Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.TECH (CE)/SEM-3/CE-304/2009-10

2009

STRUCTURAL MECHANICS

Time Allotted : 3 Hours | Full Marks : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : 10 × 1 = 10

i) In a cantilever with uniformly distributed load the shearing force varies following a

a) linear law b) parabolic law

c) either of these d) none of these.

ii) The rate of change of BM is equal to

a) shear force b) deflection

c) slope d) rate of loads.

iii) The shear stress distribution on a rectangular cross-section of a beam follows

a) a straight line path b) a parabolic path

c) an elliptical path d) a circular path.

iv) Intersecting point of Mohr's circle with *X*-axis represents

a) principal stress

b) normal stress on plane at 45°

c) shear stress on plane at 45°

d) none of these.

v) The maximum stress produced by a beam of tapering section is at

a) large end b) smaller end

c) middle end d) anywhere.

vi) If the end of a body yields, the magnnitude of thermal stress will

a) increase b) decrease

c) remain same d) none of these.

vii) Strain energy is the

a) maximum energy which can be stored in a body

b) energy stored in a body when stressed in elastic limit

c) energy stored in a body when stressed up to the breaking point

d) none of these.

viii) If σ_1 and σ_2 are principal stresses, the shear stress on the principal planes is given by

a) $\frac{\sigma_1 - \sigma_2}{2}$ b) zero

c) $\frac{\sigma_1 + \sigma_2}{2}$ d) $\sigma_1 - \sigma_2$.

ix) If two springs with stiffnesses k_1 and k_2 are connected in series, then stiffness of the composite spring is given by

a) $k_1 + k_2$ b) $\frac{1}{k_1} + \frac{1}{k_2}$

c) $\frac{1}{k_1} - \frac{1}{k_2}$ d) $k_1 - k_2$.

x) The maximum deflection of a cantilever beam of length L subjected to a u.d.l. of w/unit length over the span is

a) $\frac{wL^4}{3EI}$ b) $\frac{wL^4}{4EI}$

c) $\frac{wL^4}{48EI}$ d) $\frac{5wL^4}{384EI}$.

xi) The Euler load for a column is 1000 kN and crushing load is 1500 kN. The Rankine load is

a) 600 kN b) 1000 kN

c) 1500 kN d) 2500 kN.

xii) The slenderness ratio of a long column is

a) 10 – 20 b) 20 – 30

c) 50 – 60 d) above 80.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. Prove $\frac{dM}{dx} = V$, where M & V are bending moment and shear force at a distance x from origin.

3. Derive the relation between modulus of elasticity and modulus of rigidity.

4. Draw the shear force and bending moment diagram of a simply supported beam (length l m) carrying uniformly distributed load (w N/m) throughout the length.

5. Compare the strength of two identical beams except their cross-section. One is of circular section of diameter x and other is a square of side x. Which one would you prefer against bending stress ?

6. Find the deflection at the mid-point of the beam mentioned in Problem 4.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. a) Prove that $\frac{M}{I} = \frac{\sigma}{Y} = \frac{E}{R}$. 6

   b) What are the assumptions in simple theory of bending ? 4

   c) A simply supported beam of span 5 m has a cross-section 150 mm × 250 mm. If the permissible stress is 10 N/mm^2 , find

      i) maximum intensity of uniformly distributed load it can carry

      ii) maximum concentrated load P applied at 2 m from one end it can carry. 5

8. a) Prove that $\frac{T}{I_P} = \frac{\sigma}{R} = \frac{G\theta}{L}$. 5

b) A shaft is required to transmit 245 kW power at 240 rpm. The maximum torque may be 1·5 times the mean torque. The shear stress in the shaft should not exceed 40 N/mm^2 and the twist 1 per metre length. Determine the diameter required if

i) the shaft is solid

ii) the shaft is hollow with external diameter twice the internal diameter.

Take modulus of rigidity = 80 kN/mm^2 . 10

9. a) What are Mohr's circle, principal plane and principal stress ? 6

b) A state of stress is specified in the figure 1. Determine the normal and shearing stress on

i) principal planes

ii) the planes of maximum shearing stress. Show the results of part (i) and (ii) on complete sketches of differential element. 9

dia

Figure – 1

10. Write the shear force and bending moment equation for the beam shown in figure 2. Sketch the shear force and bending moment diagram and locate the position of occurrence of maximum bending moment.

dia

Figure – 2

11. Determine the deflection at the free end and middle of the span of the cantilever beam loaded as shown in figure 3. The flexural rigidity (*i.e.* EI) of the beam is uniform throughout its length.

dia

Figure – 3

12. a) A pipe of 400 mm internal diameter and 100 mm thickness contains a fluid at a pressure 80 N/mm^2 . Find the maximum and minimum hoop stresses across the section. Also sketch the radial and hoop stress distribution across the section. 8

    b) A 2 m long pin ended column of square cross-section is to be made of wood. Assuming E = 12 GPa and allowable stress being limited to 12 MPa determine the size of the column to support the following loads safely :

    i) 95 kN ii) 200 kN.

    Use factor of safety of 3 and Euler's crippling load for buckling. 7

13. a) Determine a close helical spring to have the following properties : 8

i) Stiffness = 5 N/mm

ii) Solid length = 100 mm approximately.

b) Determine the formula used to solve the above problem. 7