KATHMANDU UNIVERSITY
End Semester Examination
January/February 2024

01 FEB 2024

Marks Scored:

Level : B.E.
Year : II

Course : MEEG 202
Semester : II

Exam Roll No. :

Time: 30 mins.

F. M. : 20

Registration No.:

Date :

SECTION "A"
[20Q. × 1 = 20 marks]

Choose and mark [X] in the most appropriate option from each set of choices

1. A mild steel wire 5 mm in diameter and 1 m long. If the wire is subjected to an axial tensile load 10 kN. Find its extension of the rod, if E= 200 GPa.
[ ] $\delta = 10.55$ mm [ ] $\delta = 6.55$ mm [ ] $\delta = 2.55$ mm [ ] $\delta = 12.55$ mm

2. Consider the bolted joint shown in Figure 1. The force P is 30 kN and the diameter of the bolt is 10 mm. Determine the average value of the shearing stress existing across either of the planes a-a or b-b.
[ ] 41 MPa [ ] 81 MPa
[ ] 191 MPa [ ] 101 MPa

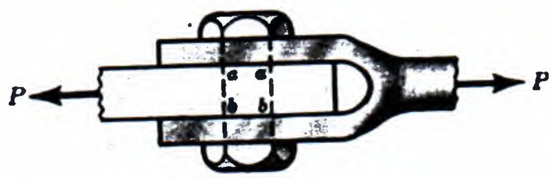


Figure 1

3. In the case of an engineering material under unidirectional stress in the x-direction, the poisons ratio is equal to
[ ] σ_y / σ_x [ ] σ_y / ε_x [ ] $\varepsilon_y / \varepsilon_x$ [ ] ε_y / σ_x

4. A cantilever beam with flexural rigidity of 200 Nm² is loaded as shown in the figure 2. The deflection (in mm) at the tip of the beam is
[ ] 2.3 mm [ ] 0.3 mm
[ ] 0.26 mm [ ] 0.6 mm

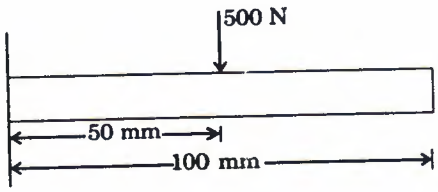


Figure 2

5. Determine the reactions R_L, R_R of a simply supported beam with a point load as shown in the figure 3
[ ] 3.5 KN, 4.5 KN [ ] 4.5 KN, 3.5 KN
[ ] 2.5 KN, 3.5 KN [ ] 3.5 KN, 2.5 KN

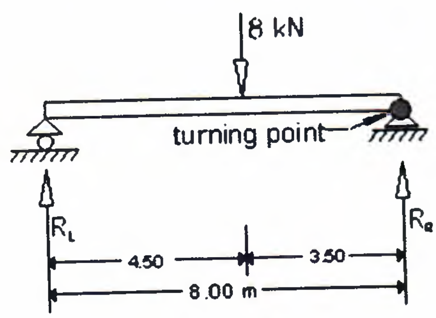


Figure 3

6. The state of stress at a point in a loaded machine member is given by the principle stresses are $\sigma 1= 600$ MPa, $\sigma 2= 0$ and $\sigma 3= -600$ MPa. Determine the magnitude of maximum shear stress.
[ ] 600 MPa [ ] 400 MPa
[ ] 200 MPa [ ] 0 MPa

7. The shapes of the bending moment diagram for a uniform cantilever beam carrying a uniformly distributed load over its length is:
[ ] A Straight Line [ ] A Hyperbola [ ] An Ellipse [ ] A Parabola

8. A steel rod of length L and diameter D, fixed at the both ends, is uniformly heated to a temperature rise ΔT. The Young's Modulus is E and the co efficient of linear expansion α. The thermal stress in the rod is
[ ] $E\alpha\Delta TL$ [ ] $E\alpha\Delta T$ [ ] 0 [ ] ΔTL

9. Let load a circular shaft beyond the onset of yield and unload it, refer the figure 4

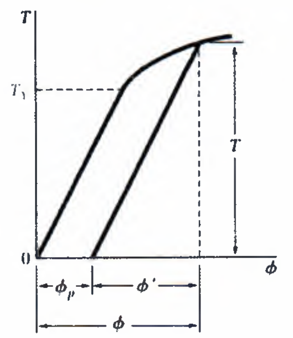


Figure 4

[ ] Results in elastic deformation and there won't be residual stresses
[ ] Results in elastic deformation and there will be residual stresses
[ ] Results in permanent deformation and there will be residual stresses
[ ] Results in permanent deformation and there won't be residual stresses

10. A beam of length L is carrying a uniformly distributed load w per unit length. The flexural rigidity of the beam is EI. The reaction at the simple support at the right end is
[ ] 3L/8 [ ] L/8 [ ] 5L/8 [ ] 3L/16

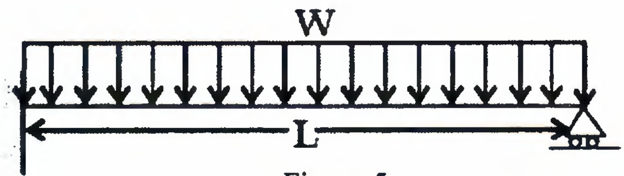


Figure 5

11. The outside diameter of a hollow shaft is twice it's inside diameter. The ratio of its torque carrying capacity to that of a solid shaft of the same material and the same outside diameter is
[ ] 1/2 [ ] 3/4 [ ] 15/16 [ ] 1/16

12. Determine the torque T that causes a maximum shearing stress of 80 MPa in the steel cylindrical shaft as shown in figure 6.

[ ] 133.8 KN.m [ ] 120.8 KN.m
[ ] 123.8 KN.m [ ] 113.8 KN.m

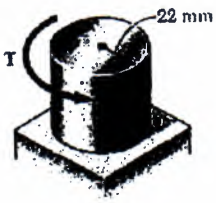


Figure 6

13. The area moment of inertia of a square of size 1 unit about its diagonal of figure 7 is ______

[ ] 1/3 [ ]1/2 [ ]1/6 [ ] 1/12

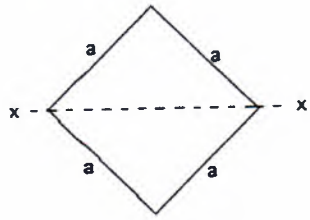


Figure 7

14. The shear force in a beam subjected to pure positive bending is

[ ] Positive [ ] Negative
[ ] Zero [ ] Non Deterministic

15. The point of contra flexure is a point where

[ ] Shear forces changes sign [ ] Shear forces are maximum
[ ] Bending moment changes sign [ ] Bending moment is maximum

16. Consider a Simply supported beam with a gradually varying load (GVL) zero at one end and w/unit length at other span. Determine R_A, R_B, $V_{X=0}$, $V_{X=L}$

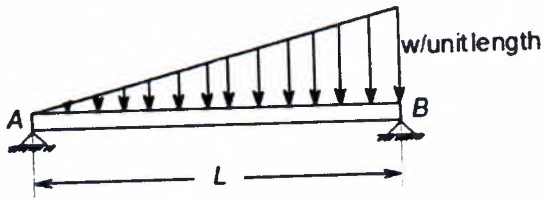


Figure 6

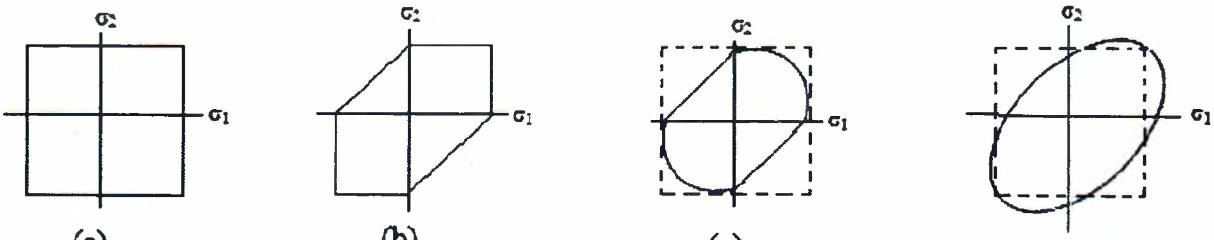
[ ] $R_A = wL/6$, $R_B = wL/3$, $V_{X=0} = wL/2$, $V_{X=L} = -wL/3$
[ ] $R_A = wL/2$, $R_B = wL/3$, $V_{X=0} = wL/6$, $V_{X=L} = -wL/3$
[ ] $R_A = wL/6$, $R_B = wL/3$, $V_{X=0} = wL/2$, $V_{X=L} = -wL/3$
[ ] $R_A = wL/6$, $R_B = wL/3$, $V_{X=0} = wL/6$, $V_{X=L} = -wL/3$

17. Consider a long and slender column with both ends pinned. The column has a length (L) and is made of a material with a modulus of elasticity (E). If the column is subjected to an axial load, derive the critical buckling load (Pcr) for this column using the Euler's formula. Assume that the column is not perfectly straight and has an initial lateral displacement at the midpoint.

[ ] $P_{cr} = \pi^2 EI/(2L)^2$ [ ] $P_{cr} = \pi^2 EI/L^2$
[ ] $P_{cr} = \pi^2 EI/(4L)^2$ [ ] $P_{cr} = \pi^2 EI/(L/2)^2$

18. Two long columns with critical load P1 and P2 are made of identical lengths "l" and flexural rigidities "EI". Column 1 is hinged at both ends whereas for column 2 one end is fixed and the other end is free.
What is the ratio of Euler's buckling load of column 1 to that column 2?
[ ] $P_1/P_2 = 1$ [ ] $P_1/P_2 = 2$ [ ] $P_1/P_2 = 1/2$ [ ] $P_1/P_2 = 4$

19. For $\sigma_1 \neq \sigma_2$ and $\sigma_3 = 0$, what is the physical boundary for Rankine's failure theory?



(a) (b) (c) (d)

[ ] a [ ] b [ ] c [ ] d

20. According to Von-Mises distortion Energy Theory, the distortion energy under three dimensional stress state is represented by
[ ] $1/ \varepsilon E\ [\sigma^2_1 + \sigma^2_2 + \sigma^2_3 - 2m\ (\sigma_1\sigma_2 + \sigma_3\sigma_2 + \sigma_1\sigma_3)]$
[ ] $1 - 2\mu/ 6E\ [\sigma^2_1 + \sigma^2_2 + \sigma^2_3 - 2m\ (\sigma_1\sigma_2 + \sigma_3\sigma_2 + \sigma_1\sigma_3)]$
[ ] $1 + \mu/ 3E\ [\sigma^2_1 + \sigma^2_2 + \sigma^2_3 - 2m\ (\sigma_1\sigma_2 + \sigma_3\sigma_2 + \sigma_1\sigma_3)]$
[ ] $1 / 3E\ [\sigma^2_1 + \sigma^2_2 + \sigma^2_3 - 2m\ (\sigma_1\sigma_2 + \sigma_3\sigma_2 + \sigma_1\sigma_3)]$

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SECTION "B"
[55 marks]

Attempt *ALL* questions. Assume suitable data if necessary.

1. a. Determine the total increase of length of a bar of constant cross section hanging vertically and subject to its own weight as the only load. The bar is initially straight.[2]

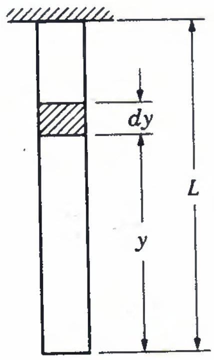


Figure 1

b. A steel pipe of 300-mm outer diameter is fabricated from 6-mm thick plate by welding along a helix that forms an angle of 25° with a plane perpendicular to the axis of the pipe. Knowing that a 250-kN axial force P is applied to the pipe, determine the normal and shearing stresses in directions respectively normal and tangential to the weld. [4]

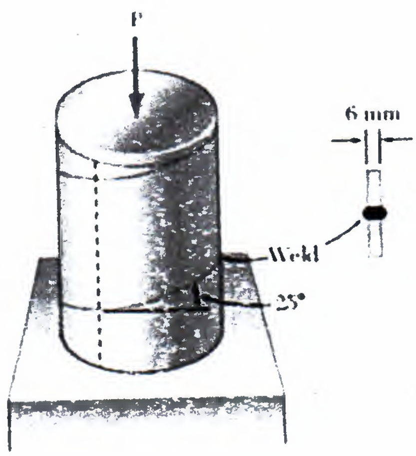


Figure 2

c. Determine the reactions at A and B for the steel bar and loading shown in Figure 3, assuming a close fit at both supports before the loads are applied. Use the details in the figure shown below. [5]

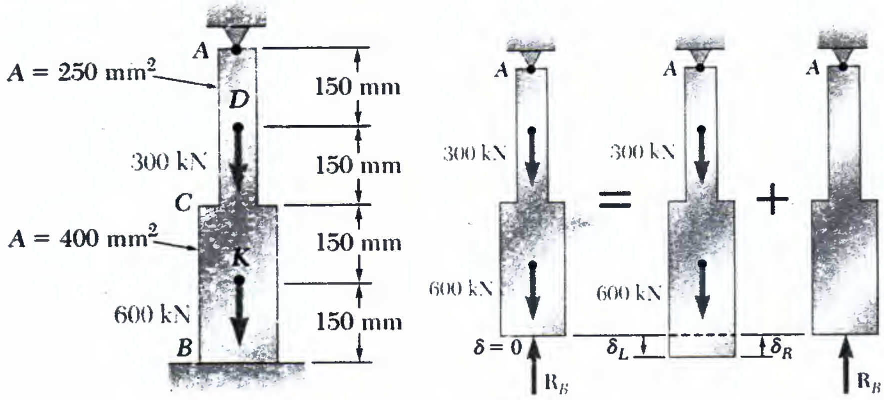


Figure 3

2. a. A 500-mm-long, 16-mm-diameter rod made of a homogenous, isotropic material is observed to increase in length by 300 mm, and to decrease in diameter by 2.4 mm when subjected to an axial 12-kN load. Determine the modulus of elasticity and Poisson's ratio of the material. [2]

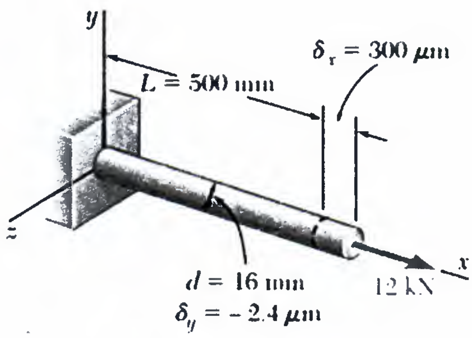


Figure 4

b. The ship at A has just started to drill for oil on the ocean floor at the depth of 1500 m. Knowing that the top of the 200-mm-diameter steel drill pipe (G = 77.2 GPa) rotates through two complete revolutions before the drill bit at B starts to operate, determine the maximum shearing stress caused in the pipe by torsion. [4]

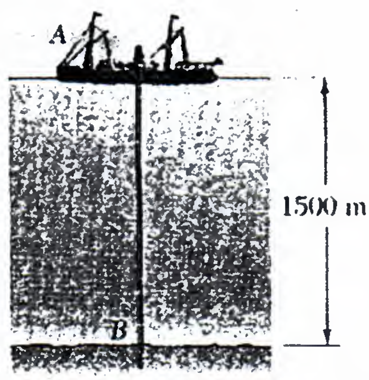


Figure 5

c. The electric motor exerts a 500 N.m-torque on the aluminum shaft ABCD when it is rotating at a constant speed. Knowing that G= 27 GPa and that the torques exerted on pulleys B and C are as shown in figure 6, determine the angle of twist between (a) B and C, (b) B and D. [5]

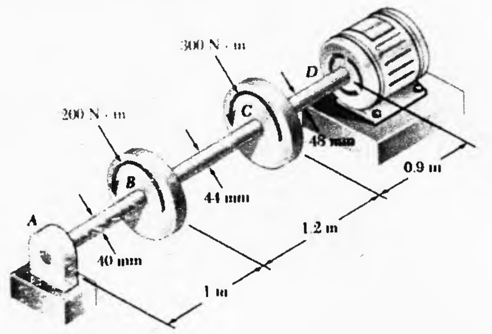


Figure 6

3. a. Determine the equation of the deflection curve for a simple beam AB supporting a uniform load of intensity q acting throughout the span of the beam as shown in the figure. Also, determine the maximum deflection δ_{max} at the midpoint of the beam and the angles of rotation θ_A and θ_B at the supports as shown in the figure 7.
(Note: The beam has length L and constant flexural rigidity EI.) [6]

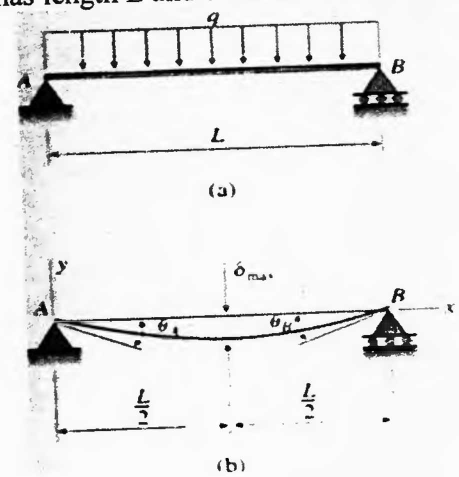


Figure 7

b. The cantilever beam AC in Figure 8 is loaded by the uniform load of 600 N/m over the length BC together with the couple of magnitude 4800 N.m at the tip C. Determine the shearing force and bending moment diagrams. [5]

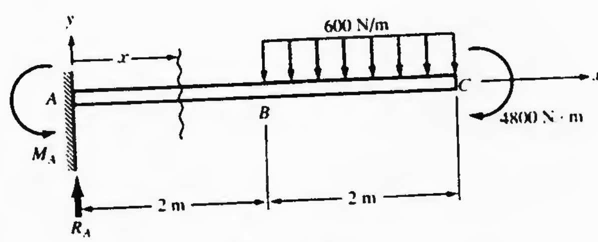


Figure 8

4. a. Knowing that W = 3 kips, draw the shear and bending moment diagrams for the beam AB and determine the maximum normal stress due to bending. [5]

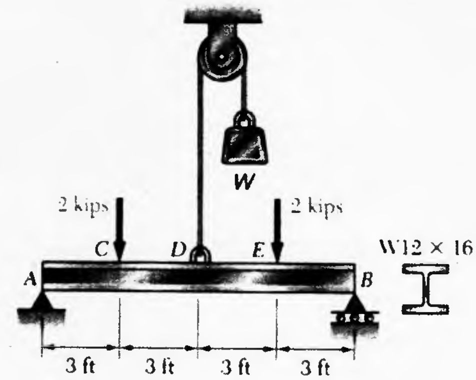
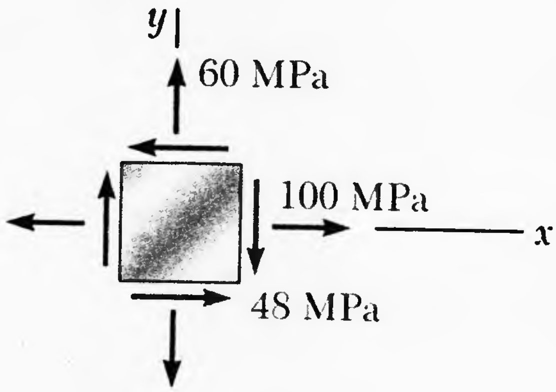


Figure 9

b. For the state of plane stress shown in figure 10, determine (i) the principal planes and the principal stresses, (ii) the stress components exerted on the element obtained by rotating the given element counterclockwise through 30^0. [6]



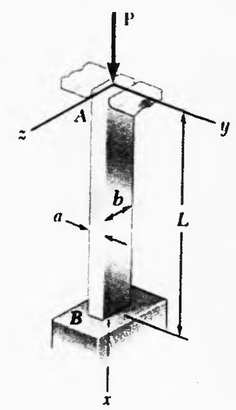


Figure 10

Figure 11

5. a. An aluminum column of length L and rectangular cross section has a fixed end B and supports a centric load at A as shown in figure 11. Two smooth and rounded fixed plates restrain end A from moving in one of the vertical planes of symmetry of the column, but allow it to move in the other plane. [6]

i. Determine the ratio a/b of the two sides of the cross section corresponding to the most efficient design against buckling.

ii. Design the most efficient cross section for the column, knowing that L = 20 in., $E = 10.1 \times 10^6$ psi, P = 5 kips, and that a factor of safety of 2.5 is required.

b. List all types of Failure Theory and Explain in detail The Von Mises Stress Theory. [5]