NAME: **STUDENT #:**

Question 1 [30 Marks]

Figure Q1 below shows a drive system running at an angular speed of 750 rev/min by an ac prime mover. The power input to the drive is 150 kW, of which 60 kW is delivered to a dryer on the right through a gearing system. The remaining power is delivered to a washer on the left. Determine the diameter of the solid shaft carrying the gears.

You may assume that the maximum allowable shear stress of the shaft material is 60 MPa.

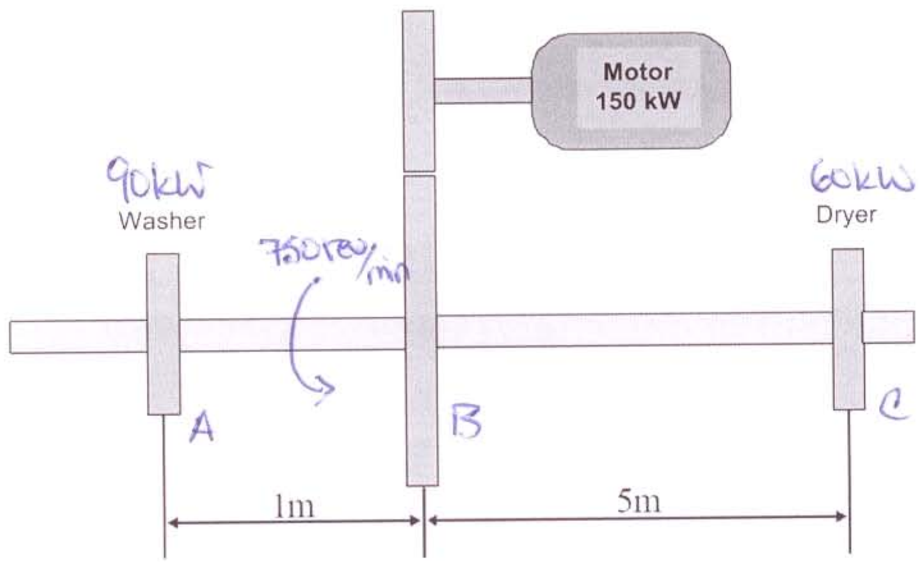

Fig. Q1

Use back of page for your solution, if necessary. You must place your final answers as required in the boxes provided.

Start your solution below this line

d =

$\omega = 750\,rev/min = 78.54\ rad/sec$

$P_{in} = 150\ kW$

$P_C = 60\ kW$

$\Rightarrow P_A = 90\ kW$

$\tau_{max} = 60\ MPa.$

$T \cdot \omega = P$

$\Rightarrow T = \dfrac{P}{\omega}$

$T_{AB} = \dfrac{90\times10^3}{78.54} = 1145.913\ N \cdot m$

$T_{CB} = \dfrac{60\times10^3}{78.54} = 763.942\ N\cdot m$

$\tau_{max} = \dfrac{T_{AB}\cdot d/2}{\pi/32 \cdot d^4} = \dfrac{16T}{\pi d^3}$

$\Rightarrow d^3 = \dfrac{16T}{\pi \tau_m} = \dfrac{16(1145.913)}{\pi(60\times10^6)} = 9.7268\times10^{-5}\ m^3$

$\Rightarrow d = 45.99\ mm$

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Question 2 [40 Marks]

A cast iron frame for a punch press has the proportions shown in the Fig. Q2. All dimensions are in mm.

a. Determine the moment of inertia *I* for the cross-section shown at A-A about the neutral axis. (15 marks)
b. Determine the maximum force *P* which can be applied to the frame, if the allowable stresses at section A-A are 65 MPa in tension and 150 MPa in the compression. (15 marks)
c. Draw the resulting stress distribution acting on the cross-section A-A. (10 marks)

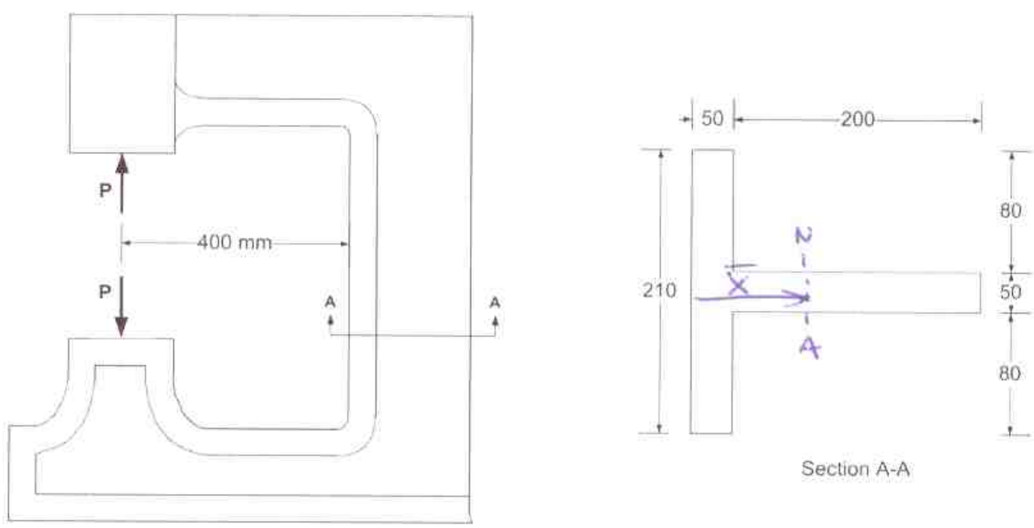


Fig. Q2

Use back of page for your solution, if necessary. You must place your final answers as required in the boxes provided.

Start your solution below this line

I = 1.16×10^8 mm^4
P = 159 kN

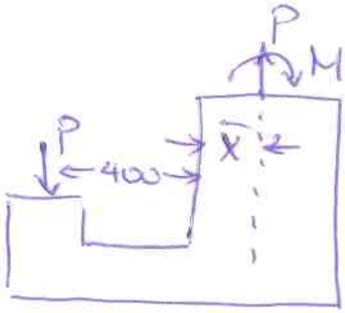
$$\bar{X} = \frac{\Sigma(A \cdot x)}{\Sigma A} = \frac{(210)(50)(\frac{50}{2}) + (50)(200)(\frac{200}{2}+50)}{(210)(50) + (50)(200)}$$

$$= 85.98 \text{ mm}.$$

$$I_{\bar{x}} = I_{CA} + Ad^2$$

$$= \frac{210(50)^3}{12} + (210)(50)(85.98-25)^2 + \frac{(200)^3(50)}{12} + (200)(50)(150-85.98)^2$$

$$= 1.16 \times 10^8 \text{ mm}^4$$



$M = P(400+\bar{x}) = 485.89P$

$\sigma_{ten} = \dfrac{P}{A} = \dfrac{P}{(210)(50)+(200)(50)} = 4.8781 \times 10^{-5} P$

$\sigma_{ten/ben} = \dfrac{M y_{ten}}{I} = \dfrac{485.89P(85.98)}{1.16 \times 10^{8}} = 3.6 \times 10^{-4} P$

$\sigma_{com/ben} = \dfrac{M y_{com}}{I} = \dfrac{485.89P(250-85.98)}{1.16 \times 10^{8}} = 6.8 \times 10^{-4} P$

$\sigma_{ten/tot} = \sigma_{ten} + \sigma_{ten/ben} \leq \sigma_{all/ten}$

$\Rightarrow [4.8781 \times 10^{-5} + 3.6 \times 10^{-4}]P \leq 65$

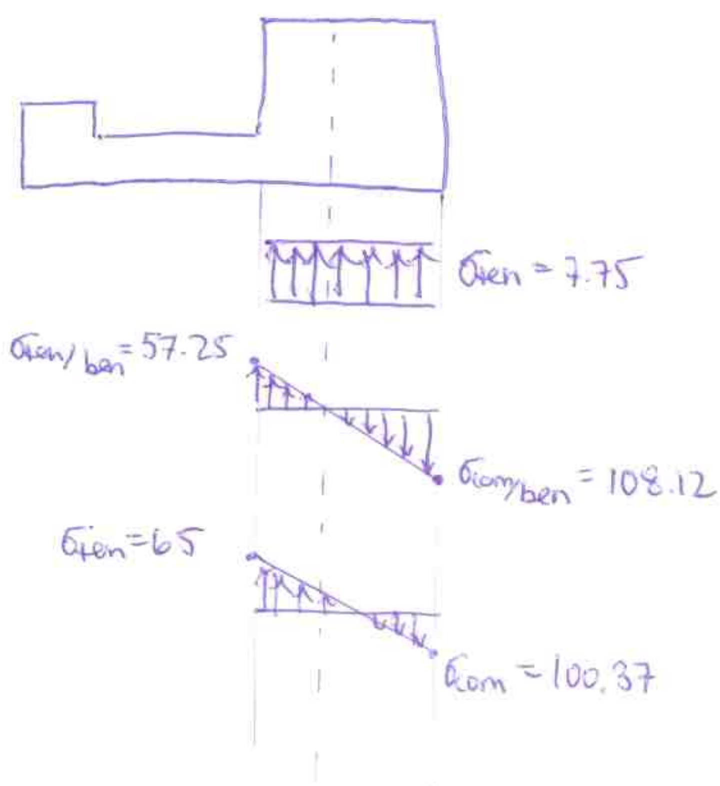
$\Rightarrow P = 159 \text{ kN}$

$\therefore P_{max} = 159 \text{ kN}.$

$\sigma_{com/tot} = \sigma_{com/ben} - \sigma_{ten} \leq \sigma_{all/com}.$

$\Rightarrow [6.8 \times 10^{-4} - 4.8781 \times 10^{-5}]P \leq 150$

$\Rightarrow P = 237.6 \text{ kN}$



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Question 3 [30 Marks]

The tapered steel bar shown in Fig. Q3 is cut out from a steel plate 25 mm thick and is welded to a rigid structure at A. Find the extension of the end C caused by the 100kN force applied at B.

Hint: Consider the origin of the coordinate axes at the point of intersection of the tapered bar.

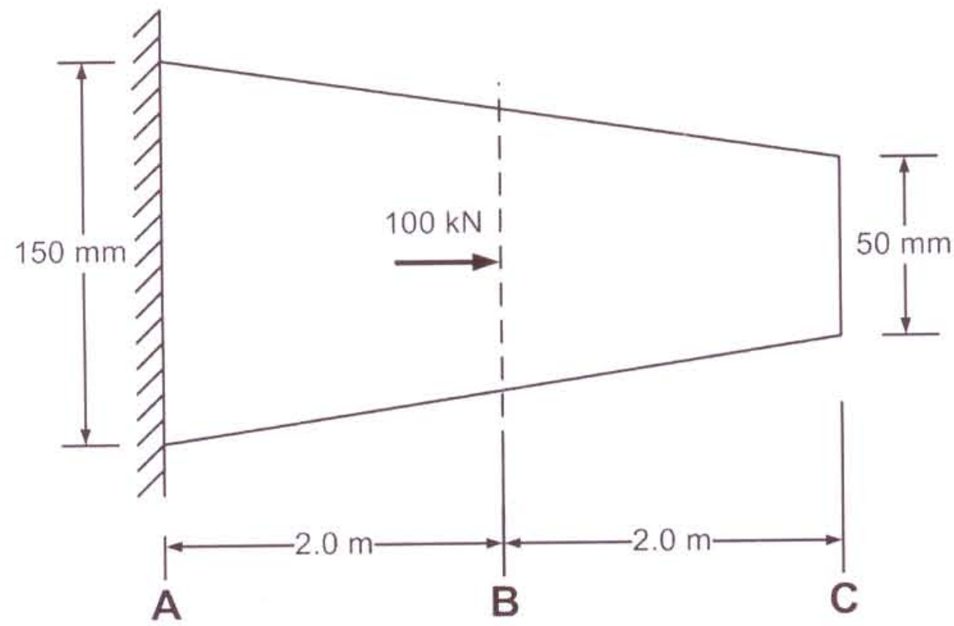


Fig. Q3

Use back of page for your solution, if necessary. You must place your final answers as required in the boxes provided.

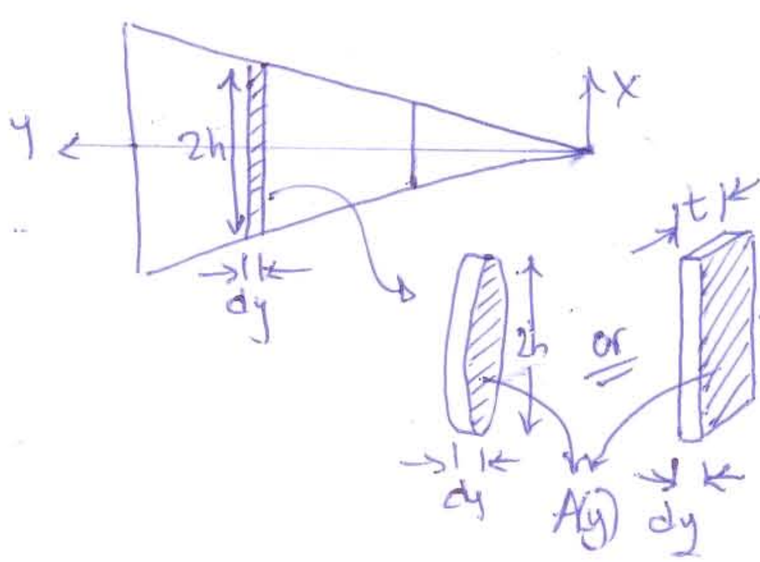
Start your solution below this line

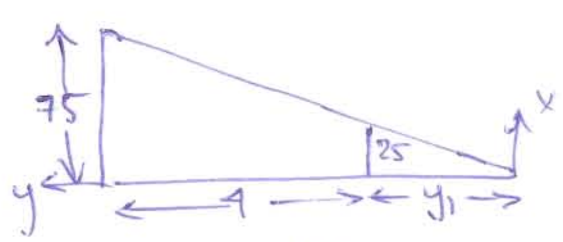
$\Delta L =$

$$\Delta l = \int_y \frac{P\,dy}{A(y)E}$$

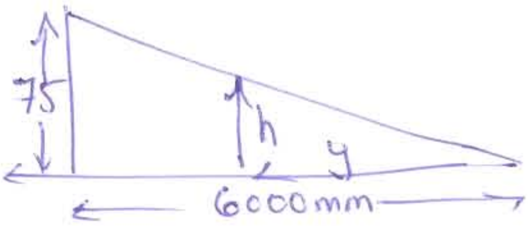
$$\underset{\text{circle}}{A(y)} = \frac{\pi}{4}(2h)^2$$

$$\underset{\text{Square}}{A(y)} = 2ht$$





$$\frac{75}{(4+y_1)} = \frac{25}{y_1} \Rightarrow y_1 = 2m$$



$$\frac{75}{6000} = \frac{h}{y} \Rightarrow h = \frac{75}{6000}y$$
$$= \frac{3}{240}y.$$

$$\underset{\text{circle}}{A(y)} = \frac{\pi}{4}\left(\frac{6}{240}y\right)^2 = \frac{9\pi}{57600}y^2$$

$$\underset{\text{square}}{A(y)} = 2\left(\frac{3}{240}y\right)\overset{t}{25} = \frac{15}{24}y.$$

$$\underset{\text{circle.}}{\Delta l} = \int \frac{P\,dy}{A(y)E} = \int_{4000}^{6000} \frac{(100\times10^3)\,dy}{\frac{9\pi}{57600}y^2 E}$$
$$= \frac{6.4\times10^8}{\pi E}\int_{4000}^{6000}\frac{dy}{y^2}$$
$$= \frac{6.4\times10^8}{\pi E}\left|-\frac{1}{y}\right|_{4000}^{6000}$$
$$= \frac{16976.52}{E}\ \text{mm}$$

$$\underset{\text{square}}{\Delta l} = \int \frac{P\,dy}{A(y)E} = \int_{4000}^{6000}\frac{(100\times10^3)\,dy}{15/24\,y\,E} = \frac{160000}{E}\int_{4000}^{6000}\frac{dy}{y}$$
$$= \frac{160000}{E}\left|\ln y\right|_{4000}^{6000}$$
$$= \frac{64874.42}{E}\ \text{mm}$$