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SECTION A

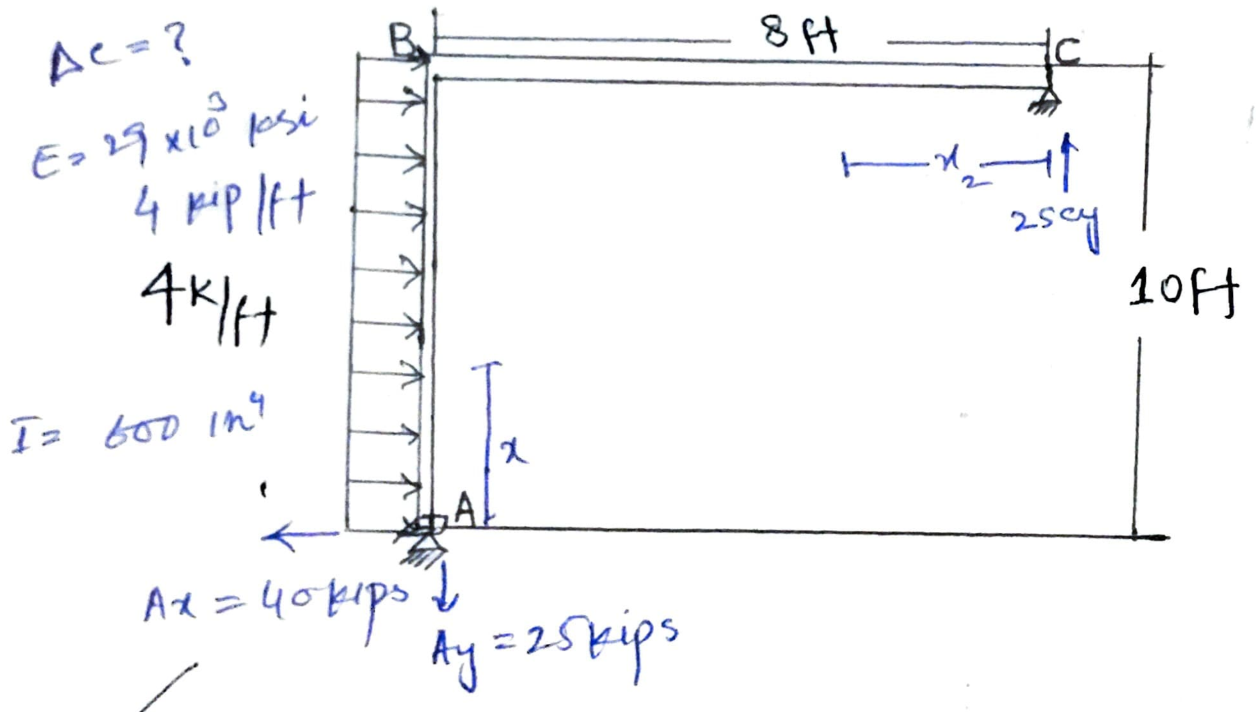
PAPER STRUCTURE I

SUBMITTED TO ENGR. AMJID ISLAM

DATE 26|JUNE|2020

QUESTION # 01:

Determine the vertical displacement of free end point C on the Frame shown in Fig. Take $E = 29 \times 10^3$ ksi and $I = 600\ in^4$. For both members. Use method of Virtual Work.



Solution:

First finding Reactions

$$\Sigma M_A = 0$$

$$-4(10)(5) + C_y(8) = 0$$

$$-200 + 8C_y = 0$$

$$\boxed{C_y = 25}$$

$\rightarrow \quad \Sigma F_y = 0 \quad \uparrow^{+}$

$$25 + A_y = 0$$

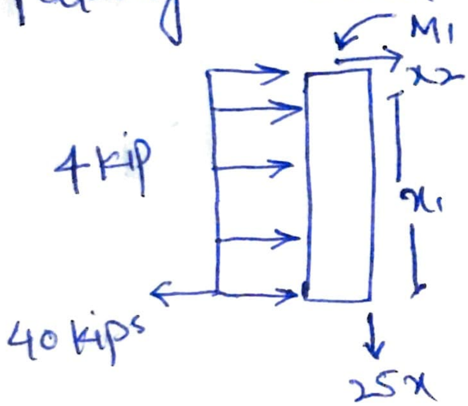
$$\boxed{A_y = -25 \text{ kips}}$$

$\rightarrow \quad \Sigma F_x = 0 \quad \xrightarrow{} +$

$$40 - A_x = 0$$

$$\boxed{A_x = 40 \text{ kips}}$$

Taking Section

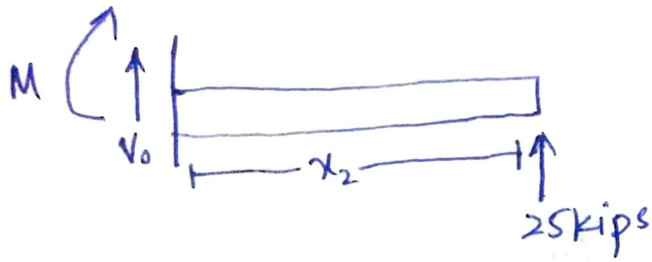


Real Moment:

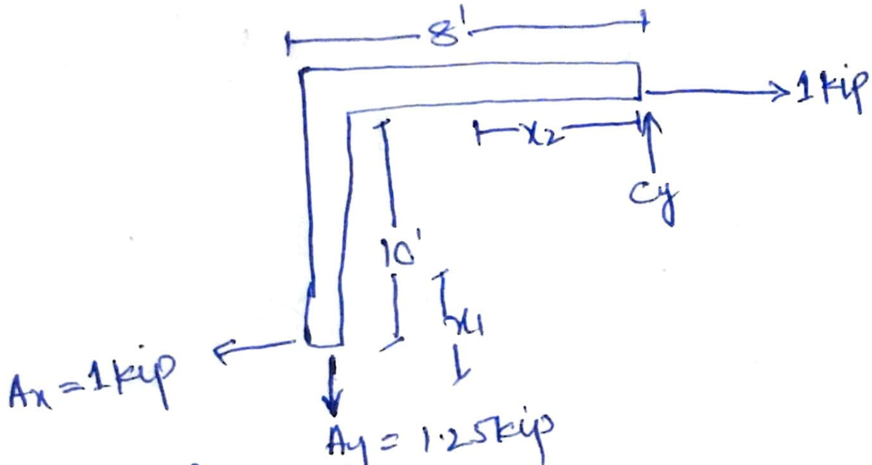
$\circlearrowleft^{+} \quad \Sigma M_1 = 0$

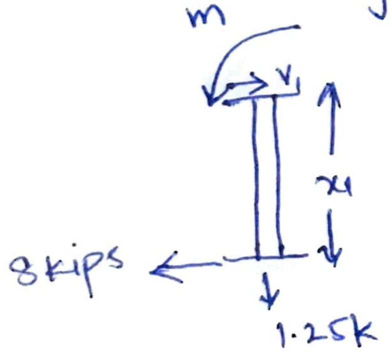
$$-40(x_1) + 4(x_1) \cdot \frac{x_1}{2} + x_1 = 0$$

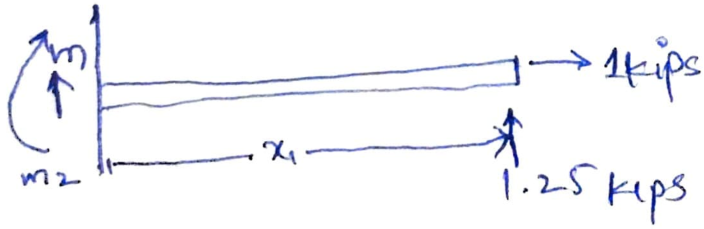
$$x_1 = 40x_1 + 2x_1^2 .$$



→ Virtual Moment:







$\circlearrowleft^{+} \Sigma M_A = 0$

$cy\,(8') - 1(10') = 0$

$cy = 1.25 \text{ kips}$

$\circlearrowleft^{+} \Sigma M_1 = 0$

$-1(x_1) + m_1 = 0$

$\boxed{m_1 = 1x_1}$

$-m_2 + 1.25x_2 = 0$

$\boxed{m_2 = 1.25x_2}$

$\Sigma F_y = 0 \uparrow^{+}$

$\boxed{Ay = 1.25}$

$\Sigma F_x = 0 \xrightarrow{+}$

$1 + Ax = 0$

$\boxed{Ax = -1}$

Virtual Work Equations:

$$1 \cdot \Delta = \int_0^L \frac{Mm}{EI} dx$$

$$1k \cdot \Delta_{Cn} = \int_0^{10} \frac{(40x_1 - 2x_1^2)(1x_1)}{EI} dx$$

$$= \frac{1}{EI}\left[\int_0^{10} (40x_1^2 - 2x_1^3) dx + \int_0^8 2(1.25x^2) \right.$$

$$\Delta_{Cn} = \frac{8333.3}{EI} + \frac{5333.3}{EI}$$

$$\Delta_{Cn} = \frac{13666.7}{EI} \ k \cdot ft^2$$

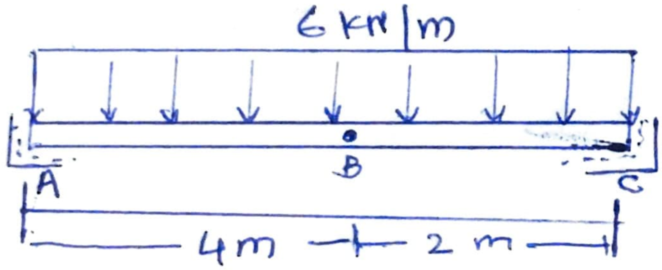
$$\Delta_{Cn} = \frac{13{,}666.7}{29 \times 10^3 \ k/in \times 600 \ in^4}$$

$$\boxed{\Delta_{Cn} = 1.36 \ inch.}$$

QUESTION #02:

Determine the slope and displacement at point B. Assume the support at A is a pin and C is rollar. Take $E = 200$ Gpa, $I = 60 \times 10^6 \, mm^4$. Use castigliano's theorem.

Solution:

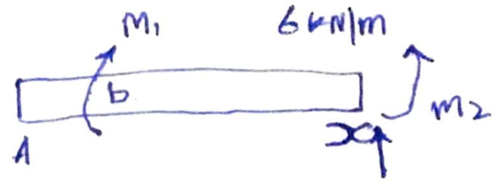


$E = 200$ Gpa

$I = 60 \times 10^6 \, mm$

To find slope & displacement.

Now we know that



$$m' - m_2 = \frac{1}{2}(x_2)(6 + x_1)$$

$$m' = m' + \frac{6x_2 + x_1^2}{2}$$

$$m = -m' + 3x_2 + \frac{x_1^2}{2}$$

$$m = -m' + 3x_2 + x_1^2/2$$

Taking partial derivatives with respect to m.

$$\frac{2M_2}{2p} = -x$$

$$\Delta B = \int_0^2 m\frac{(2m)}{2p}\frac{du}{E}$$

$$= \int_0^6 \frac{-3x^2(-x)\,dx}{EI} + \int_0^4 \frac{-3x^2(-x)\,dx}{EI}$$

$$\Delta B = \frac{-3x^2}{4EI}\Big|_0^6 + \frac{-3x^4}{4EI}\Big|_0^4$$

Put the value of EI

and I.

$$\Delta B = \left.\frac{-3x^2}{2(200)(60\times10^6)}\right|_0^6 + \left.\frac{-3x^4}{4(200)(60\times10^6)}\right|_0^4$$

$$\Delta B = -\frac{216\ KN\cdot Ft^3}{4.8\times60} + \frac{-614.4\ KN\cdot Ft^3}{4.8\times10^{12}}$$

$$\Delta B = -4.5\times10^{-9} + (-1.28\times10^{-8})$$

$$\Delta B = 5.76\times10^{-10}\ \text{inch}$$

For Slope:

$$\cancel{M=}\quad M+\frac{1}{2}x\,(6x_1) = 0$$

$$M = -\tfrac{1}{2}x\,(6x_2) = -3x^2$$

So;

$$\frac{2m_1}{2m_1'} = 0$$

$$m_1' - m_2 - \frac{1}{2}(x_2)\,(6+x_2)$$

$$m = -m' + 6x_2 + x_2^2$$

$$m = -m' + 3x^2 + \frac{x^2}{2}$$

$$\frac{\partial m_2}{\partial m_1} = 1$$

$$= \int_0^6 \frac{-3x^2 \, dx}{EI} + \int_0^{10} \left(-2 + 6x^2 + \frac{x^2}{2}\right) dx$$

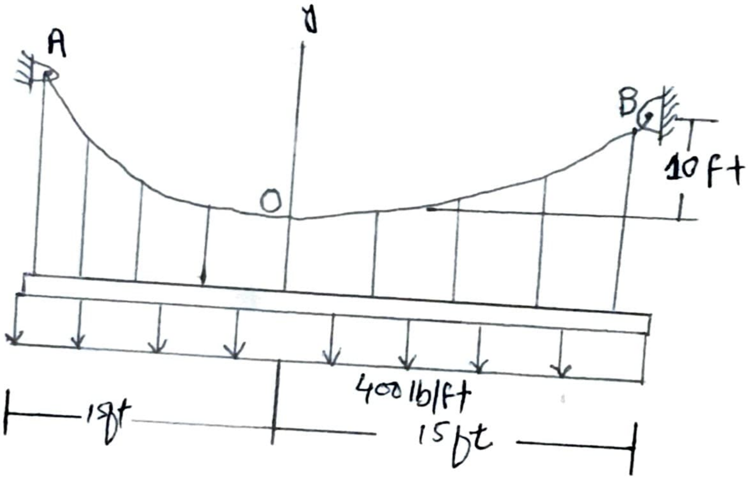
$$= 0 + \left(-x + \frac{6x^3}{3} + \frac{x^3}{6}\right)\Big|_0^{10} \left(\frac{1}{EI}\right)$$

$$= \frac{1}{200 \times (60 \times 10^6)} \left(-x + \frac{6x^3}{3} + \frac{x^3}{6}\right)\Big|_0^{10}$$

$$\Rightarrow \phi = 4.125 \times 10^{-7} \text{ inch}$$

QUESTION # 03:

The cable is subjected to the uniform loading. If the slope of the cable at point O is zero, determine the equation of the curve and the force in the cable at O and B.



Solution:

As we know that

$$Y = \frac{h}{L^2} \cdot x^2$$

putting the values

$$Y = \frac{8}{(15)^2} \cdot x^2$$

$$Y = \frac{8}{225} x^2$$

$$\boxed{Y = 0.0355 x^2}$$

Now;

$$T_o = F_B = \frac{W_o L^2}{2h}$$

putting the values

$$F_B = \frac{400 \ (15)^2}{2 \times 10}$$

$$= \frac{9000}{20}$$

$$= 4500 \text{ lb}$$

$$\boxed{F_B = 4.500 \text{ k}}$$

So;

$$T_B = T_{max} = \sqrt{(F_B)^2 + (W_o L)^2}$$

Putting the values

$$= \sqrt{(4500)^2 + [(400)(15)]^2}$$

$$= \sqrt{20250,000 + 36,000,000}$$

$$= \sqrt{56250,000}$$

$$= 7500 \text{ lb's}$$

$$= 7.50 \text{ K}$$

Now;

$$T_B = T_{max} = W_o L \sqrt{1 + (L/2h)^2}$$

$$= 400 (15) \sqrt{1 + \left(\frac{15}{2(10)}\right)^2}$$

$$= 6000 \sqrt{1 + 0.5625}$$

$$= 6000 \sqrt{1.5625}$$

$$= 7500 \text{ lb}$$

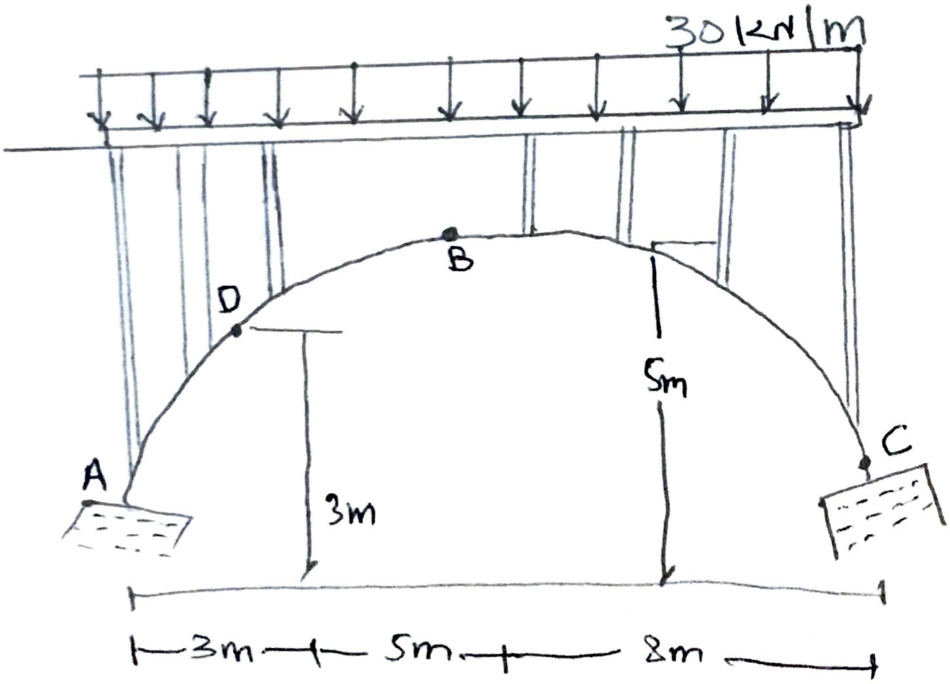
$$\boxed{T_B = 7.50 \text{ K}}$$

QUESTION 4:

The three hinged spandrel arch is subjected to the uniform load of 30 kN/m. Determine the internal moment in the arch at point D.

Solution:

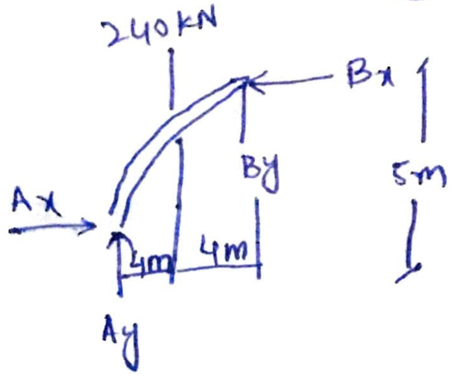
As we know that



Member AB:

$$\circlearrowright^{+} \Sigma M_A = 0$$

$$\Rightarrow B_x(5) + B_y(8) - 240(4) = 0$$



Member AB

MEMBER BC:

$$\curvearrowright + \quad M_c = 0$$

$$-B_x(5) + B_y(8) + 240(4) = 0$$

$$B_x = 192 \text{ KN}, \quad B_y = 0$$

SEGMENT BD:

$$\curvearrowright + \quad \Sigma M_D = 0$$

$$= 192(2) - 150(2.5) - M_D = 0$$

$$M_D = 9 \text{ KN.m}.$$