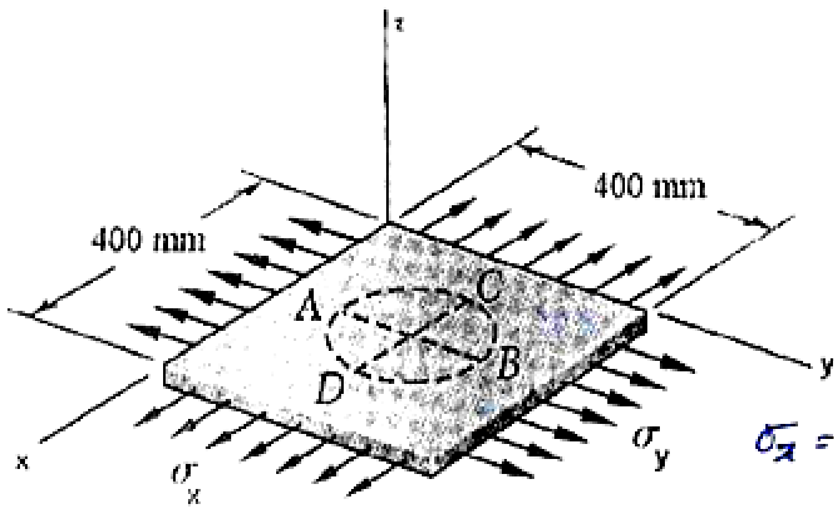
Problem 1:
A circle ACBD of original diameter d = 250 mm is marked on an unstressed aluminum plate of thickness t = 20 mm, as shown in Fig. P-1. Then a set of normal stresses σ_x = 140 MPa, and σ_y = 80 MPa are applied on the plate as shown in the Figure.

Fig. P-1: A plate with applied stresses.



$\sigma_z = 0$

Taking E = 0.7 × 10⁵ MPa, and Poisson's ratio ν = 0.30, *determine* the followings:

i) Change in the length of diameter AB.
ii) Change in the length of diameter CD.
iii) Change in the thickness t of plate.
iv) Change in the volume of plate ($\Delta V = e\,V_o$).

(i) $\Delta d_{AB} = d\,\epsilon_y$ 03

$\epsilon_y = \frac{1}{E}\left[\sigma_y - \nu(\sigma_x + \sigma_z)\right] = \frac{1}{0.7\times10^5}\left[80 - 0.3(140+0)\right] = 5.4285\times10^{-4}$ mm/mm

$\therefore \Delta d_{AB} = 250 \times 5.4285\times10^{-4} = 0.1357$ mm Ans 02

(ii) $\Delta d_{CD} = d\,\epsilon_x$ 03

$\epsilon_x = \frac{1}{E}\left[\sigma_x - \nu(\sigma_y + \sigma_z)\right] = \frac{1}{0.7\times10^5}\left[140 - 0.3(80+0)\right] = 1.6571\times10^{-3}$ mm/mm

$\therefore \Delta d_{CD} = 250 \times 1.6571\times10^{-3} = 0.414$ mm Ans 02

(iii) $\Delta t = t\,\epsilon_z$ 03

$\epsilon_z = \frac{1}{E}\left[\sigma_z - \nu(\sigma_x + \sigma_y)\right] = \frac{1}{0.7\times10^5}\left[0 - 0.3(140+80)\right] = -9.4285\times10^{-4}$ mm/mm

$\therefore \Delta t = 20 \times (-9.4285\times10^{-4}) = -0.0188$ mm Ans 02

(iv) $\Delta V = e\,V_o$

$e = \epsilon_x + \epsilon_y + \epsilon_z = 1.2571\times10^{-3}$

$V_o = 400\times400\times20 = 32\times10^5$ mm³ 03

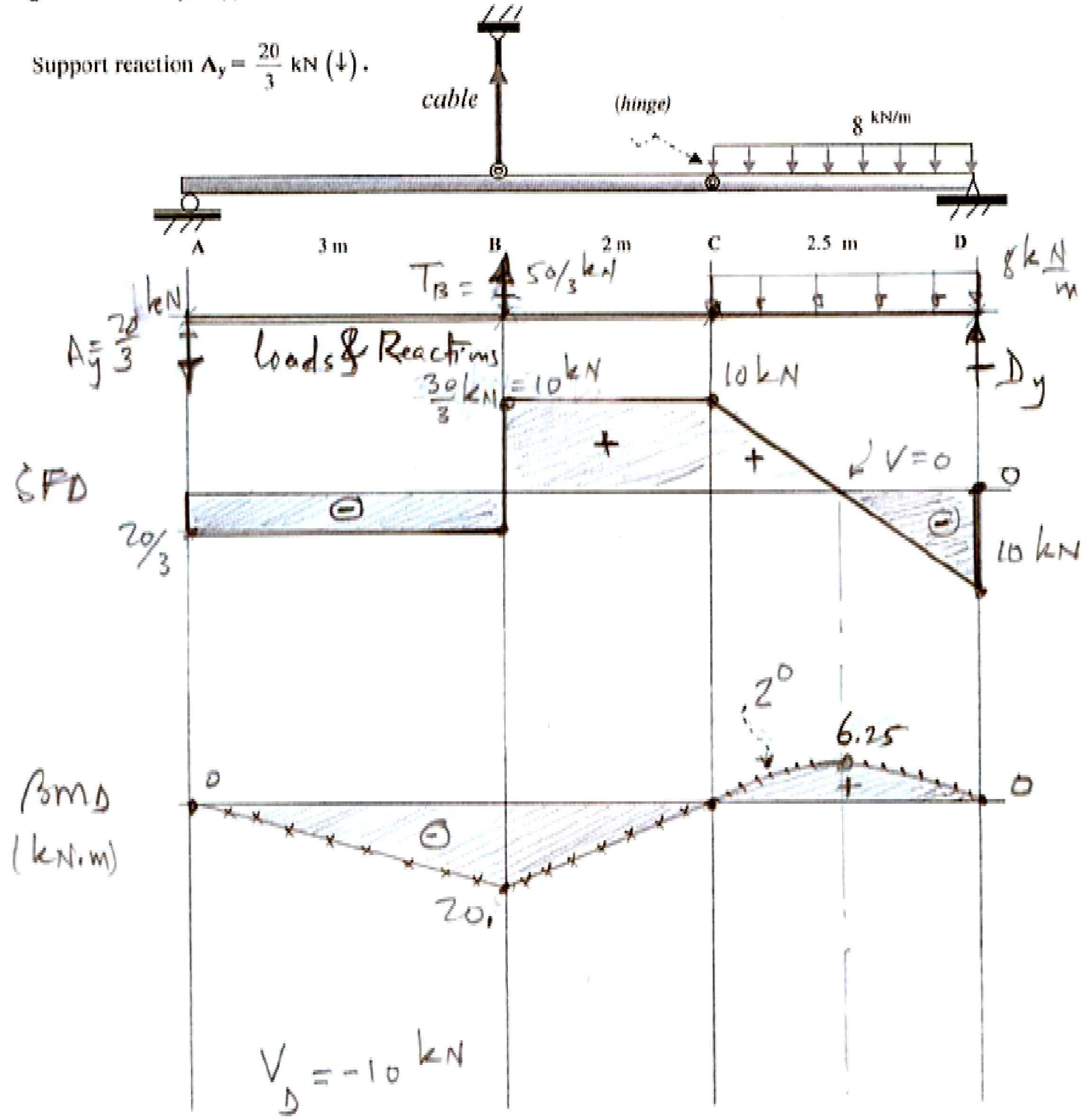
$\therefore \Delta V = 1.2571\times10^{-3} \times 32\times10^5 = 4022.8$ mm³ Ans 02

Problem 2:

i) Draw the SFD for the beam.
ii) From the SFD determine reaction D_y.
iii) Draw the BMD for the beam.

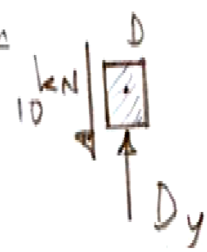
Fig. P-2 Geometry, supports and loads for a beam ABCD.

Support reaction $A_y = \frac{20}{3}$ kN (↓).



Note: show your calculations and also show clear labels on the the SFD and the BMD.

Element Equilibrium at D:



$D_y - 10 = 0$

$\therefore D_y = 10$ kN (↑).

Problem 3:

Solution:-

a) $P = T\omega$

(2) $T = 30{,}000$ N.m , $\omega = 60$ rad/sec.

$$T = \frac{30000}{60} = 500 \text{ N.m}$$

(4) $$\tau_{ave} = \frac{T}{2tA_m} = \frac{500}{2\times 0.006\times a^2} = 50\times 10^6$$

(4) $$a = \sqrt{\frac{500}{2\times 0.006\times 50\times 10^6}} = 0.02886 \text{ m}$$

say $a \doteq 30^{mm}$

b)

(3) $$\phi = \frac{TL}{4A_m^2 Gt}\oint ds = \frac{T.L.4a}{4a^4 Gt}$$

(3) $$\frac{1\times 2\times \pi}{180} = \frac{500\times 2\times \cancel{4}a}{\cancel{4}a^4\times 75\times 10^9\times 0.006}$$

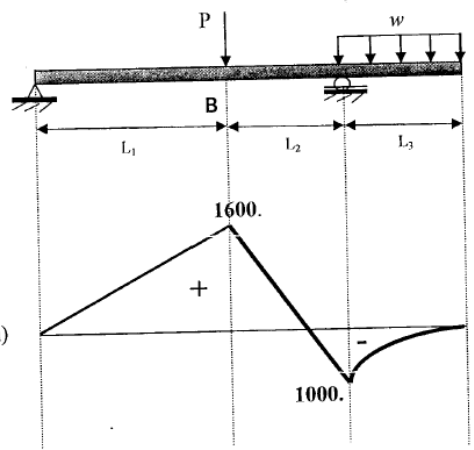
$$a^3 = \frac{500\times 2\times 180}{2\pi\times 75\times 10^9\times 0.006} = 0.000063 \text{ m}^3$$

(4) $a = 0.04^{m}$ ← controls

Problem 4:

The beam shown in Fig. P-4 is subjected to a loading which results in the given bending moment diagram (BMD). For the T-shaped cross-section of the beam with the details shown in the Figure, *determine*:

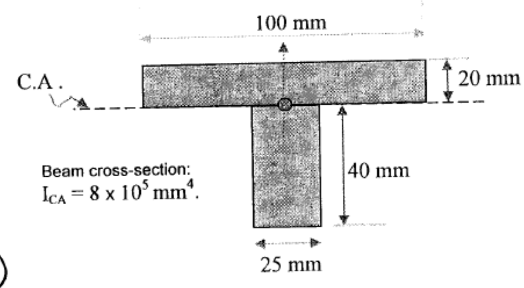
i) The absolute maximum stress (expressed in MPa) in the beam.
ii) The resultant force on the *vertical* board of cross-section passing through **B**.



$$\sigma_x = -\frac{M_z y}{I_z} \quad 5$$

max stress at max moment & max distance from N.A.

$\because$ at the bottom of a section through B

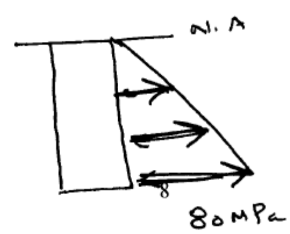


5

$$\sigma_{max} = -\frac{(1600\times10^3)(-40)}{8\times10^5}$$

$$\boxed{\sigma_{max} = 80\ MPa} \quad 5$$

ii) $F_{on\ board} = \int \sigma\, dA = \bar{\sigma} A$ 2



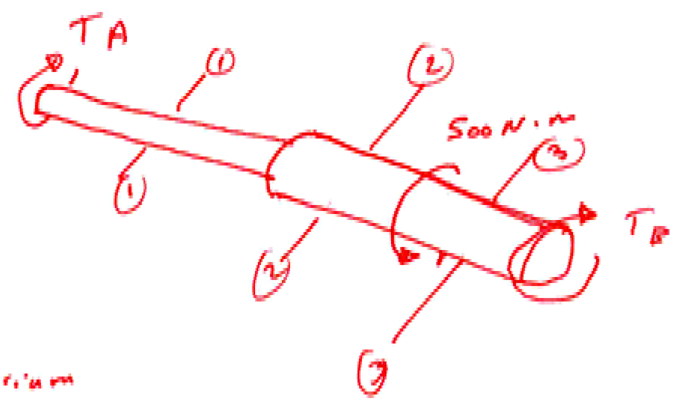
$$= \left(\frac{80+0}{2}\right)(40\times25) =$$

$$= 40{,}000\ N$$

$$= 40\ KN \quad 3$$

(problem 5 2^{nd} Major Exam − 092)

(i)



From equilibrium

$\Sigma T = 0, \quad -T_A - T_B + 500 = 0$

$\boxed{T_A + T_B = 500}$ — ①

Statically indeterminate :-

From compatibility

$\Sigma \phi = 0 \quad \Sigma \frac{TL}{GJ} = 0,$

$\phi_{A/C} + \phi_{C/D} + \phi_{D/B} = 0$

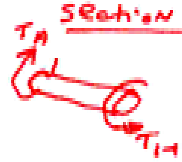
$$\frac{T_A(0.1)}{\cancel{G}\frac{\pi}{2}(0.005)^4} + \frac{T_A(0.16)}{\cancel{G}\frac{\pi}{2}(0.01)^4} + \frac{(T_A - 500)(.24)}{\cancel{G}\frac{\pi}{2}(0.01)^4} = 0$$

$$\frac{T_A(0.1)}{9.8175\times10^{-10}} + \frac{T_A(0.16)}{1.5708\times10^{-8}} + \frac{(T_A - 500)(.24)}{1.5708\times10^{-8}} = 0$$

$\Rightarrow T_A = 60 \text{ N·m}$

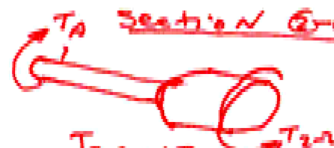
From ① $\quad T_B = 500 - 60 = 440 \text{ N·m}$

Section ①-①



$T_{1-1} = +T_A$

Section ②-②

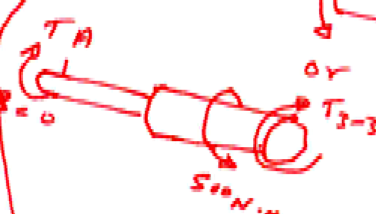


$T_{2-2} = +T_A$

Section ③-③

$T_{3-3} = -T_B$

or



$T_{3-3} = -(500 - T_A)$
$= (T_A - 500)$

(ii) $\quad \tau_{A/C} = \frac{60(0.005)}{\frac{\pi}{2}(0.005)^4} = \boxed{305.57 \text{ MPa}}$ max

$\tau_{C/D} = \frac{60(.01)}{\frac{\pi}{2}(.01)^4} = 38.197 \text{ MPa}$

$\cancel{\tau_{D/B}} = \cancel{440(}$

$\tau_{B/D} = \frac{440(.01)}{\frac{\pi}{2}(.01)^4}$
$= 280.11 \text{ MPa}$