03	Part-C	Application(A)	8	5	4	20 Marks
Total Marks						40 Marks

Unit No	Questions to be set for SEE				
	R		U		A
I	Q4	Q1		Q9(a)	Q13(a)
II					
III		Q2		Q10(a)	Q14(a)
IV					
V		Q3	Q5,Q6	Q9(b), Q11(a), Q11(b)	Q13(b), Q15(a), Q15(b)
VI			Q7,Q8	Q10(b), Q12(a), Q12(b)	Q14(b), Q16(a), Q16(b)
Total Questions	8		8	8	

State Board of Technical Education and Training, Telangana
Model Question paper
DCE I year
Mid Semester-I Examination

Course Code: CE-104
Course Name: Structural Mechanics

Duration: 1 Hour
Max. Marks: 20 Marks

PART-A

Answer **all** questions, Each Question carries *one* mark **4x1 = 4 Marks**

- 1) Define parallel forces.
- 2) Draw BMD and SFD for a simply supported beam with point load at centre.
- 3) What is point of contraflexure
- 4) List types of supports.

PART-B

Answer **two** questions. Each question carries *three* marks **2x 3 = 6 Marks**

- 5) a) Define Force. State parallelogram law of forces
(OR)
b) Two forces of magnitude 60N and 80N act at a point at an angle of 50° . Find the magnitude and direction of resultant force? 80 N force acts Horizontally.
- 6) a) Draw the sketch of a Simply supported beam of 5m length with a central point load of 20 kN and UDL of 15kN/m over the right half portion. Sketch BMD and SFD
(OR)
b) Draw the neat sketches free body diagrams of any six types beams.

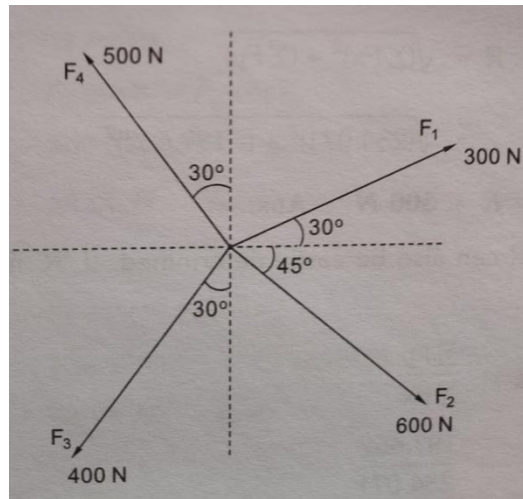
PART-C

Answer **two** questions. Each question carries *five* marks **2x5 = 10Marks**

- 7) a) Four forces of 100N, 200N 300N and 400N are acting at a point in the East, North-East, North-West and South-West directions respectively. Find the resultant and its direction.

OR)

- b) A point is acted upon by a system of four coplanar forces as shown in fig. below. Determine the magnitude and direction of the resultant of the force system.



- 8) a) A cantilever 4m length is subjected to two point loads of 20kN and 30kN at 2m and 3m from the free end. It also carries a udl of 15kN/m over a length of 2 m from free end. Draw a neat sketch of the beam and Calculate Support reactions of the beam.

(OR)

- b) Draw the neat sketch and Determine the support reactions of a beam of 9m length simply supported at the right end and at 6m from the right end. It carries a udl of 15kN/m over a length of 6m from right end and a concentrated load of 10kN at 1m from left end.

State Board of Technical Education and Training, Telangana
Model Question paper
DCE I Year

Mid Semester-II Examination

Course Code: CE-104
Course Name: Structural Mechanics

Duration: 1 Hour
Max. Marks: 20 Marks

PART-A

Answer **all** questions, Each Question carries one mark. **4x1 = 4 Marks**

- 1) Define Centroid.
- 2) Give the position of centroid of a semi-circular section
- 3) Define Stress and Strain
- 4) State Hooke's law.

PART-B

Answer **two** questions. Each question carries *three* marks **2x 3 = 6 Marks**

- 5) a) Find the Centroid of an inverted T-section with flange 80mm x 15mm and web 120mm x 12 mm.

(OR)

- 6) The moment of inertia of rectangular section beam about x-x and y-y axes passing through the centroid are $250 \times 10^6 \text{ mm}^4$ and $40 \times 10^6 \text{ mm}^4$ respectively. Calculate the size of the section.
- 7) A material has Young's modulus of $2.1 \times 10^5 \text{ N/mm}^2$ and Poisson's ratio of 0.3. Calculate the modulus of rigidity and bulk modulus

(OR)

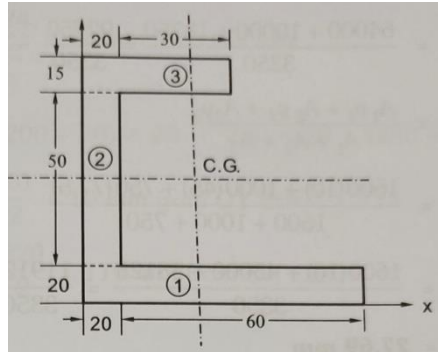
- 8) Define Strain Energy, proof resilience and Modulus of resilience

PART-C

Answer **two** questions. Each question carries *five* marks

2x5 = 10Marks

- 9) a) Determine the position of centroid for the given figure shown below.



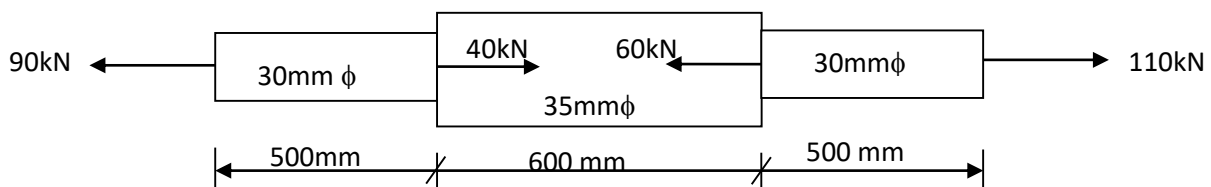
(OR)

- b) Find the position of centroid of one side vertical trapezoidal dam section of top width 2m, base width 8m and height 9m from vertical face.

- a) 8(a) A cylindrical bar is 25mm dia of 1.2m long. During a tensile test it is found that the linear strain is 4 times the lateral strain. Calculate the shear and bulk modulus if the bar is elongated 0.06mm under axial tensile load of 50kN.

(OR)

- b) A steel bar 1.6 long is acted upon by forces as shown in fig. below. Find the elongation of the bar. Given $E=200\text{GPa}$.



State Board of Technical Education and Training, Telangana
Model Question paper
DCE I Year
Semester End Examination

Course Code: CE-104
Course Name: Structural Mechanics

Duration: 2 Hours
Maximum. Marks: 40 Marks

PART-A

Answer **all** questions. Each question carries **one** mark.

8x1 = 8 Marks

- 1) State the classification of Engineering Mechanics.
- 2) Define centroid.
- 3) Write the units of section modulus
- 4) State “Triangle law of forces”.
- 5) Define the moment of resistance.
- 6) What is the neutral axis?
- 7) Write the formula for the power transmitted by a circular shaft.
- 8) Define hoop stress.

PART-B

Answer **four** questions. Each question carries **three** marks.

4x3= 12 Marks

- 9)
 - a) State any three characteristics of a couple.

(OR)

 - b) A steel bar 5 meters long and 50 mm in diameter is stretched by 5.0mm by a load of 120kN in pulling it axially. Determine the modulus of elasticity of the bar.
- 10)
 - a) The M.I of a triangle about its base is $1526.5 \times 10^4 \text{ mm}^4$, the width of base is 120mm. Find the height of the triangle

(OR)

 - b) Define i) Ductility ii) stiffness iii) Malleability
- 11)
 - a) Sketch the shear stress distribution for an I-section beam

(OR)

- b) A material has Young's modulus of $2.1 \times 10^5 \text{ N/mm}^2$ and Poisson's ratio of 0.3. Calculate the modulus of rigidity and bulk modulus

- 12) a) A boiler shell is made of 10mm thick plate having limiting tensile stress of 120 N/mm^2 . The efficiencies of longitudinal and circumferential joints are 70% and 40% respectively. Find the maximum permissible diameter of the shell to withstand a pressure of 1.5 N/mm^2 .

(OR)

- B) Define i) Strain energy ii) Resilience

PART-C

Answer **four** questions. Each question carries **five** marks

4x 5=20 Marks

13)

- a) A telephone pole has five wires radiating from the top of the pole, producing the following concurrent pulls.
- i) 260 N due West
 - ii) 180 N due East
 - iii) 170 N at 30° East of North
 - iv) 240 N due North West
 - v) 200N due South West
- Find the resultant pull in magnitude and direction.

(OR)

- b) A tensile test is carried out on a steel bar of 12 mm diameter over a gauge length of 60mm. The bar yields at a load 25 kN, reaches a maximum load of 47 kN and breaks at 37 kN. The diameter of the ruptured neck is 9.5mm and the final gauge length is 74mm. Determine
- (a) Yield strength
 - (b) Ultimate strength
 - (c) Percentage reduction in area and
 - (d) percentage elongation.

14)

- a) Find the moment of inertia about centroidal axis parallel to XX direction of the built up I-section.

Top plate: 220mm x 20mm

Top flange: 140 mm x 40 mm

Web: 160 mm x 20mm

Bottom flange: 220mm x 40 mm

(OR)

- b) A cylindrical bar is 25mm dia. of 1.2m long. During a tensile test it is found that the linear strain is 4 times the lateral strain. Calculate the shear and bulk modulus if the bar is elongated 0.06mm under axial tensile load of 50kN.

15)

- a) A cast iron beam of symmetrical I-section with top flange 150mm x 10mm, bottom flange 150mm x 10mm and web 280mm x 10mm is simply supported over a span of 6m. If the permissible bending stress is 110 N/mm², what uniformly distributed load can be safely applied on the beam?

(OR)

- b) A symmetrical I-section with flange dimensions 180mm x 10mm and web 12 x 250mm is used as a beam having overall depth 270mm to resist a Shear Force of 60kN. Find the maximum Shear stress developed in the beam.

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- a) A solid steel shaft is to transmit a torque of 1×10^8 N.mm. If the shearing stress does not exceed 45 N/mm², Find the minimum diameter of the shaft.

(OR)

- b) A steel beam is required to safely resist the maximum bending moment of 60 kN.mm. If permissible bending stress is 165N/mm², Determine 1) The required Section Modulus 2) the depth of beam if width is restricted to 120mm