FINAL EXAM SPRING 2020

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DEPARTMENT : BE(Civil)

SECTION : "B"

PAPER : STRUCTURAL ANALYSIS

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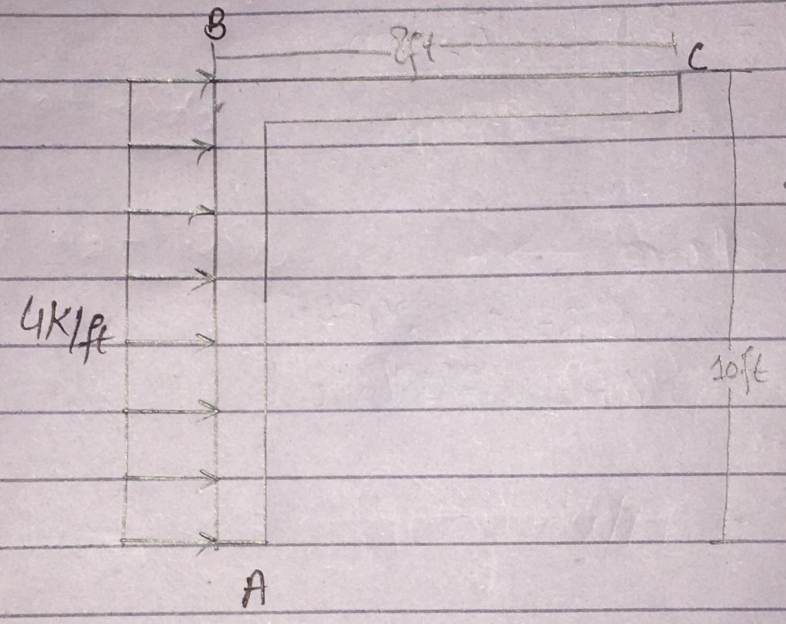
DATE : 26/06/2020

QUESTION No. 1

Determine the vertical Displacement - - -
- - - virtual work.

GIVEN DATA:



$E = 29 \times 10^3$ ksi
$I = 600$ in^4

REQUIRED DATA:

vertical displacement = ?

SOLUTION:

FOR REACTION:

$\Sigma M_A = 0$

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

$\Rightarrow \quad C_y = 25$ kips.

$\Sigma F = 0 \quad \uparrow +$

$25 + A_y = 0$

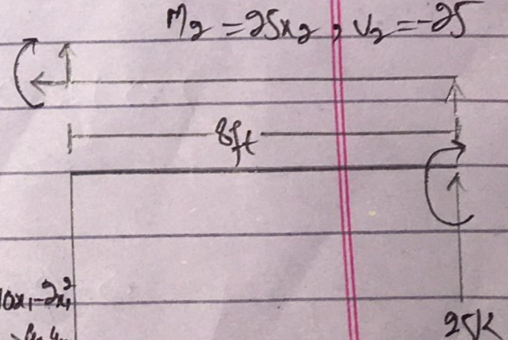
$A_y = -25$ kips.

$\Sigma F_x = 0 \quad \rightarrow +$

$40 - A_x = 0$

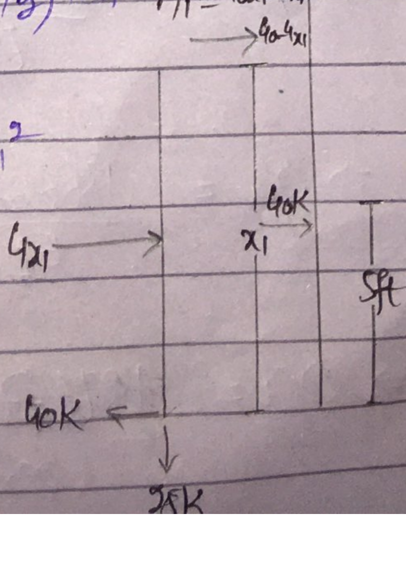
$\Rightarrow A_x = 40$ kips.

REAL MOMENT:



$\Sigma M_1 = 0$

$\Rightarrow -40(x_1) + 4x_1(x_1/2) + M_1 = 0$ $\quad M_1 = 40x_1 - 2x_1^2$

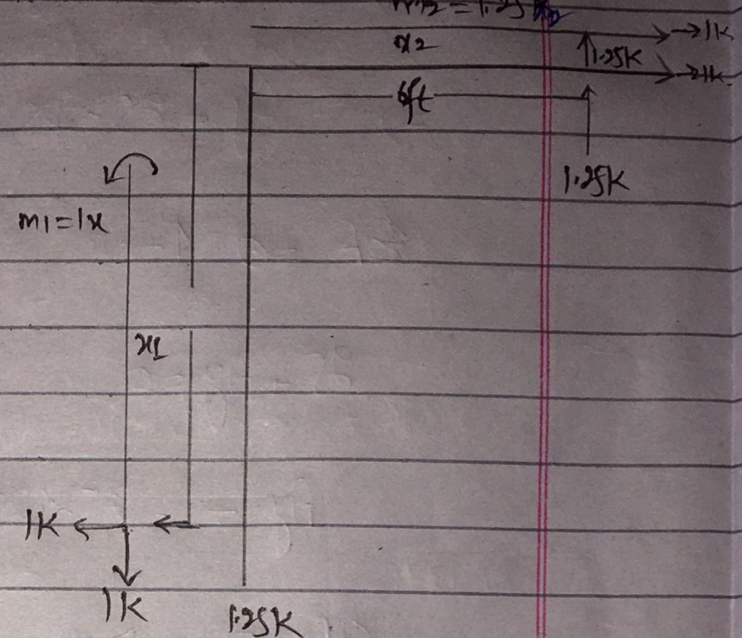


$\Rightarrow M_1 = 40x_1 - 2x_1^2$

$\Rightarrow 25x_2 + M_2 = 0$

$M_2 = 25x_2$

VIRTUAL MOMENTS:



$\Sigma m_1 = 0$

$\Rightarrow -1(x_1) + m_1 = 0$

$\Rightarrow m_1 = 1x_1$

$-m_2 + 1.25x_2$

$\Rightarrow m_2 = 1.25x_2$

Now from virtual work equation.

$$1k \cdot \Delta C_v = \int_0^L m\, M\, dx/EI$$

$$\Rightarrow 1k \cdot \Delta C_v = \int_0^{18} \frac{(40x_1 - 2x_1^2)(1x_1)}{EI}\, dx$$

$$\Rightarrow \Delta C_v = \frac{8333.3}{EI} + \frac{5333.3}{EI}$$

$$\Rightarrow \Delta C_v = \frac{13666.7}{EI}\ k^2 ft^3$$

$$\Rightarrow \Delta C_v = \frac{13666.7\ k^2 \cdot ft \times (12^3\ in^3)}{(29\times10^3)(600)}$$

$\Rightarrow \boxed{OCv = 1.357 \text{ inch}}$

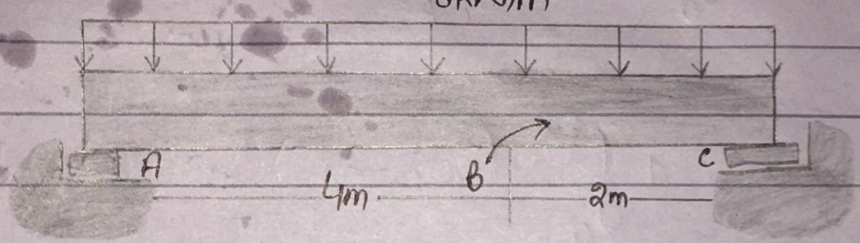
RESULT:

Hence $OCv = 1.357$ inches.

QUESTION No.2

Determine the slope and displacement - - - - - -
- - - - - - - . Use Castigiliano's Theorem.

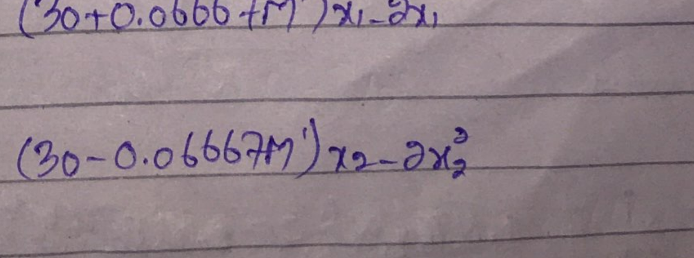
GIVEN DATA:



REQUIRED DATA:

We have to find the Slope and displacement.

SOLUTION:



$$M_1 = (30+0.06667M')x_1 - 2x_1^2$$

$$M_2 = (30-0.06667M')x_2 - 2x_2^3$$

Now $\frac{\partial M_1}{\partial M'} = 0.06667x_1$ and $\frac{\delta M_2}{\delta M'} = 0.0667x_2$

set $M' = 0$

Now $M_1 = (30x_1 - 2x_1^2)$ k.ft

& $M_2 = (30x_2 - 2x_2^2)$ k.ft

Thus

$$\theta_B = \int_0^L M\left(\frac{\partial M}{\partial M'}\right)\frac{dx}{EI}$$

$$= \int_0^{4m} \frac{(30x_1 - 2x_1^2)(0.06667x_1)\,dx_1}{EI}$$

$$+ \int_0^{2m} \frac{(30x_2 - 2x_2^2)(0.06667x_2)\,dx_2}{EI}$$

$$= \frac{1}{EI}\left[\int_0^{4m} (2.001x_1^2 - 0.1334x_1^3)\,dx_1\right.$$

$$\left. + \int_0^{2m} (2.001x_2^2 - 0.1334x_2^2)\,dx_2\right]$$

$$= \frac{1}{EI}\left[\frac{2.001x_1^3}{3}\Big|_0^4 - \frac{0.1334x_1^3}{4}\Big|_0^4\right.$$

$$\left. + \frac{2.001x_2^2}{3}\Big|_0^2 - \frac{0.1334x_2^3}{4}\Big|_0^2\right]$$

$$= \frac{1}{EI}\left[0.667x_1^3\Big|_0^4 - 0.03335x_1^4\Big|_0^4 + 0.667x_2^3\Big|_0^2 - 0.03335x_2^4\Big|_0^2\right.$$

$$\theta_B \Rightarrow \frac{1}{EI}\left[(42.688 - 8.5376) + (5.336 - 0.5336)\right]$$

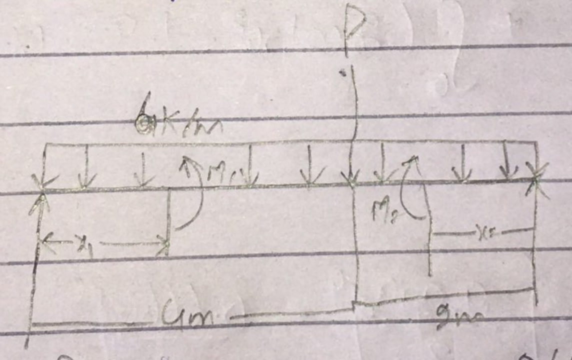
$$\Rightarrow \theta_B = \frac{38.9504}{EI}$$

$$\Rightarrow \theta_B = \frac{38.9504}{(200\times10^9)\times(60\times10^6\ mm^4)}$$

$$\Rightarrow \theta_B = \frac{38.9504}{(200\times10^9)(6\times10^{-5})}$$

$$\Rightarrow \boxed{\theta_B = 0.03245\times10^{-4}\ \text{radian}}$$

Now displacement.



0.3333P+30 0.6667P+30

Now $M_1 = (0.333P+30)x_1 - 2x_1^2$

$M_2 = (0.6667P+30)x_2 - 2x_2^2$

Now $\frac{\partial M_1}{\partial P} = 0.333x_1$ & $\frac{\partial M_2}{\partial P} = 0.6667x_2$

Set $P=0$

$M_1 = (30x_1 - 2x_1^2)$ and $M_2 = (30x_2 - 2x_2^2)$

$$\delta B = \int_0^1 M\left(\frac{\partial M}{\partial P}\right)\frac{dx}{EI}$$

$$\Rightarrow \delta B = \frac{1}{EI}\left[\int_0^4 (30x_1 - 2x_1^2)\,0.3333x_1\,dx_1 + \int_0^2 (30x_2 - 2x_2^2)\,0.6667\,dx_2\right]$$

$$\Rightarrow \delta B = \frac{1}{EI}\left[\int_0^4 (9.999x_1^2 - 0.6666x_1^3)\,dx_1 + \int_0^2 (20.001x_1^2 - 1.3334x_1^3)\,dx_2\right]$$

$$\Rightarrow \delta B = \frac{1}{EI}\left[\frac{9.999x_1^3}{3}\Big|_0^4 - \frac{0.6666x_1^4}{4}\Big|_0^4 + \frac{20.001x_2^3}{3}\Big|_0^2 - \frac{1.3334x_2^4}{4}\Big|_0^2\right]$$

$$\Rightarrow \delta B = \frac{1}{EI}\left[(213.33 - 42.6624) + (53.336 - 5.336)\right]$$

$$OB = \frac{218.6676}{(200\times10^{9})\times(60\times10^{-5})}$$

$$\Rightarrow OB = 0.1822\times10^{-4}\ ft$$

$$\Rightarrow \boxed{OB = 2.186\times10^{-4}\ inch}$$

RESULT:

Hence

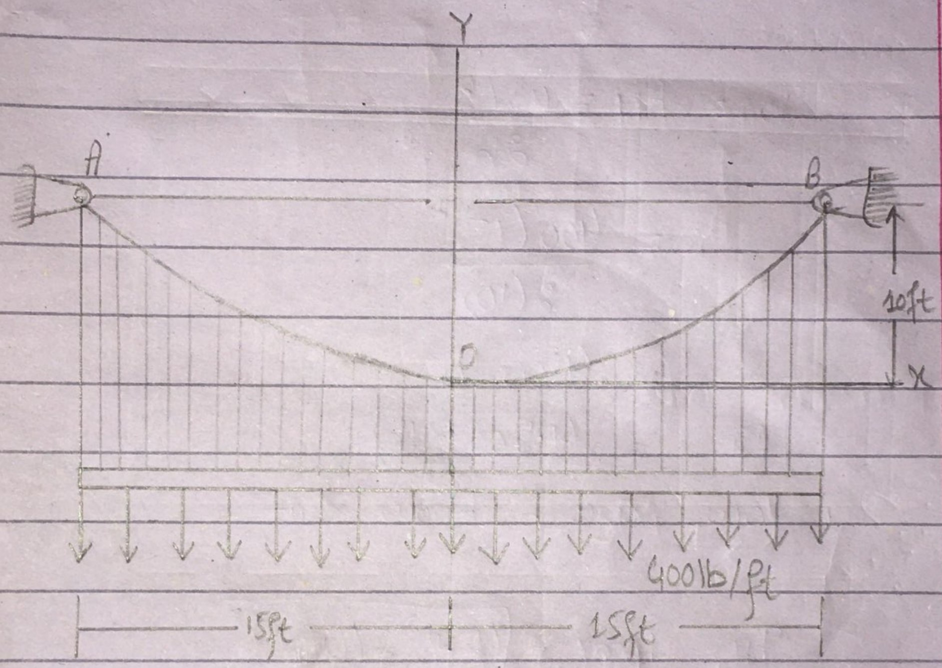
$$OB = 0.03245\times10^{-4}$$

$$OB = 2.186\times10^{-4}$$

QUESTION No. 3

The Cable is Subjected to uniform - - - - -
- - - - - in the Cable at O and B.

GIVEN DATA:



Slope = 0

REQUIRED DATA:

We have to find the equation of the curve and the force in the cable at O and B.

SOLUTION:

As we know that

$$y = \frac{h}{l^2} x^2$$

$$\Rightarrow y = \frac{(10)^2}{(15)^2} x^2$$

$$\Rightarrow y = 0.444 x^2$$

Now we know that.

$$T_0 = F_H = \frac{w_0 L^2}{2h}$$

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

$$= 4500 \text{ lb}$$

$$\boxed{F_H = 4.500 \text{ Klb}}$$

Now we know that

$$T_H = T_{max} = \sqrt{(F_H)^2 + (w_0 L)^2}$$

$$\Rightarrow T_{max} = \sqrt{(4500)^2 + (400 \times 15)^2}$$

$$\Rightarrow \boxed{T_{max} = 7500 \text{ lb} = 7.500 \text{ Klb}}$$

Now we know that.

$$T_B = T_{max} = w_0 L \sqrt{1 + (L/2h)^2}$$

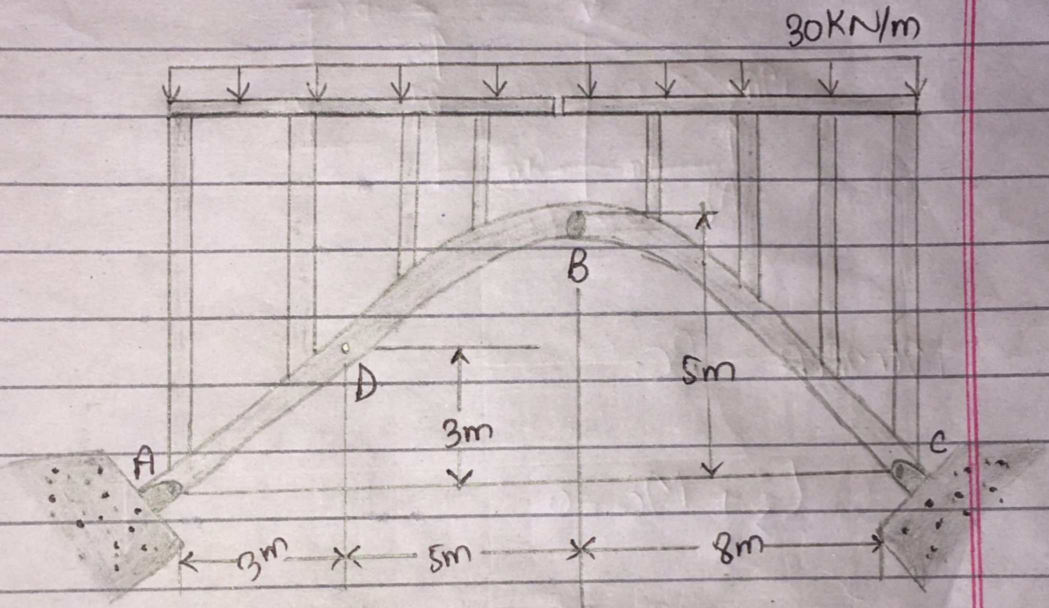
$$\Rightarrow T_{max} = (400)(15) \sqrt{1 + (15/(2 \times 10))^2}$$

$$\Rightarrow \boxed{T_{max} = 7500 \text{ lb} = 7.500 \text{ Klb}}$$

QUESTION No.4

The three-hinged spandrel arch is subjected ---
--- moment in the arch at Point D.

GIVEN DATA:



REQUIRED DATA:

We have to find the internal moment in the arch at point D.

SOLUTION:

As we have to to find the Moment at different members.

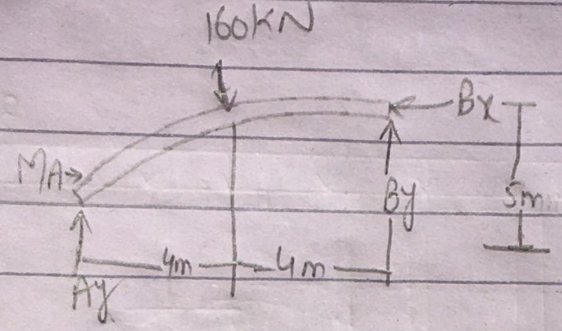
MEMBER AB:

$$\circlearrowright + \Sigma M_A = 0$$

$\Rightarrow \quad Bx(5) + By(8) - 240(4) = 0$

$\Rightarrow \quad 5Bx + 8By = 960$

~~MEMBER~~



MEMBER BC:

$\circlearrowright + M_c = 0$

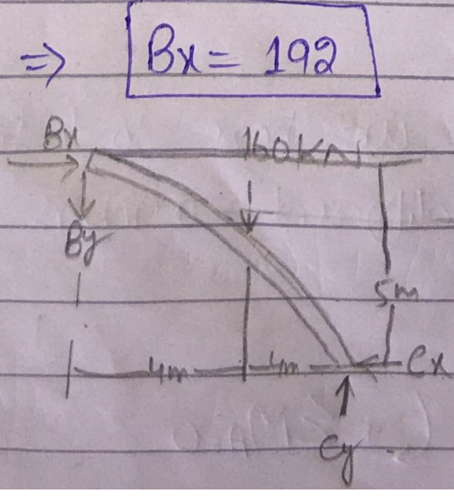
$\Rightarrow \quad -Bx(5) + By(8) + (240)4 = 0$

As $By = 0$

$\Rightarrow \quad -5Bx + 0 + 960$

$\Rightarrow \quad 5Bx = 960$

$\Rightarrow \quad \boxed{Bx = 192}$



NOW SEGMENT BD:

$\circlearrowleft \sum M_D = 0$

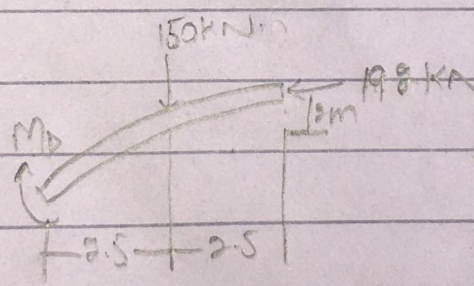
$\Rightarrow (B_x)(2) - (150 \times 2.5) - M_D = 0$

$\Rightarrow (192 \times 2) - (375) - M_D = 0$

$\Rightarrow 384 - 375 - M_D = 0$

$\Rightarrow 09 - M_D = 0$

$\Rightarrow \boxed{M_D = 9\ kN.m}$



RESULT:

Hence $M_D = 09\ kNm$.