Index Number:

UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 2 Examination in Engineering: March 2026

Module Number: CE2302 **Module Name**: Mechanics of Materials (C23)

Part A - [Two Hours]

Answer all questions. Circle the most appropriate answer for questions 1-25. Questions 1 to 5 carry 1.2 marks each, and questions 6 to 25 carry 1.5 marks each.

All notations have their usual meanings

1. The shear stress in the flanges of an I-beam compared to the web is,

   (i) Much higher (ii) Nearly zero or negligible (iii) Equal to web shear stress (iv) Twice the web shear stress

2. In a beam under pure bending, the normal stress distribution across the cross-section is,

   (i) Uniform (ii) Linear (iii) Parabolic (iv) Zero

3. The maximum load recorded during a tensile test, divided by the original cross-sectional area of the specimen, is defined as its----------

   (i) True stress (ii) Breaking stress (iii) Yield strength (iv) Ultimate tensile strength

4. For a simply supported rectangular beam (depth > width) subjected to a uniformly distributed load (UDL) along its entire span, what is the most effective method of reducing the mid-span deflection?

   (i) Reducing length (ii) Increasing depth (iii) Increasing width (iv) Reducing UDL

5. Which property of a stress tensor remains unchanged for different orientations of the stress block?

   (i) Shear stress, τ_{xy}

   (ii) Difference between normal stresses, $\sigma_x - \sigma_y$

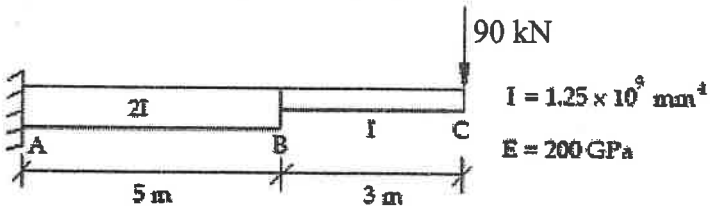
   (iii) Sum of the normal stresses, $\sigma_x + \sigma_y$

   (iv) Orientation of the principal planes

6. A tubular shaft to be used at a construction site must transmit 120 kW at 1.75 Hz. The inner diameter of the shaft is to be half of the outer diameter. If the allowable shear stress in the shaft is 45 MPa, what is the minimum required outer diameter?

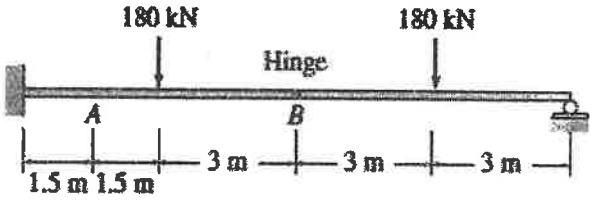
   (i) 85 mm (ii) 103 mm (iii) 110 mm (iv) 120 mm

7. What is the deflection at the free end of the cantilever beam shown below?



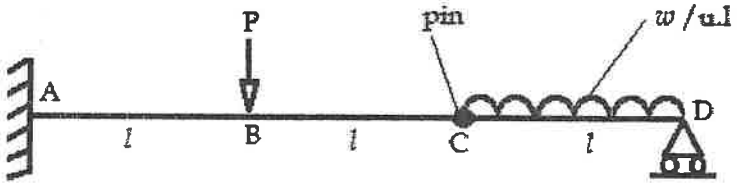
(i) 32.3 mm (ii) 28.5 mm (iii) 16.2 mm (iv) 14.3 mm

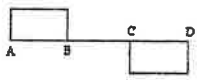
8. For the propped cantilever beam shown below, the bending moment at section A is:

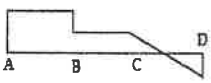


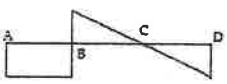
(i) 540 kNm (ii) 675 kNm (iii) 1080 kNm (iv) 0

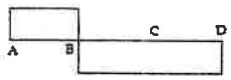
9. Beam ABCD is fixed at A, supported by a roller at D, and has an internal hinge at C. It carries a point load at B and a uniformly distributed load along span CD. The most appropriate shear force diagram for the beam is:



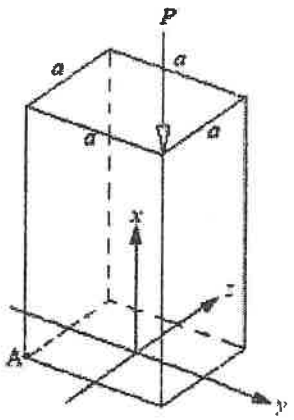
(i) 

(ii) 

(iii) 

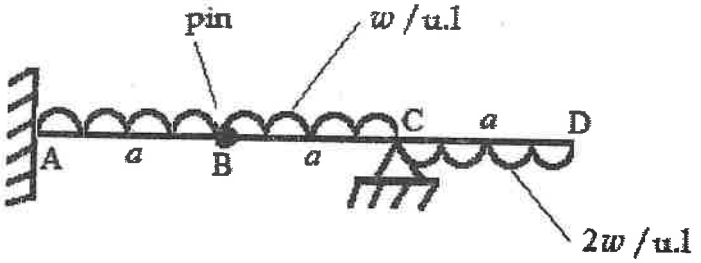
(iv) 

10. A short, solid square column is subjected to an eccentric load P, as illustrated in the figure below. Given that the cross-section has equal sides of length a, the normal stress developed at corner point A is:



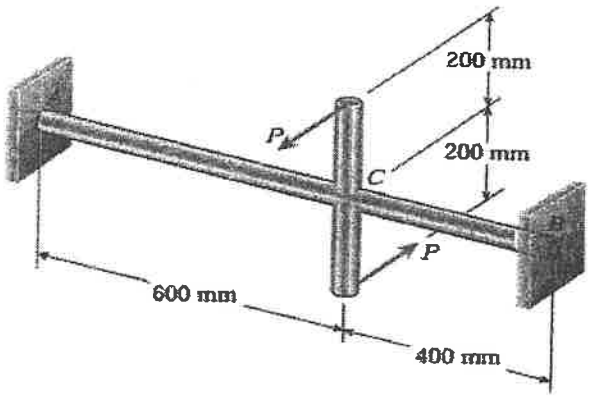
(i) $7P/a^2$ (ii) $5P/a^2$ (iii) $2P/a^2$ (iv) P/a^2

11. For the overhanging beam ABCD (AB = BC = CD = a) as shown below, the maximum hogging and maximum sagging bending moments are:



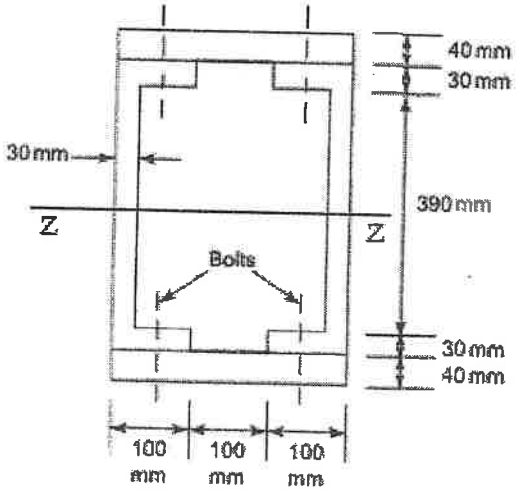
(i) wa^2, wa^2 (ii) $2wa^2$, $2wa^2$ (iii) $2wa^2$, wa^2 (iv) wa^2, $2wa^2$

12. A hollow steel shaft ACB, with an outer diameter of 50 mm and an inner diameter of 40 mm, is rigidly fixed at both ends A and B, as shown in the figure. Horizontal forces P are applied at the ends of a vertical arm, welded to the shaft at point C. If the maximum permissible shear stress in the shaft is 45 MPa, what are the allowable value of the forces P?



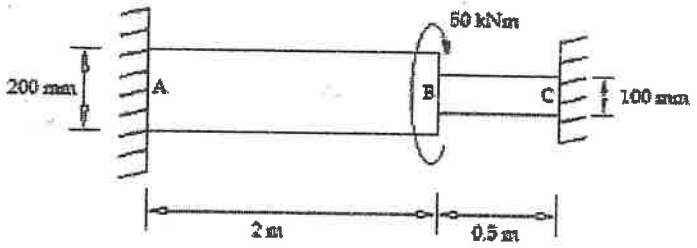
(i) 1.81 kN (ii) 2.72 kN (iii) 3.4 kN (iv) 4.08 kN

13. A steel box beam section, as shown in the following figure, is subjected to a maximum shear force of 250 kN. If the second moment of area of the section about z-z axis, Iz = 2270.5 × 10^6 mm^4 and the shear capacity of a bolt is 150 kN, what is the most appropriate bolt spacing along the beam?



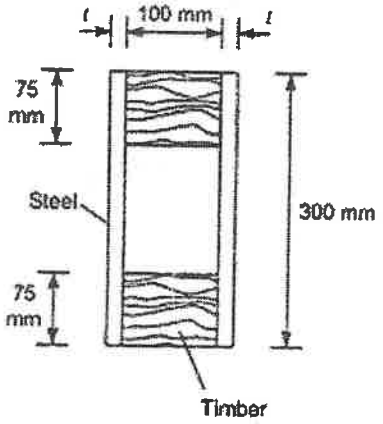
(i) 230 mm (ii) 460 mm (iii) 925 mm (iv) 1850 mm

14. A circular shaft ABC is shown below. The shaft is firmly fixed at both ends and is subjected to a torque of 50 kNm at point B. Given that the shear modulus G=80000 N/mm², the maximum shear stress in the shaft is:



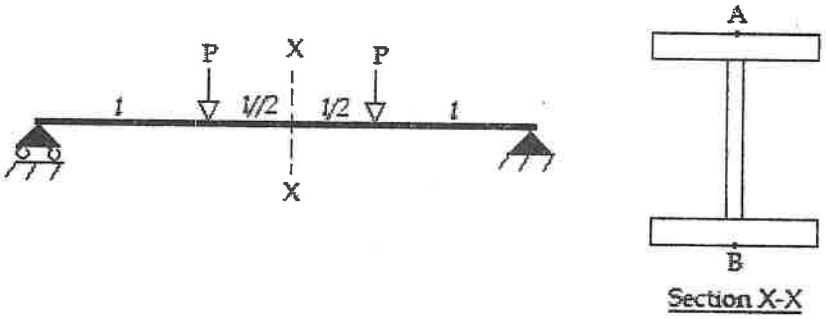
(i) 50.9 MPa (ii) 25.5 MPa (iii) 63.7 MPa (iv) 40.1 MPa

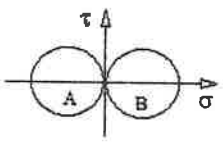
15. A simply supported beam with a span of 4 m carries a uniformly distributed load of 10 kN/m. The beam is constructed as a composite section, as shown in the figure. If the allowable stresses are 124 N/mm² for steel and 8 N/mm² for timber, what is the most appropriate thickness of the steel plate? Assume a modular ratio of steel to timber is 20.

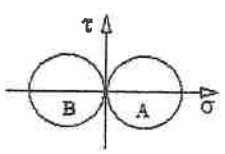


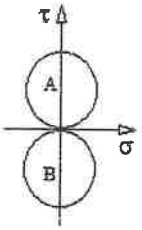
(i) 2 mm (ii) 4 mm (iii) 6 mm (iv) 8 mm

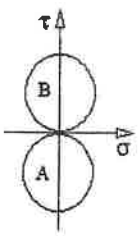
16. Which of the following Mohr's circles represents the state of stress at points A and B on cross-section X–X of a simply supported beam?



(i) 

(ii) 

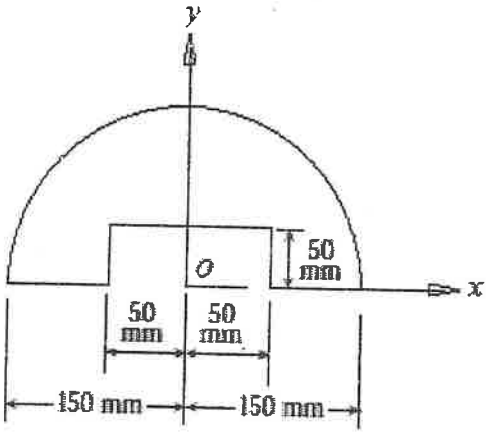
(iii) 

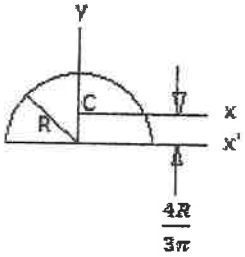
(iv) 

17. A cantilever beam of rectangular cross-section (with depth d > width b) carries a UDL of intensity w over its full span L. If both the load intensity and the depth of the beam are doubled, what is the resulting deflection at the free end? Assume all other parameters remain unchanged.

(i) Reduced by factor of 2 (ii) Increased by factor of 2 (iii) Increased by factor of 4 (iv) Reduced by factor of 4

18. A semicircular area has a rectangular cutout as shown below. The second moment of area, I_x, about x- axis is approximately:





$I_{x'} = \frac{4R^4}{8}$

(i) 195x10⁶ mm⁴ (ii) 199x10⁶ mm⁴ (iii) 183x10⁶ mm⁴ (iv) 190x10⁶ mm⁴

19. The stress tensor at a point in a stressed body is shown below. What is the transformed stress tensor (in MPa), when the corresponding element is rotated by 15° clockwise. The normal and shear stress transformation equations, using standard notation and sign conventions, are given as follows

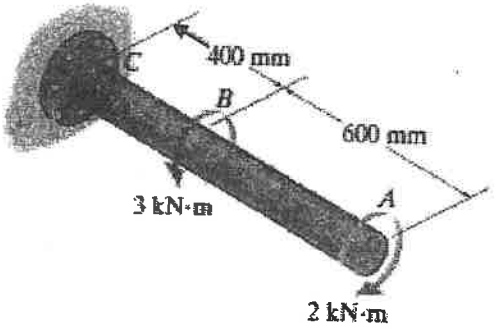
$$[\sigma] = \begin{bmatrix} -46 & -19 \\ -19 & 12 \end{bmatrix} MPa$$

$$\sigma_{x1} = \left(\frac{\sigma_x+\sigma_y}{2}\right) + \left(\frac{\sigma_x-\sigma_y}{2}\right) cos\,2\theta + \tau_{xy}\, sin\,2\theta$$

$$\tau_{x1y1} = -\left(\frac{\sigma_x-\sigma_y}{2}\right) sin\,2\theta + \tau_{xy}\, cos\,2\theta$$

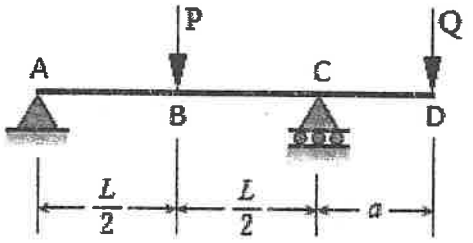
(i) $\begin{bmatrix} -51.6 & 2 \\ 2 & 17.6 \end{bmatrix}$ (ii) $\begin{bmatrix} -32.6 & -31 \\ -31 & -1.4 \end{bmatrix}$ (iii) $\begin{bmatrix} -32.6 & 31 \\ 31 & -1.4 \end{bmatrix}$ (iv) $\begin{bmatrix} -1.4 & -31 \\ -31 & -32.6 \end{bmatrix}$

20. The 60 mm diameter steel shaft is subjected to the torques as shown below. What is the angle of twist at end A with respect to support C. Assume G = 75 GPa.



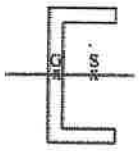
(i) 15.72x10⁻³ rad (ii) 12.57x10⁻³ rad (iii) 8.38x10⁻³ rad (iv) 4.19x10⁻³ rad

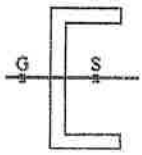
21. The overhanging beam ABCD supports two concentrated loads P and Q as shown below. For what ratio P/Q will the deflection at point B be zero?

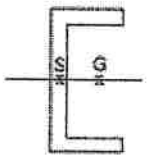


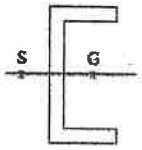
(i) $\frac{a}{L}$ (ii) $\frac{2a}{L}$ (iii) $\frac{3a}{L}$ (iv) $\frac{4a}{L}$

22. For a thin-walled channel (C) section as shown below, which section shows the correct positions of centroid G and shear center S?

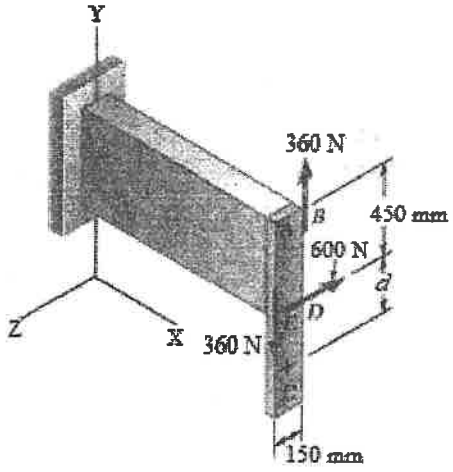
(i) 

(ii) 

(iii) 

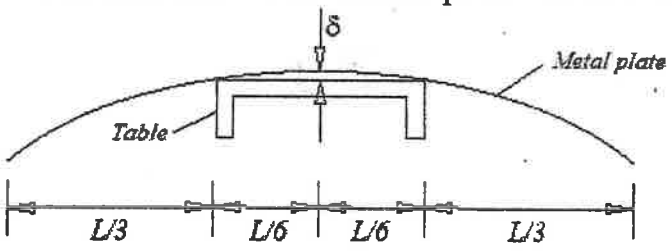
(iv) 

23. A wall bracket is subjected to a loading system as shown below. For the stability of wall bracket, what is the load required at point C and the distance, *d* to C, from the ED line?



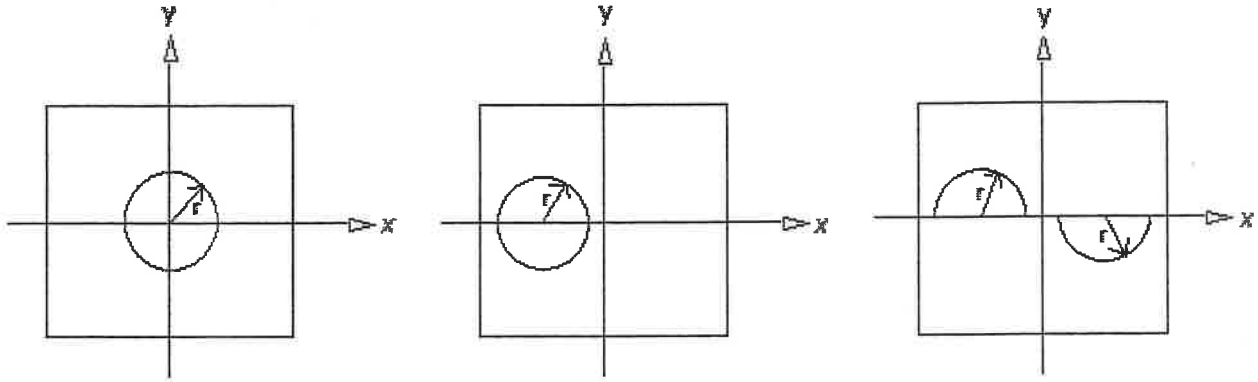
(i) 600N in Z -ve d=150 mm (ii) 600N in Z +ve d=450mm (iii) 600N in Z -ve d=90 mm (iv) 600N in Z +ve d=90 mm

24. A thin metal plate of total weight *W* and length L is placed across the top of a flat table of width *L/3* as shown below. The clearance δ between the plate and the middle of the table is,



(i) $\frac{19WL^3}{31104EI}$ (ii) $\frac{WL^3}{1296EI}$ (iii) $\frac{5WL^3}{31104EI}$ (iv) $\frac{WL^3}{3456EI}$

25. Consider three square cross sections shown below. If an area of circle having radius r is removed from each cross sections, what is the correct order of radius of gyration r_x about x axis for the remaining area?



(i) a > b > c (ii) c > b > a (iii) a = b < c (iv) a = b =c