

1a

$$F = ma$$

$$F = 850 \times 4$$

$$= 3400 \text{ N}$$

5

1b

$$V = \pi r^2 h$$

$$= \pi \times 0.3^2 \times 0.95$$

$$= \underline{\underline{0.269 \text{ m}^3}}$$

2

$$\rho = \frac{m}{V}$$

$$\therefore m = \rho V$$

$$= 700 \times 0.269$$

$$= 188.3 \text{ kg}$$

2

$$\text{Barrel} + \text{oil} = 188.3 + 8$$

Combined weight

$$= (188.3 + 8) \times 9.81$$

$$= \underline{\underline{1.926 \text{ kN}}}$$

1

1c

$$n = 300 \text{ rpm}$$

$$\omega = \frac{2\pi n}{60}$$

$$= \frac{2 \times \pi \times 300}{60}$$

$$= 10\pi \text{ rads/s}$$

$$V = \omega r$$

$$= 10\pi \times \frac{0.75}{2}$$

$$= 5\pi \times 0.75$$

$$= 11.78 \frac{\text{m}}{\text{s}}$$

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2

3

1d

Mass is defined as the amount of matter in a body

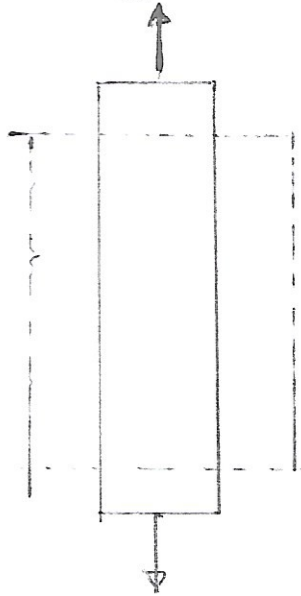
Or: As a measure of the inertia of a body

Weight is the force exerted by a body due to the effect of gravity.

Unit: mass kg

Weight N.

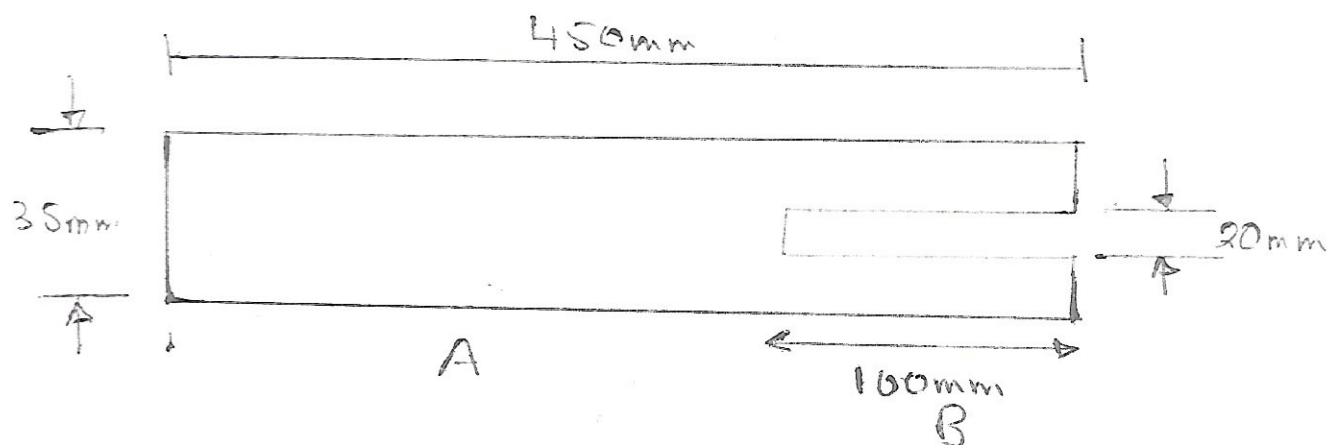
2a Poisson's ratio is a measure of the deformation of a material in directions perpendicular to the line of a force acting on the body



$$\text{Poisson's ratio } \nu = \frac{\text{lateral strain}}{\text{longitudinal strain}}$$

Normal values 0.2 to 0.5 (dimensionless)

2b



Consider section A

$$\sigma' = \frac{F}{a} = \frac{4F}{\pi d^2}$$

$$= \frac{4 \times 190 \times 10^3}{\pi \times 0.035^2}$$

$$\sigma' = 197 \text{ MPa}$$

$$E = \frac{\sigma}{\epsilon}$$

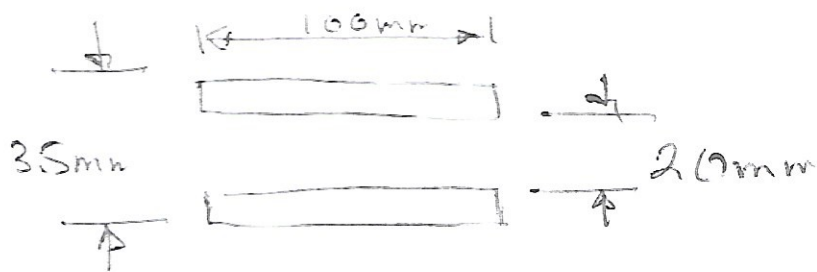
$$\epsilon = \frac{\sigma}{E} = \frac{197 \times 10^6}{85 \times 10^9}$$

$$= 0.00232$$

$$\epsilon = \frac{x}{L} \therefore x = \epsilon L$$

$$\begin{aligned} \text{Thus: } \sigma_A &= 0.00232 \times 350 \\ &= 0.812 \text{ mm} \end{aligned}$$

2b Consider section B



$$\sigma = \frac{F}{a} \quad \text{and} \quad a = \frac{\pi (D_o^2 - d^2)}{4}$$

$$\sigma = \frac{4F}{\pi (D_o^2 - d^2)}$$

$$= \frac{4 \times 100 \times 10^3}{\pi (0.035^2 - 0.02^2)}$$

$$\sigma = 293 \text{ MPa}$$

$$\epsilon = \frac{\sigma}{E} = \frac{293 \times 10^6}{85 \times 10^9}$$
$$= 0.0034$$

$$\Delta = 0.0034 \times 100 = 0.34 \text{ mm}$$

$$\text{Total extension} = 0.812 + 0.34 = 1.152 \text{ mm}$$

3a

$$! \quad V = u + at$$

$$V = 1.5 + 2 \times 7$$

$$= 15.5 \frac{\text{m}}{\text{s}}$$

$$a = 2 \frac{\text{m}}{\text{s}^2}$$

$$u = 1.5 \frac{\text{m}}{\text{s}}$$

$$t = 7 \text{ s}$$

4

ii

$$V^2 = u^2 + 2as$$

$$8^2 = 1.5^2 + 2 \times 2 \times s$$

$$64 = 2.25 + 4s$$

$$s = \frac{64 - 2.25}{4}$$

$$= 15.44 \text{ m}$$

$$a = 2 \frac{\text{m}}{\text{s}^2}$$

$$u = 1.5 \frac{\text{m}}{\text{s}}$$

$$V = 8 \frac{\text{m}}{\text{s}}$$

4

3b.

$$i. \quad V = 30 \frac{\text{km}}{\text{hr}}$$

$$= \frac{30}{3.6} \frac{\text{m}}{\text{s}}$$

$$V = u + at$$

$$\frac{30}{3.6} = 0 + 4a$$

$$a = \frac{\frac{30}{3.6}}{4} = 2.08 \frac{\text{m}}{\text{s}}$$

$$u_1 = 0$$

$$V = 30 \frac{\text{km}}{\text{hr}}$$

4

3b i

Then  $a = r\alpha$

$$2.08 = \frac{0.8^2}{2} \times \alpha$$

$$\alpha = \frac{2.08}{0.4}$$

$$= 5.2 \frac{\text{rad}}{\text{s}^2}$$

2

ii

$$\omega_1 = 0$$

$$\omega_2 = \frac{V}{r}$$

$$= \frac{\frac{30}{3.6}}{0.4}$$

2

$$\omega_2 = 20.8 \frac{\text{rad}}{\text{s}}$$

$$\omega_2^2 = \omega_1^2 + 2\alpha\theta$$

$$20.8^2 = 0 + 2 \times 5.2 \times \theta$$

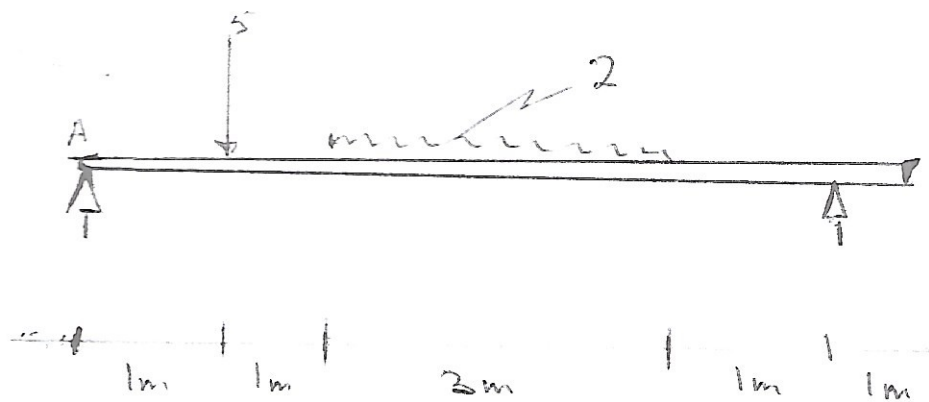
$$\theta = \frac{20.8^2}{10.4} = 41.6 \text{ rads}$$

2

$$\frac{41.6}{2\pi} = 6.62 \text{ revs}$$

2

4.



$$\sum M = 0$$

$$6 R_R - (5 \times 1) - (2 \times 3 \times 8.5) = 0$$

$$6 R_R - 5 - 21 = 0$$

$$R_R = \frac{26}{6} = \underline{\underline{4.33 \text{ kN}}}$$

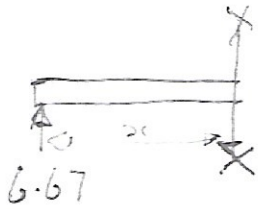
$$\sum F_y = 0$$

$$R_L + 4.33 - 5 - (2 \times 3) = 0$$

$$R_L = 5 + 6 - 4.33$$

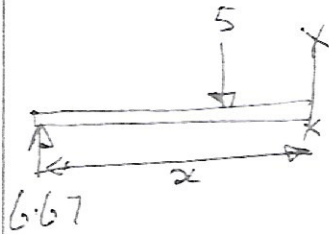
$$= \underline{\underline{6.67 \text{ kN}}}$$

4.



$$0 < x < 1$$

$$BM = 6.67x$$

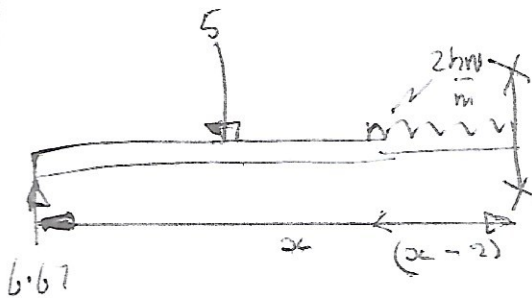


$$BM = 6.67x - 5(x-1)$$

$$1 < x < 2$$

$$= 6.67x - 5x + 5$$

$$= 1.67x + 5$$



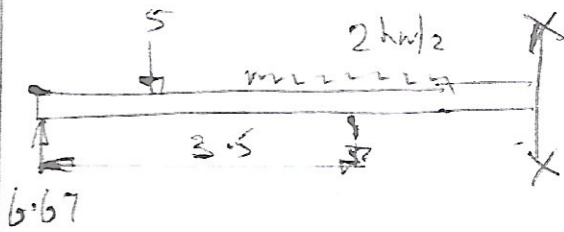
$$2 < x < 5$$

$$BM = 6.67x - 5(x-1) - \left\{ 2(x-2) \times \frac{x-2}{2} \right\}$$

$$= 6.67x - 5x + 5 - \left\{ x^2 - 4x + 4 \right\}$$

$$= 6.67x - 5x + 5 - x^2 + 4x - 4$$

$$BM = -x^2 + 5.67x + 1$$

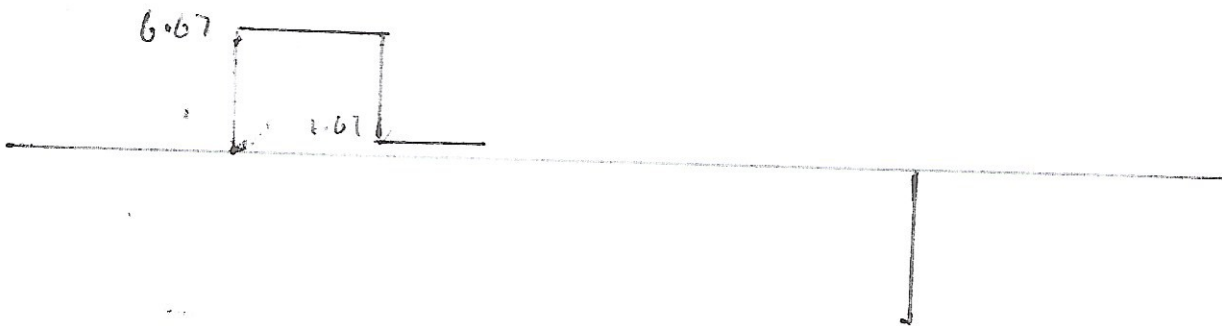
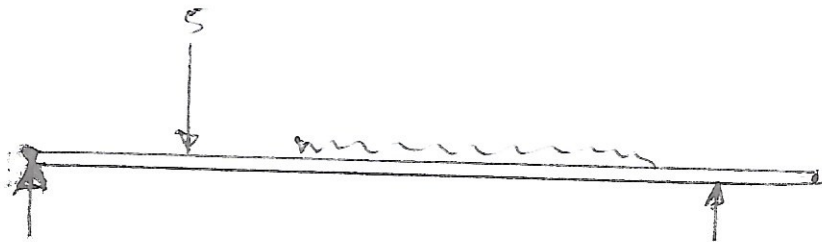


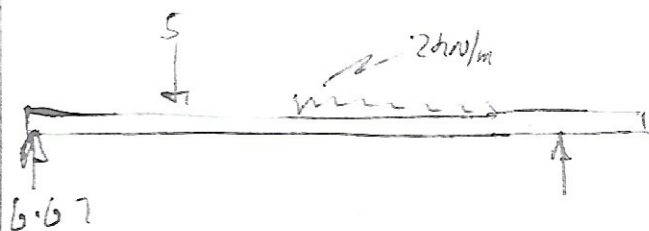
$$5 < x < 6$$

$$BM = 6.67x - 5(x-1) - 2 \times 3 \times (x-3.5)$$

$$= 6.67x - 5x + 5 - 6x + 21$$

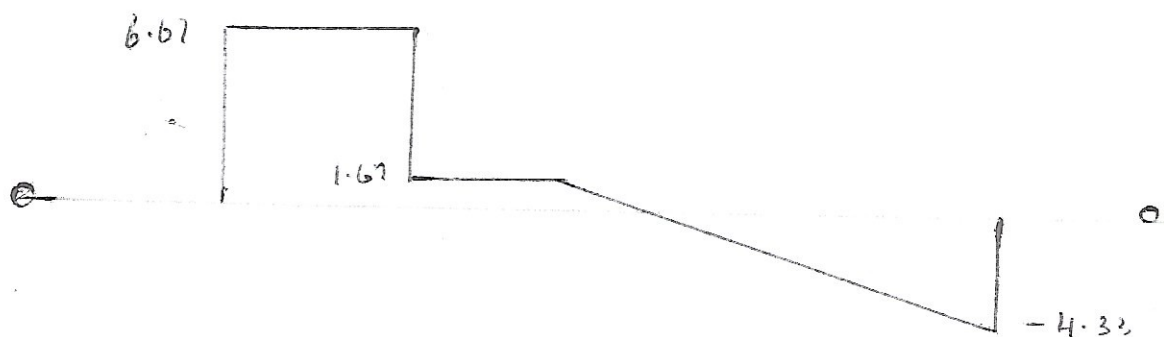
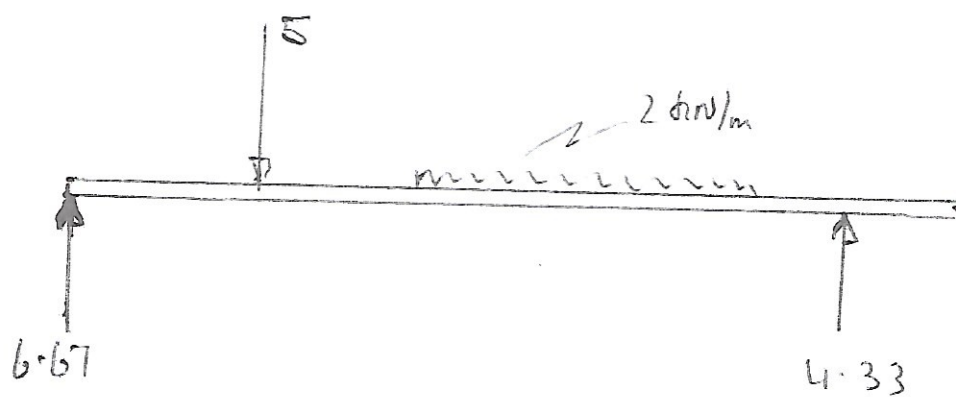
$$= \underline{\underline{26 - 4.33x}}$$



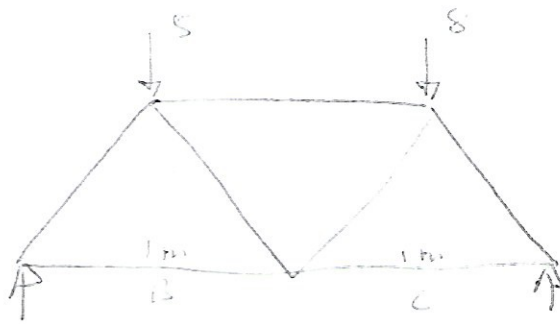


$$5 < x < 6$$

$$\begin{aligned}
 Bm &= 6.67x - 5(x-5) - 2 \times 3(x-3.5) \\
 &= 26 - 4.33x
 \end{aligned}$$



5



Calculate reactions:

$$\sum M = 0$$

$$2R_2 - (0.5 \times 5) - (1.5 \times 8) = 0$$

$$2R_2 = 2.5 + 12$$

$$R_2 = \frac{14.5}{2}$$

$$R_2 = 7.25 \text{ kN}$$

$$\sum F_y = 0$$

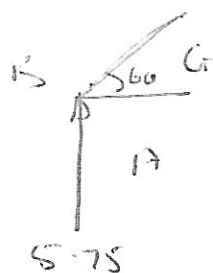
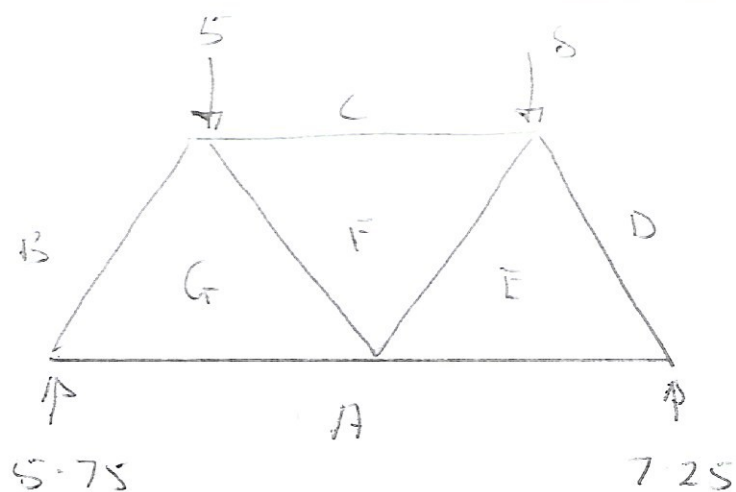
$$R_1 + 7.25 - 5 - 8 = 0$$

$$R_1 = 13 - 7.25 = 5.75 \text{ kN}$$

2

2

5



$$\sum F_y = 0$$

$$5.75 + b_g \sin 60 = 0$$

$$b_g = \frac{-5.75}{\sin 60}$$

$$b_g = -6.64 \text{ kN (STRETCH)}$$

$$\sum F_x = 0$$

$$g_a + b_g \cos 60 = 0$$

$$g_a - 6.64 \cos 60 = 0$$

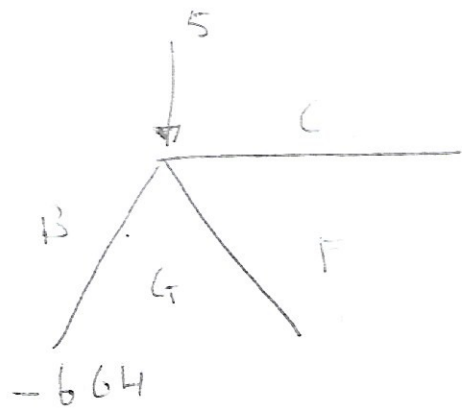
$$g_a = 6.64 \cos 60$$

$$= 3.32 \text{ kN (TIE)}$$

2

2

5



$$\sum F_y = 0$$

$$-5 + f_g \sin 300 - 6.64 \sin 240 = 0$$

$$f_g \sin 300 = 6.64 \sin 240 + 5$$

$$f_g = \frac{6.64 \sin 240 + 5}{\sin 300}$$

$$f_g = 0.87 \text{ kN (TIE)}$$

$$\sum F_x = 0$$

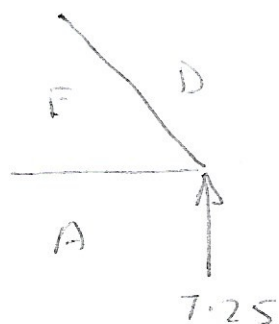
$$-6.64 \cos 240 + 0.87 \cos 300 + C = 0$$

$$C = 6.64 \cos 240 - 0.87 \cos 300$$

$$C = -4.07 \text{ kN (STRUT)}$$

2

2



$$\sum F_y = 0$$

$$7.25 + d \sin 120 = 0$$

$$d = \frac{-7.25}{\sin 120}$$

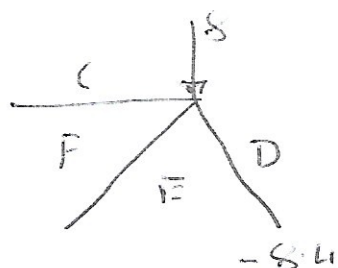
$$d = -8.4 \text{ kN (strut)}$$

$$\sum F_x = 0$$

$$e - 8.4 \cos 120 = 0$$

$$e = 8.4 \cos 120$$

$$= -4.2 \text{ (strut)}$$



$$\sum F_y = 0$$

$$-8.4 \sin 300 + f \sin 240 - 8 = 0$$

$$f \sin 240 = 8.4 \sin 300 + 8$$

$$f = \frac{8.4 \sin 300 + 8}{\sin 240}$$

$$= -8.84 \text{ (strut)}$$

$$\sum F_x = 0$$

$$-0.84 \cos 240 - 8.4 \cos 300 + C = 0$$

$$C = 0.84 \cos 240 + 8.4 \cos 300$$

$$= 3.78 \text{ kN (tie)}$$

$$\frac{T}{J} = \frac{\tau}{r}$$

$$T = 40 \text{ Nm}$$

$$\tau = 8 \text{ MPa}$$

$$J = ?$$

$$\frac{40 \times 10^3}{J} = \frac{80 \times 10^6}{\frac{d}{2}}$$

$$\frac{(40 \times 10^3 \times \frac{d}{2})}{80 \times 10^6} = J$$

$$\frac{20 \times 10^3 d}{80 \times 10^6} = J$$

$$25 \times 10^4 d = \frac{\pi d^4}{32}$$

$$32 \times 25 \times 10^4 = \frac{\pi \times d^4}{d^3}$$

$$d = \left\{ \frac{32 \times 25 \times 10^4}{\pi} \right\}^{\frac{1}{3}}$$

$$d = \sqrt[3]{0.0255}$$

$$d = 0.29 \text{ m}$$

b.

$$\frac{T}{J} = \frac{G\theta}{L} = \frac{\tau}{r}$$

$$T = 40 \text{ kNm}$$

$$\tau = 80 \text{ MPa}$$

$$D = 1.5d$$

$$\frac{G\theta}{L} = \frac{\tau}{r}$$

$$\theta = \frac{\tau L}{G r}$$

$$= \frac{80 \times 10^6 \times 1}{80 \times 10^9 \times \left(\frac{0.29}{2}\right)}$$

$$\theta = 6.89 \times 10^3 \text{ rads}$$