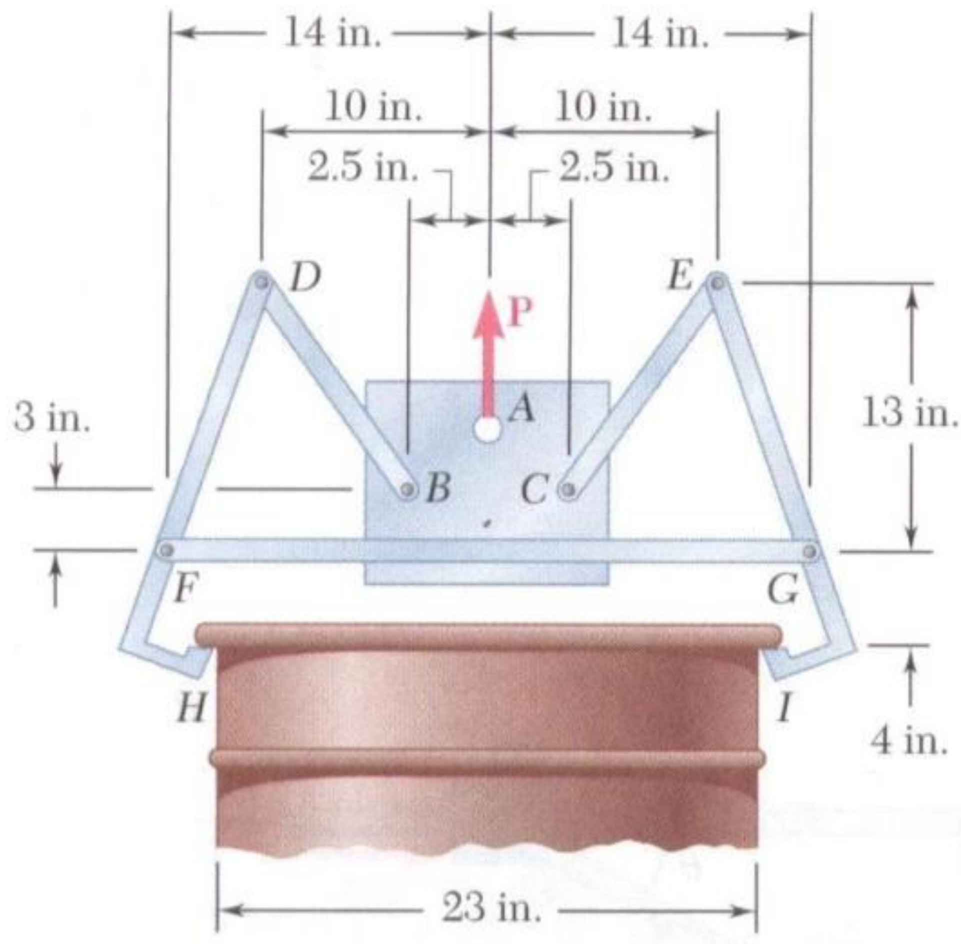
Wright State University
Department of Mechanical and Materials Engineering

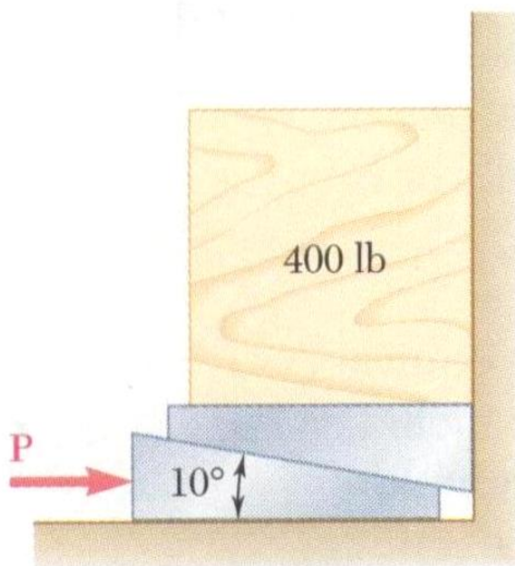
Fall 2019

ME 2120: STATICS
FINAL EXAM
OPEN BOOK, CLOSED NOTES

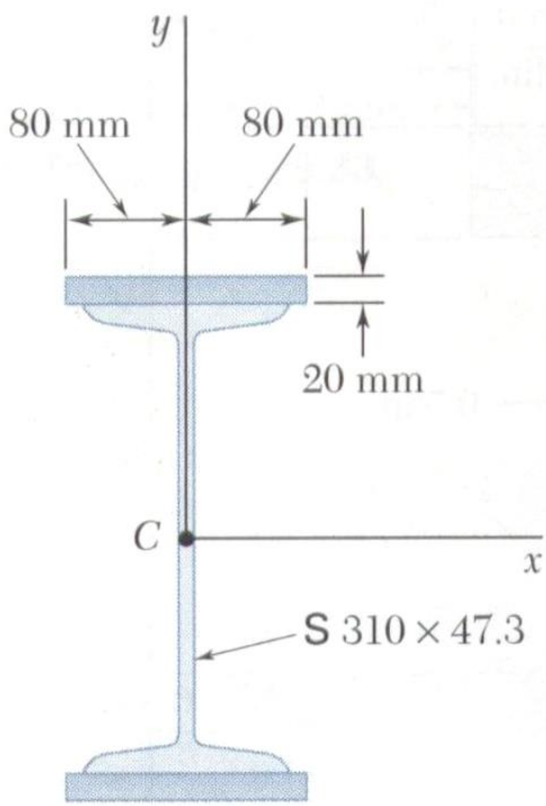
Problem 1 (9 points): The drum lifter shown is used to lift a steel drum. Knowing that the weight of the drum and its contents is 110 lb, determine the forces exerted at *F* and *H* on member *DFH*.



Problem 2 (9 points): Two 10° wedges of negligible weight are used to move and position the 400-lb block. Knowing that the coefficient of static friction at all surfaces of contact is 0.25, determine the smallest force **P** that should be applied as shown to the bottom wedge.

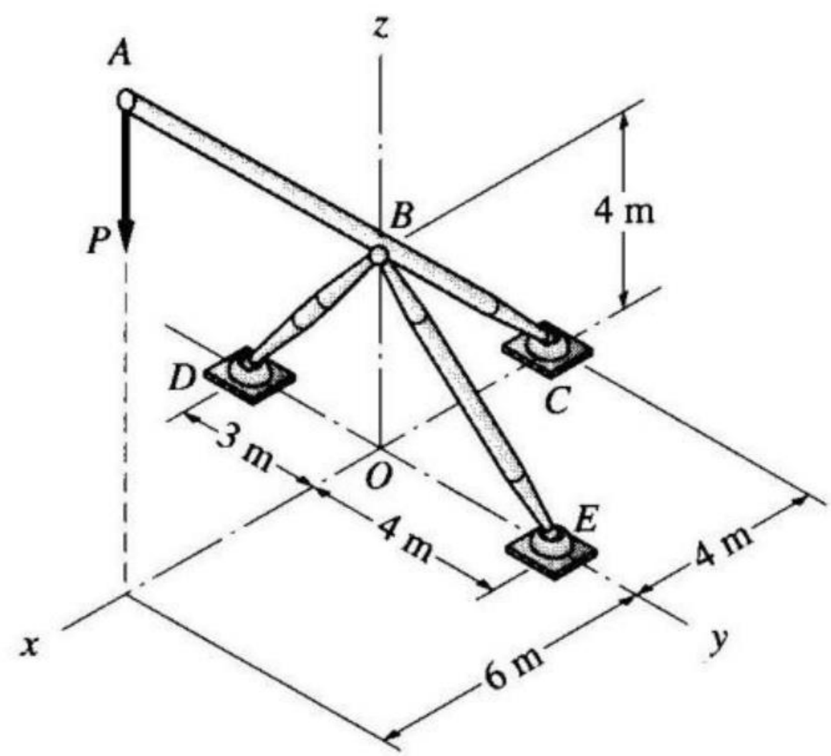


Problem 3 (10 points): Two 20-mm steel plates are welded to a rolled S section as shown. Determine the moment of inertia of the section with respect to the centroidal *x* axis.

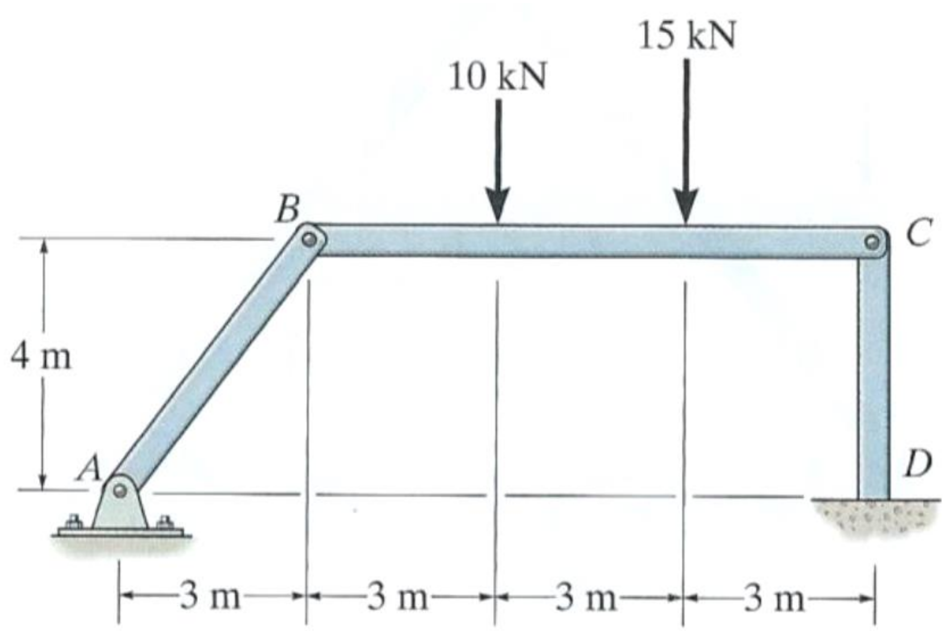


Problem 4 (1 point each, no partial credit): Draw the free-body diagram(s) for the following situations. **Do not solve for the numerical answers!**

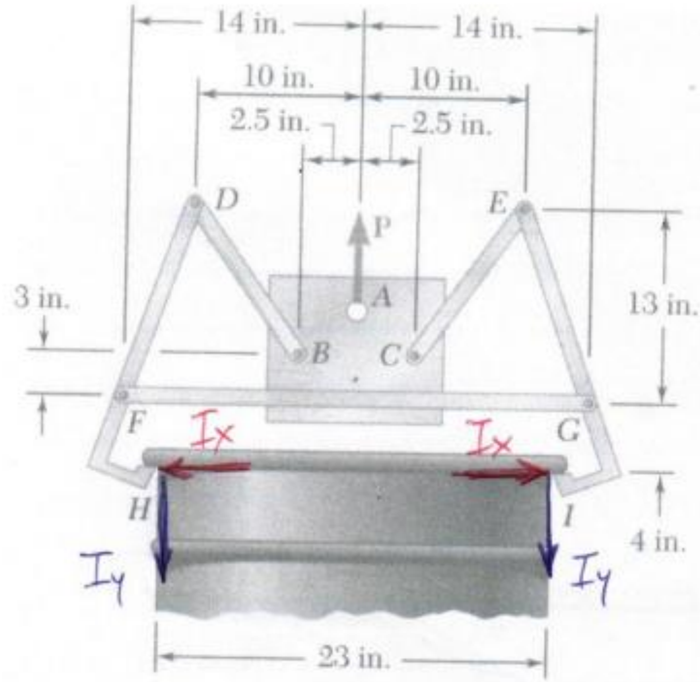
A. A hoist is formed by connecting bars *BD* and *BE* to member *ABC*. Neglecting the weights of the members and assuming that all connections are ball-and-socket joints, determine the magnitudes of the forces in bars *BD* and *BE* in terms of the applied load *P*.



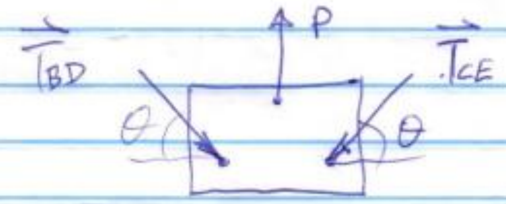
B. Determine the reactions at *D*.



Problem 1 (points): The drum lifter shown is used to lift a steel drum. Knowing that the weight of the drum and its contents is 110 lb, determine the forces exerted at F and H on member DFH.



$\Sigma F_y = 0: \quad I_y = \frac{1}{2} P = \frac{1}{2}(110^{LB}) = 55^{LB}$



$\theta = TAN^{-1}\left(\frac{10}{7.5}\right) = 53.1°$

$\vec{T}_{CE} = (-T_{CE} \cdot COS\,53.1°)\,\hat{i} + (-T_{CE} \cdot SIN\,53.1°)\,\hat{j}\ ^{LB}$

$\vec{T}_{CE} = (-0.6\,T_{CE})\,\hat{i} + (-0.8\,T_{CE})\,\hat{j}\ ^{LB}$

(2)

PROB. 1, CONT.

$\vec{T}_{BD} = (T_{BD} \cdot \cos 53.1°)\hat{i} + (-T_{BD} \cdot \sin 53.1°)\hat{j}$ LB

$\vec{T}_{BD} = (0.6\,T_{BD})\hat{i} + (-0.8\,T_{BD})\hat{j}$ LB

$\Sigma F_y = 0: \quad P - 0.8\,T_{CE} - 0.8\,T_{BD} = 0$

BY INSPECTION/SYMMETRY, $T_{CE} = T_{BD}$

$P = 1.6\,T_{BD}$

$T_{BD} = \frac{1}{1.6}(110^{LB}) = 68.75^{LB}$

$\vec{T}_{BD} = (-T_{BD} \cdot \cos\theta)\hat{i}$

$\quad + (T_{BD} \cdot \sin\theta)\hat{j}$ LB

$\vec{T}_{BD} = (-68.75 \cdot \cos 53.1°)\hat{i}$

$\quad + (68.75 \cdot \sin 53.1°)\hat{j}$ LB

$\vec{T}_{BD} = (-41.28)\hat{i} + (54.98)\hat{j}$ LB

$\Sigma F_x = 0: \; -41.28 - T_{FG} - I_x = 0$

$\Sigma F_y = 0: \; 54.98 - I_y = 0 \quad \boxed{I_y = 54.98^{LB}}$

PROB. 1, CONT.

$\Sigma M_H = 0$ $\circlearrowleft +$:

$(4^{IN})\,T_{FG} + (11.5 - 10^{IN})(54.98^{LB})$

$+ (17^{IN})(41.28^{LB}) = 0$

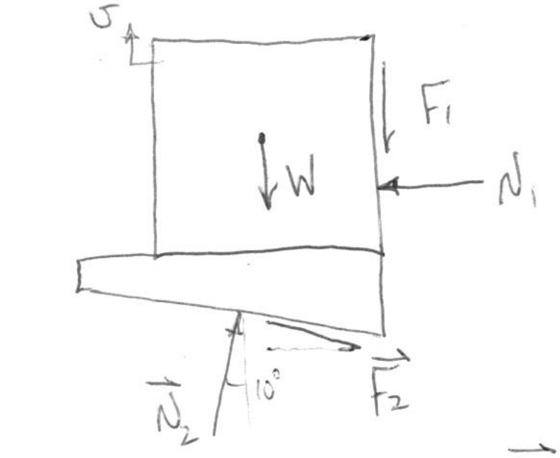
$\boxed{|\vec{T}_{FG}| = -196^{LB}}$ T

$I_x = -41.28 - (-196)$

$\boxed{I_x = 155^{LB}}$

PROB. 8.64

$W = 400^{LB}$, $\mu_s = 0.25$, FIND P_{MIN}



IMPENDING MOTION:

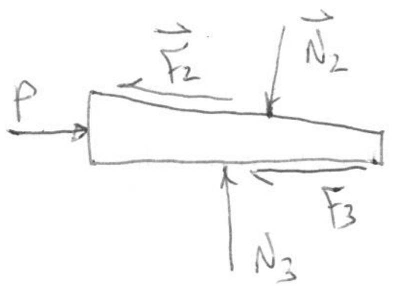
$$F = \mu_s \cdot N$$

$$\vec{N}_2 = (N_2 \cdot \sin 10^\circ)\,\hat{i} + (N_2 \cdot \cos 10^\circ)\,\hat{j}^{\,LB}$$

$$\vec{N}_2 = (0.1736\,N_2)\,\hat{i} + (0.9848\,N_2)\,\hat{j}^{\,LB}$$

$$\vec{F}_2 = (F_2 \cdot \cos 10^\circ)\,\hat{i} + (-F_2 \cdot \sin 10^\circ)\,\hat{j}^{\,LB}$$

$$\vec{F}_2 = (0.9848\,F_2)\,\hat{i} + (-0.1736\,F_2)\,\hat{j}^{\,LB}$$



BLOCK AND WEDGE:

$$\Sigma F_x = 0: \quad -N_1 + 0.1736 N_2 + 0.9848 F_2 = 0 \qquad ①$$

$$\Sigma F_y = 0: \quad -F_1 - W + 0.9848 N_2 - 0.1736 F_2 = 0 \qquad ②$$

EQN. ①:

$$-N_1 + 0.1736 N_2 + 0.9848 \cdot (0.25 \cdot N_2) = 0$$

$$\boxed{N_1 = 0.4198 \cdot N_2}$$

EQN. (2) :

$$-(0.25\,N_1) - 400 + 0.9848\,N_2 - 0.1736(0.25\,N_2) = 0$$

$$-0.25(0.4198\,N_2) - 400 + 0.9414\,N_2 = 0$$

$$0.8365\,N_2 = 400$$

$$\boxed{N_2 = 478.2^{LB}}$$

$$\boxed{N_1 = 0.4198 \cdot (478.2) = 200.8^{LB}}$$

EQN. (1) :

$$-N_1 + 0.1736\,N_2 + 0.9848\,F_2 = 0$$

$$F_2 = \left(\frac{1}{0.9848}\right)\left[(200.8) - 0.1736(478.2)\right]$$

$$\boxed{F_2 = 119.6^{LB}}$$

$$\vec{N}_2 = \left[0.1736(478.2)\right]\hat{i} + \left[0.9848(478.2)\right]\hat{j}^{\;LB}$$

$$\vec{N}_2 = (83.02)\hat{i} + (470.9)\hat{j}^{\;LB}$$

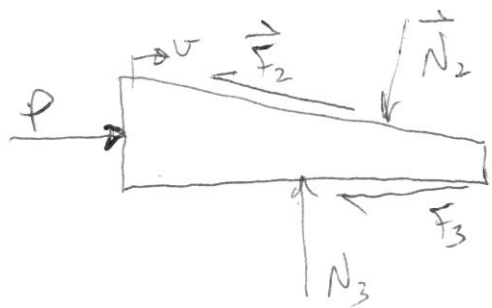
$$\vec{R}_2 = \sqrt{(83.02 + 117.8)^2 + (470.9 - 20.76)^2} =$$

8-64, CONT. ③

$$\vec{F}_2 = \left[0.9848(119.6)\right]\hat{i} + \left[-0.1736(119.6)\right]\hat{j} \text{ LB}$$

$$\vec{F}_2 = (117.8)\hat{i} + (-20.76)\hat{j} \text{ LB}$$

LOWER WEDGE: FLIP SIGNS ON $\vec{N}_2$ AND $\vec{F}_2$



$$\vec{N}_2 = (-83.02)\hat{i} + (-470.9)\hat{j} \text{ LB}$$

$$\vec{F}_2 = (-117.8)\hat{i} + (20.76)\hat{j} \text{ LB}$$

$$\Sigma F_x = 0: \quad P - F_3 - 117.8 - 83.02 = 0$$

$$P = F_3 + 200.8$$

$$P = 0.25 N_3 + 200.8 \quad ①$$

$$\Sigma F_y = 0: \quad N_3 + 20.76 - 470.9 = 0$$

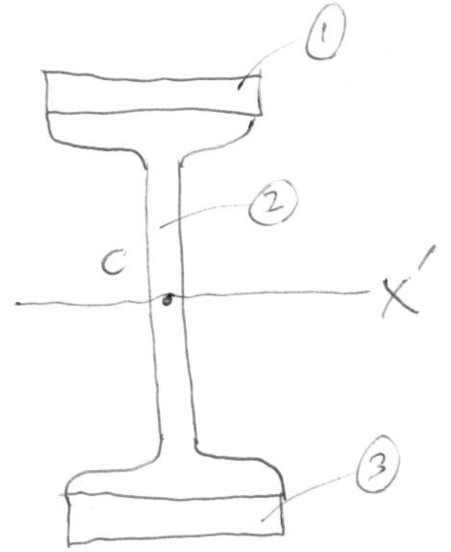
$$\boxed{N_3 = 450.1 \text{ LB}}$$

$$P = 0.25(450.1) + 200.8$$

$$\boxed{P = 313.3 \text{ LB}}$$

PROB. 9.49

FIND $\bar{I}_{x'}$



$$(I_x)_1 = \bar{I}_x + A_1 d_1^2 = \frac{1}{12} bh^3 + bhd_1^2$$

$$(I_x)_1 = \frac{1}{12}(160^{mm})(20^{mm})^3 + (160^{mm})(20^{mm})\left(\frac{305}{2} + 10^{mm}\right)^2$$

$$(I_x)_1 = 8.46 \times 10^7 \text{ mm}^4$$

$$(I_x)_3 = 8.46 \times 10^7 \text{ mm}^4$$

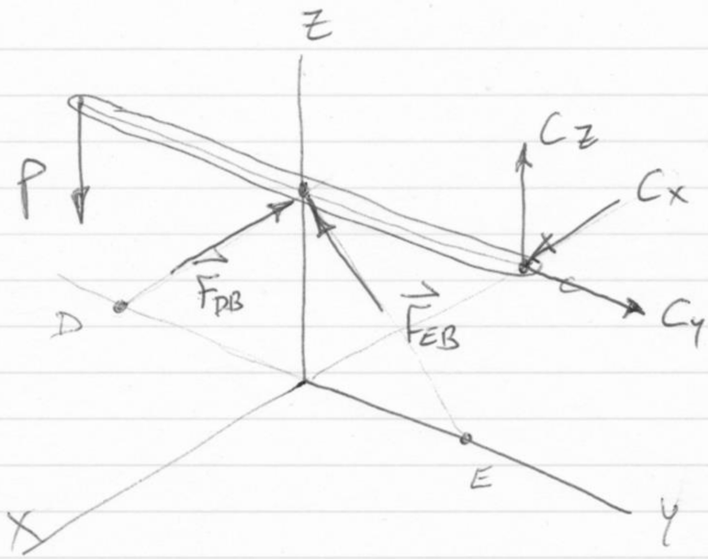
$$(I_x)_2 = 90.7 \times 10^6 \text{ mm}^4$$

$$\bar{I}_{x'} = (I_x)_1 + (I_x)_2 + (I_x)_3$$

$$\bar{I}_{x'} = (8.46 \times 10^7) + (90.7 \times 10^6) + (8.46 \times 10^7)^{\text{mm}^4}$$

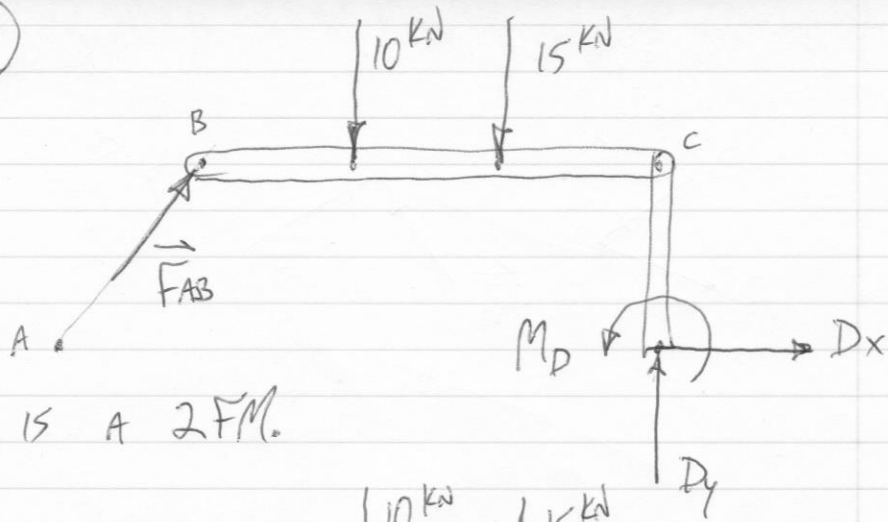
$$\boxed{\bar{I}_{x'} = 2.60 \times 10^8 \text{ mm}^4}$$

A

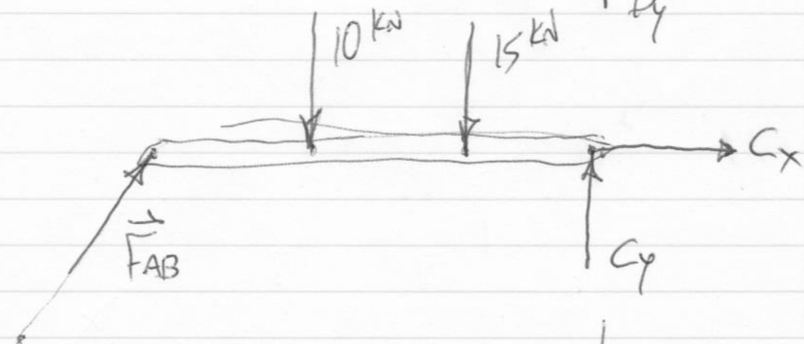


DB AND
EB ARE
2FM's

B



AB IS A 2FM.



CD IS A

CANTILEVERED BEAM.