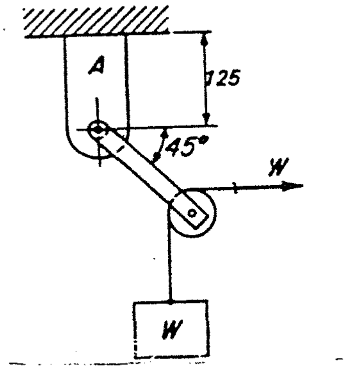
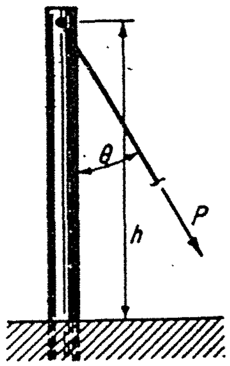
SELF-ASSESSMENT QUESTIONS:

Before studying any more topics attempt the following questions. The solutions are shown at the end of this unit.

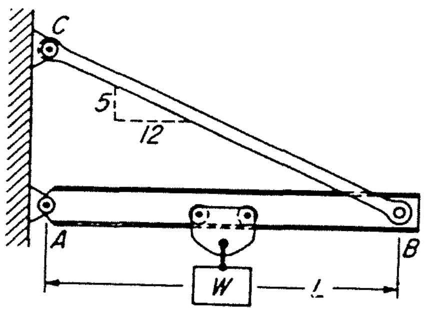


1. The steel plate A in the figure is 100 mm wide and 16 mm thick. Calculate the load W which will produce a maximum combined stress of 69 MPa in the plate.



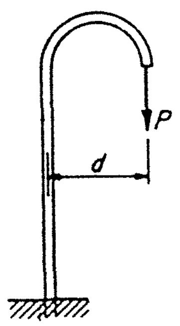
2. A 60.3 mm-diameter 3.2 mm-wall steel pipe extends vertically out of a solid support as shown. Calculate the value of P which will produce a combined stress of 150 MPa when h = 500 mm and Θ = 30°

   For pipe A = 583 mm^2
   $I_x = 0.238 \times 10^6 mm^4$



3. Member AB of the crane shown is a steel universal section, 150UC 23, and its length L is 2.4m. Calculate the maximum combined stress in AB when a load of 22.5 kN is applied at the mid-point and mass of beam and its deflection are neglected.

   For 150UC 23 A = 2980 mm^2
   $I_x = 12.6 \times 10^6 mm^4$
   Beam height 152 mm.



4. A section of 60.3 mm diameter 3.2 mm wall steel pipe is solidly embedded in a concrete footing, as shown. Calculate the stresses on the left and right side of the vertical portion of the pipe when P = 2.2 kN and d = 500 mm.

   For pipe A = 583 mm^2
   $I_x = 0.238 \times 10^6 mm^4$

SELF-ASSESSMENT QUESTIONS

Before studying any more topics attempt the following questions.The solutions are shown at the end of this unit.

Calculate the principal stresses and maximum shear stresses for the following stress conditions.

5. $f_x = 10$ MPa

   $f_y = 15$ MPa

   $f_s = 8$ MPa

6. $f_x = 50$ MPa

   $f_y = 40$ MPa

   $f_s = 20$ MPa

7. $f_x = 50$ MPa

   $f_y = 40$ MPa

   $f_s = 0$ MPa

8. $f_x = 30$ MPa

   $f_y = 0$ MPa

   $f_s = 20$ MPa

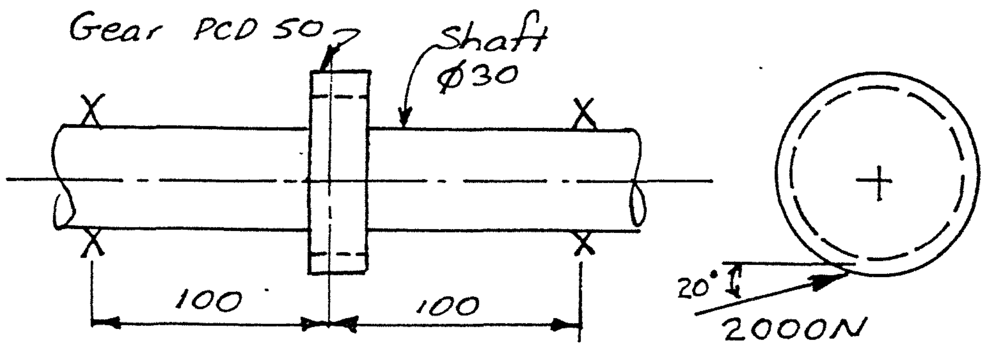
SELF-ASSESSMENT QUESTIONS

Before studying any more topics attempt the following questions. The solutions are show at the end of this unit.

9. A 25 mm shaft is subjected to a torque of 50 Nm and a bending moment of 80 Nm.

Calculate:
(a) The equivalent torque.
(b) Equivalent moment.
(c) Max. shear stress.
(d) max. tensile stress.

10.

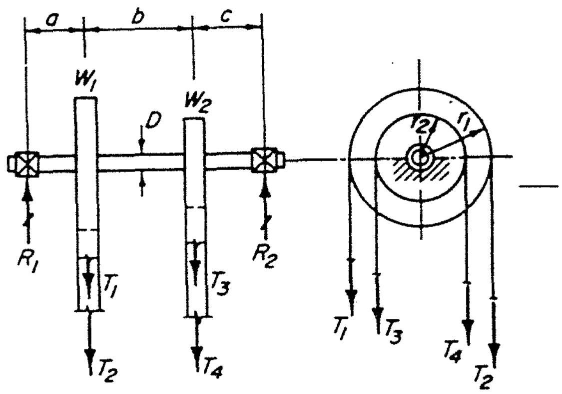


Calculate:
(a) Torque.
(b) Bending moment at gear
(c) Equivalent torque.
(d) Equivalent moment.
(e) Max. sheer stress.
(f) Max. tensile stress.

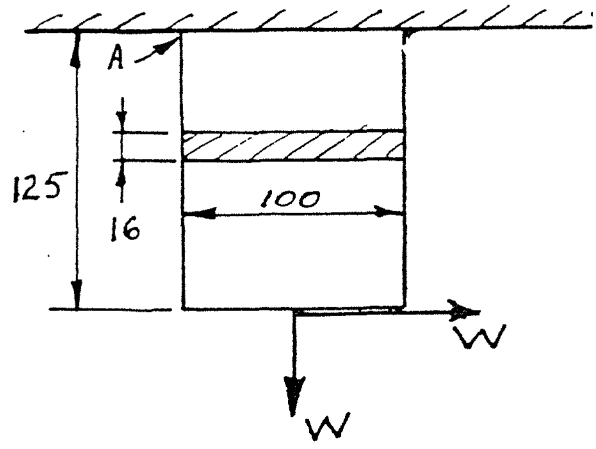
(Self-Assessment Questions continued)

11. A shaft carried a torque of 75 Nm and a bending moment of 100 Nm. The allowable shear stress is 50 MPa and the allowable tensile stress is 60 MPa. What size should the shaft be?

12. For the shaft shown, a = 150 mm, b = 300 mm, C = 375 mm, r_1 = 200 mm, r_2 = 100 mm, W_1 = 270N, W_2 = 225N, T_1 = 135N, T_2 = 45N, T_3 = 135N and T_4 = 315N. Calculate the required shaft diameter D if the permissable stress is 56 MPa



SOLUTIONS TO SELF-ASSESSMENT QUESTIONS



$$I = \frac{bh^3}{12}$$

$$= \frac{16 \times 100^3}{12}$$

$$= 1.33 \times 10^6 \text{ mm}^4$$

MAX BENDING MOMENT OCCURS AT A

$$M = W \times 125$$

BENDING STRESS $f_B = \frac{My}{I}$

$$= \frac{W \times 125 \times 50}{1.33 \times 10^6}$$

TENSILE STRESS $f_T = \frac{F}{A}$

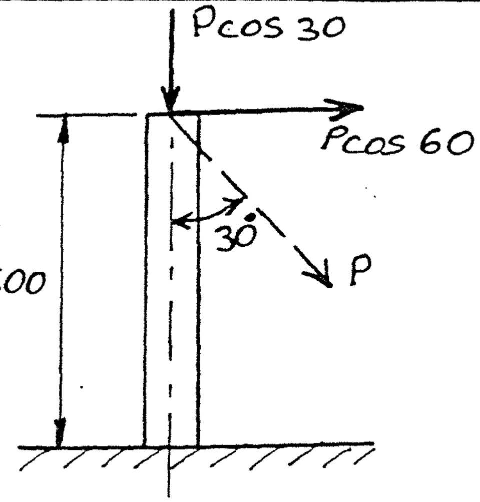
$$= \frac{W}{1600}$$

MAX COMBINED STRESS $f = f_B + f_T$

$$69 = \frac{W \times 125 \times 50}{1.33 \times 10^6} + \frac{W}{1600}$$

$$\underline{\underline{W = 12.7 \text{ kN}}}$$

Problem 2.



Bending Stress $f_B = \frac{My}{I}$

$$= \frac{P\cos 60^\circ \times 500 \times 30.15}{0.238 \times 10^6}$$

Compressive Stress $f_c = \frac{F}{A}$

$$= \frac{P\cos 30^\circ}{583}$$

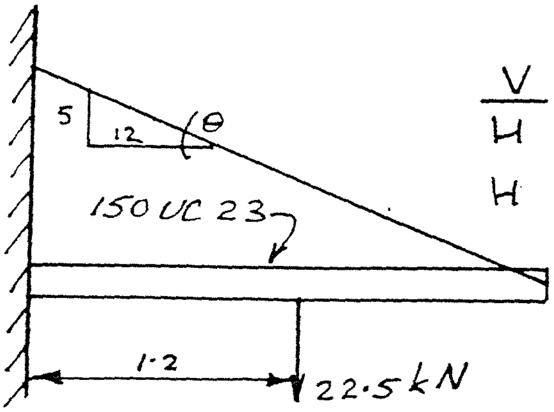
Max Combined Stress

$$f = f_B + f_c$$

$$150 = \frac{P\cos 60^\circ \times 500 \times 30.15}{0.238 \times 10^6} + \frac{P\cos 30^\circ}{583}$$

$$P = 4524 \text{ N}$$

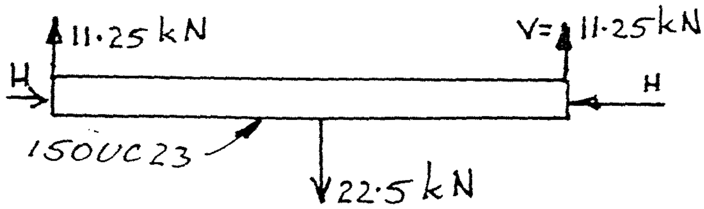
Problem. 3.



$$\frac{V}{H} = \frac{5}{12}$$

$$H = 11 \cdot 25 \times \frac{12}{5}$$

$$= 27 \text{ kN}$$



MAXIMUM BENDING MOMENT:

$$M = 11 \cdot 25 \times 1 \cdot 2$$

$$= 1 \cdot 35 \text{ kN m}$$

$$= 1 \cdot 35 \times 10^6 \text{ N mm}$$

BENDING STRESS $f_B = \frac{My}{I}$

$$= \frac{1 \cdot 35 \times 10^6 \times 76}{12 \cdot 6 \times 10^6}$$

$$= 81 \cdot 4 \text{ MPa}$$

COMPRESSIVE STRESS $f_C = \frac{F}{A}$

$$= \frac{27 \times 10^3}{2980}$$

$$= 9 \cdot 06 \text{ MPa}$$

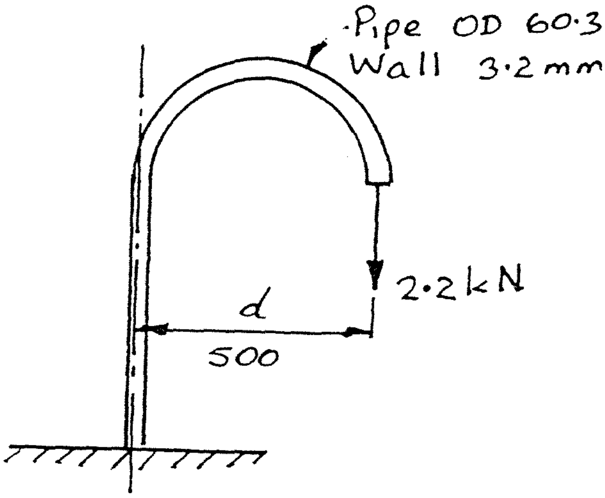
MAX COMBINED STRESS

$$f = f_B + f_C$$

$$= 81 \cdot 4 + 9 \cdot 06$$

$$f = 90 \cdot 46 \text{ MPa}$$

Problem. 4.



BENDING STRESS $f_B = \frac{My}{I}$

$= \frac{2.2 \times 10^3 \times 500 \times 30.15}{0.238 \times 10^6}$

$= 139$ MPa

COMPRESSIVE STRESS $f_c = \frac{F}{A}$

$= \frac{2.2 \times 10^3}{583}$

$= 3.77$ MPa

MAX TENSILE STRESS

$f = f_B - f_c$

$= 139 - 3.77$

$f = 135.2$ MPa

THIS OCCURS ON THE LEFT HAND SIDE OF THE PIPE

MAX COMPRESSIVE STRESS

$f = f_B + f_c$

$= 139 + 3.77$

$f = 142.8$ MPa

THIS OCCURS ON THE RIGHT HAND SIDE OF THE PIPE

Problem. 5.

$$f_1, f_2 = \frac{f_x + f_y}{2} \pm \sqrt{\left(\frac{f_x - f_y}{2}\right)^2 + f_s^2}$$

$$= \frac{10 + 15}{2} \pm \sqrt{\left(\frac{10 - 15}{2}\right)^2 + 8^2}$$

$$= 12{\cdot}5 \pm 8{\cdot}38$$

$$f_1 = 20{\cdot}88 \text{ MPa}$$

$$f_2 = 4{\cdot}12 \text{ MPa}$$

$$q = 8{\cdot}38 \text{ MPa}$$

Problem. 6.

$$f_1, f_2 = \frac{f_x + f_y}{2} \pm \sqrt{\left(\frac{f_x - f_y}{2}\right)^2 + f_s^2}$$

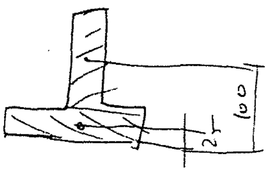
$$= \frac{50 + 40}{2} \pm \sqrt{\left(\frac{50 - 40}{2}\right)^2 + 20^2}$$

$$= 45 \pm 20{\cdot}6$$

$$f_1 = 65{\cdot}6 \text{ MPa}$$

$$f_2 = 24{\cdot}4 \text{ MPa}$$

$$q = 20{\cdot}6 \text{ MPa}$$



$(150 \times 50)\ 2$

$15000\,\bar{x} = 7500 \times 25 + 7500 \times 100$

$\bar{x} = 62.5$

7703P: 6

Problem 7.

$$f_1, f_2 = \frac{f_x + f_y}{2} \pm \sqrt{\left(\frac{f_x - f_y}{2}\right)^2 + f_s^2}$$

$$= \frac{50 + 40}{2} \pm \sqrt{\left(\frac{50 - 40}{2}\right)^2 + 0^2}$$

$$= 45 \pm 5$$

$$f_1 = 50 \text{ MPa}$$

$$f_2 = 40 \text{ MPa}$$

$$q = 5 \text{ MPa}$$

Problem. 8.

$$f_1, f_2 = \frac{f_x + f_y}{2} \pm \sqrt{\left(\frac{f_x - f_y}{2}\right)^2 + f_s^2}$$

$$= \frac{30 + 0}{2} \pm \sqrt{\left(\frac{30 - 0}{2}\right)^2 + 20^2}$$

$$= 15 \pm 25 \text{ MPa}$$

$$f_1 = 40 \text{ MPa}$$

$$f_2 = -10 \text{ MPa}$$

$$q = 25 \text{ MPa}$$

Problem. 9.

EQUIVALENT TORQUE $T_e = \sqrt{T^2 + M^2}$

$$= \sqrt{(50 \times 10^3)^2 + (80 \times 10^3)^2}$$

$$= 94.339 \times 10^3 \text{ Nmm}$$

EQUIVALENT BENDING MOMENT $M_e = \frac{1}{2}(T_e + M)$

$$= \frac{1}{2}(94.3 + 80)$$

$$= 87.15 \text{ Nm}$$

MAX SHEAR STRESS $q = \frac{16 T_e}{\pi D^3}$

$$= \frac{16 \times 94.339 \times 10^3}{\pi \times 25^3}$$

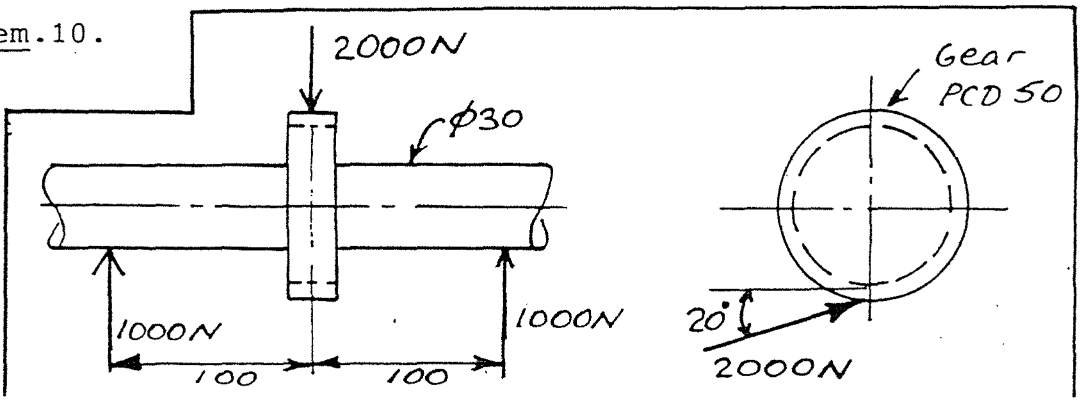
$$q = 30.7 \text{ MPa}$$

MAX TENSILE STRESS $f = \frac{32 M_e}{\pi D^3}$

$$= \frac{32 \times 87.15 \times 10^3}{\pi \times 25^3}$$

$$f = 56.8 \text{ MPa}$$

Problem.10.



$$\text{Torque } T = 2000 \cos 20^\circ \times 25$$
$$= 46.9 \text{ Nm}$$

$$\text{Bending Moment } M = 1000 \times 100$$
$$= 100 \times 10^3 \text{ Nmm}$$

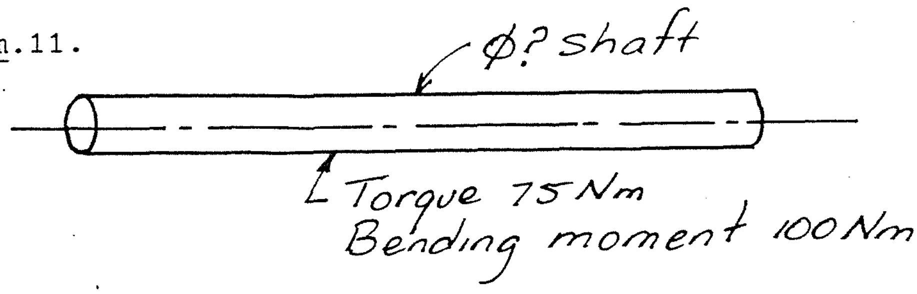
$$\text{Equiv Torque } T_e = \sqrt{T^2 + M^2}$$
$$= \sqrt{(46.9 \times 10^3)^2 + (100 \times 10^3)^2}$$
$$= 110.48 \times 10^3 \text{ Nmm}$$

$$\text{Equiv. Moment } M_e = \frac{1}{2}(T_e + M)$$
$$= \frac{1}{2}(110.48 \times 10^3 + 100 \times 10^3)$$
$$= 105.2 \times 10^3 \text{ Nmm}$$

$$\text{Max Shear Stress } q = \frac{16 T_e}{\pi D^3}$$
$$= \frac{16 \times 110.48 \times 10^3}{\pi \times 30^3}$$
$$q = 20.8 \text{ MPa}$$

$$\text{Max Tens. Stress } f = \frac{32 M_e}{\pi D^3}$$
$$= \frac{32 \times 105.2 \times 10^3}{\pi \times 30^3}$$
$$f = 39.7 \text{ MPa}$$

Problem.11.



EQUIVALENT TORQUE $T_e = \sqrt{75^2 + 100^2}$

$= 125$ Nm

EQUIVALENT MOMENT $M_e = \frac{1}{2}(T_e + M)$

$= \frac{1}{2}(125 + 100)$

$= 112 \cdot 5$ Nm

DIAMETER BASED ON MAX SHEAR STRESS

$$q = \frac{16\,T_e}{\pi\,D^3}$$

$$50 = \frac{16 \times 125}{\pi \times D^3}$$

$$D = 23 \cdot 35 \text{ mm}$$

DIAMETR BASED ON MAX TENSILE STRESS

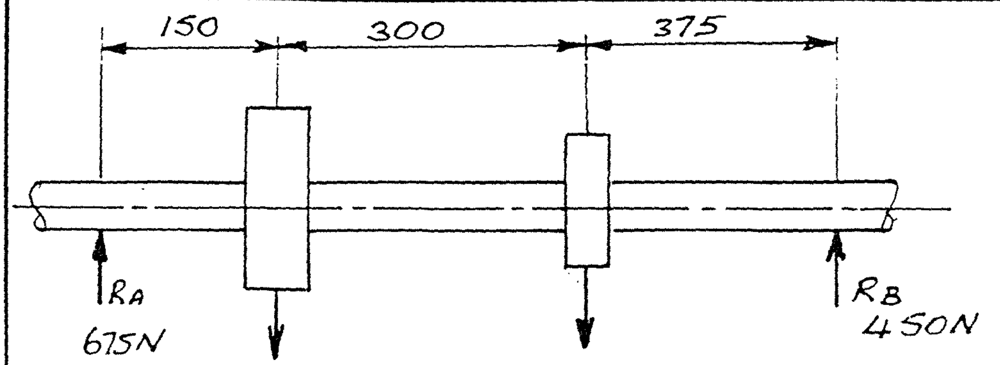
$$f = \frac{32\,M_e}{\pi\,D^3}$$

$$60 = \frac{32 \times 112 \cdot 5}{\pi \times D^3}$$

$$D = 26 \cdot 7 \text{ mm}$$

THE SHAFT MUST BE THE LARGER OF THESE TWO SIZES, THAT IS 26·7 mm

Problem .12.

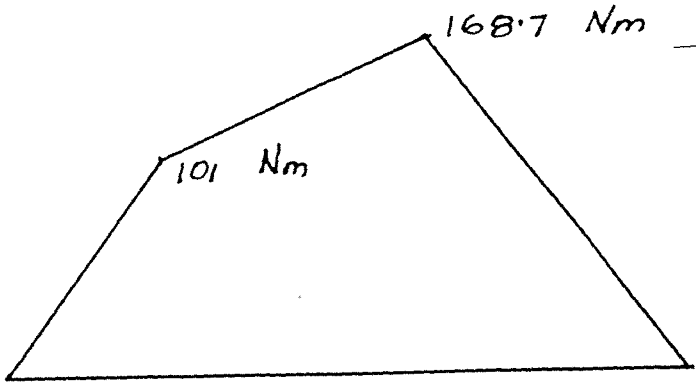


270
+ 135
+ 45
450

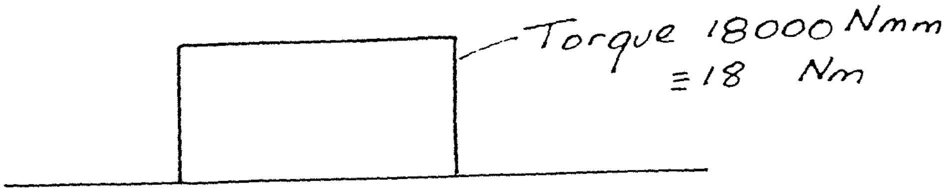
225
135
315
675

R_A = 675 N
R_B = 450 N

BENDING MOMENT DIAGRAM



TORQUE DIAGRAM



EQUIVALENT TORQUE $T_e = \sqrt{T^2 + M^2}$

$$= \sqrt{18^2 + 168{\cdot}75^2}$$

$$= 169{\cdot}7 \text{ Nm}$$

SHEAR STRESS $q = \dfrac{16\, T_e}{\pi\, D^3}$

$$56 = \frac{16 \times 169{\cdot}7 \times 10^3}{\pi\, D^3}$$

$$D = 24{\cdot}8 \text{ mm}$$