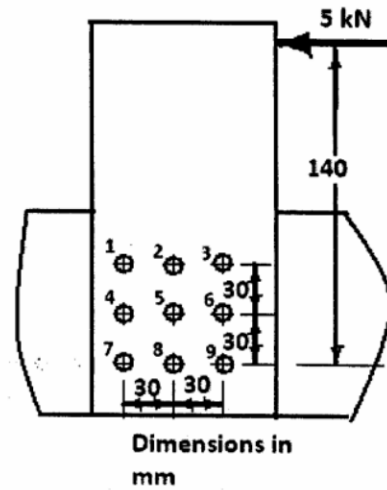


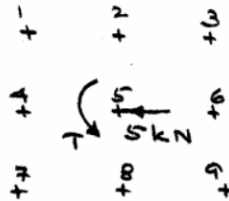
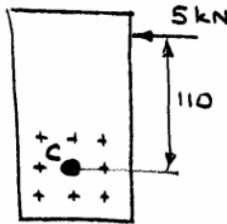
Question 1: (20 pts)

The riveted connection shown in Figure consists of nine rivets of 8 mm diameter each. This connection transmits a 5 kN horizontal force.

- (1) Determine the shear stress components in each rivet due to (a) direct shear and (b) torsion (10 pts)
- (2) Show these components in the figure provided for your answer. (6 pts)
- (3) Identify the heavily stressed rivets and determine the maximum shear stress. (4 pts)



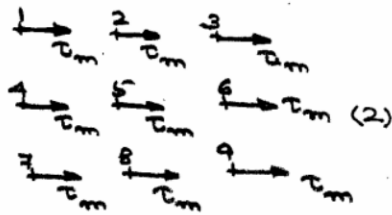
Equivalent Load:



$$T = 5 \times 10^3 \times 0.110 = 550 \text{ Nm. (CCW)}$$

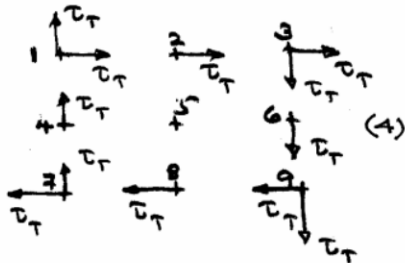
(1) (1)

Direct Shear:



$$\tau_m = \frac{5 \times 10^3}{9 \times \frac{\pi}{4} \times 8^2} = 11.05 \text{ MPa. (2)}$$

Torsion:



$$J = \left(\frac{\pi}{4} \times 8^2 \right) \left\{ 4(30^2 + 30^2) + 2(30^2 + 0^2) + 2(0^2 + 30^2) \right\} = 542867 \text{ mm}^4 \quad (2)$$

For 1, 3, 7, 9:

$$\tau_{Tx} = \tau_{Ty} = \tau_T = \frac{550 \times 10^3 \times 30}{542867} = 30.39 \text{ MPa. (3)}$$

For 2, 8

$$\tau_{Tx} = \tau_T \quad \tau_{Ty} = 0$$

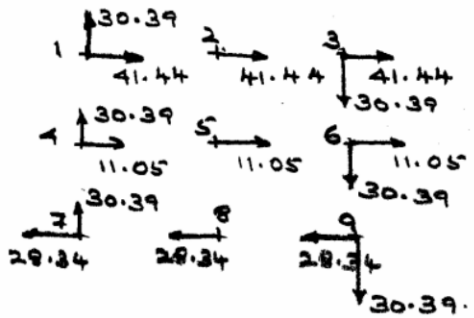
For 4, 6

$$\tau_{Tx} = 0 \quad \tau_{Ty} = \tau_T$$

For 5

$$\tau_{Tx} = 0 \quad \tau_{Ty} = 0$$

Combined Stress:



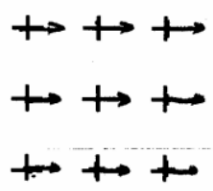
∴ ① and ③ are the heavily stressed rivets. (2)

$$\tau_{max} = \sqrt{41.44^2 + 30.39^2} = 51.39 \text{ MPa. (2)}$$

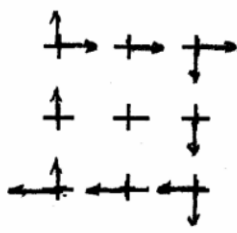
1a) $\tau_m = 11.05 \text{ MPa}$

1b) $\tau_T = 30.39 \text{ MPa}$

2a Direct



2b Torsion



3a) Rivet #: ① & ③

3b) $\tau_{max} = 51.39 \text{ MPa.}$

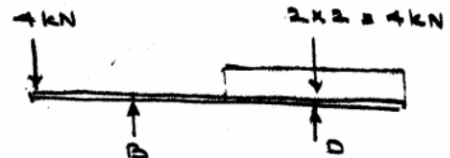
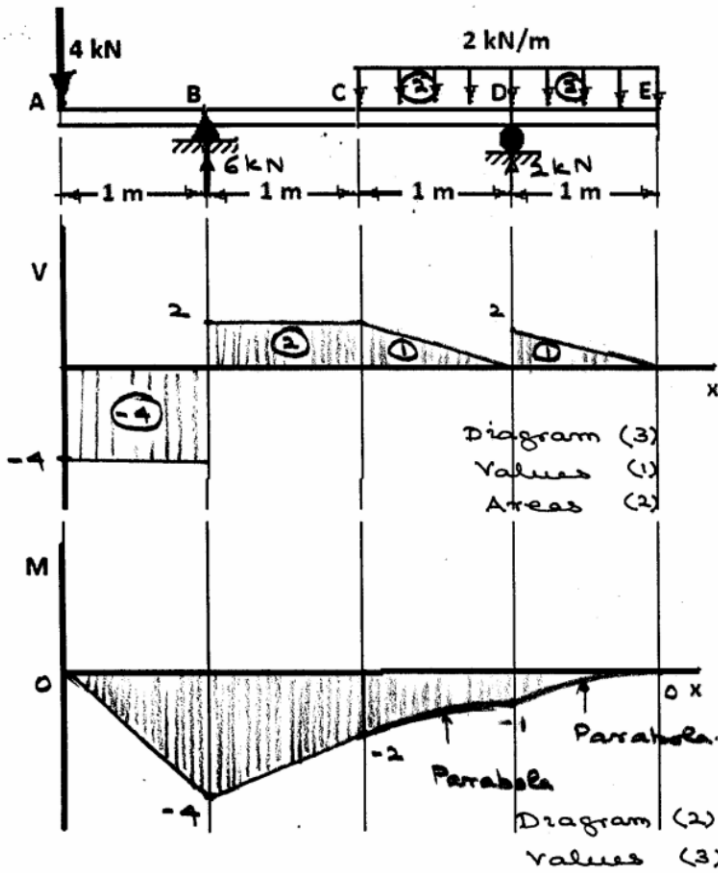
Question 2: (20 pts)

The transverse loading on a 4 m long uniform beam ABCDE is shown.

(a) Provide a neat sketch of the shear force and the bending moment diagrams. Show the important steps of your calculation. Indicate all relevant magnitudes in your sketch. (13 pts)

20

(b) Using a safety factor of 2.5, determine the minimum section modulus of an S-shape steel I-beam for your design of this beam. (7 pts)



$$\sum \circlearrowleft D - 4(3) + B(2) = 0$$

$$B = 6 \text{ kN} \quad (1)$$

$$\uparrow -4 + B - 4 + D = 0$$

$$D = 2 \text{ kN} \quad (1)$$

Max negative BM
= 4 kNm.
(1)

$$\sigma_{ult} = 400 \text{ MPa} \quad (1)$$

$$SF = 2.5$$

$$\sigma_{all} = \frac{400}{2.5} = 160 \text{ MPa} \quad (1) \quad (8)$$

$$S = \frac{M}{\sigma_{all}} = \frac{4 \times 10^3}{160 \times 10^6} \text{ m}^3 = 25 \times 10^{-6} \text{ m}^3 = 25 \times 10^3 \text{ mm}^3 \quad (1) \quad (1)$$