King Fahd University of Petroleum & Minerals

Department of Civil and Environmental Engineering

CE 201 – Statics

Semester: 151
Examination: Second Major
Date (Day): November 20, 2015 (Friday)
Time: 01:00 – 03:30 p.m.

Section	1	2	3	4	5	6	7	8
Instructor	Al-Malack	Al-Malack	Vohra	Al-Osta	Al-Attas	Essa	Al-Amoudi	Chowdhury
Time	07:00	08:00	08:00	09:00	10:00	11:00	13:10	07:00
Tick								

Student's Name	:
Student's ID	:

Problem	Assigned Grade	Earned Grade
1A	12 (Points)	
1B	13 (Points)	
2	25 (Points)	
3	25 (Points)	
4	25 (Points)	
Total	100 (Points)	

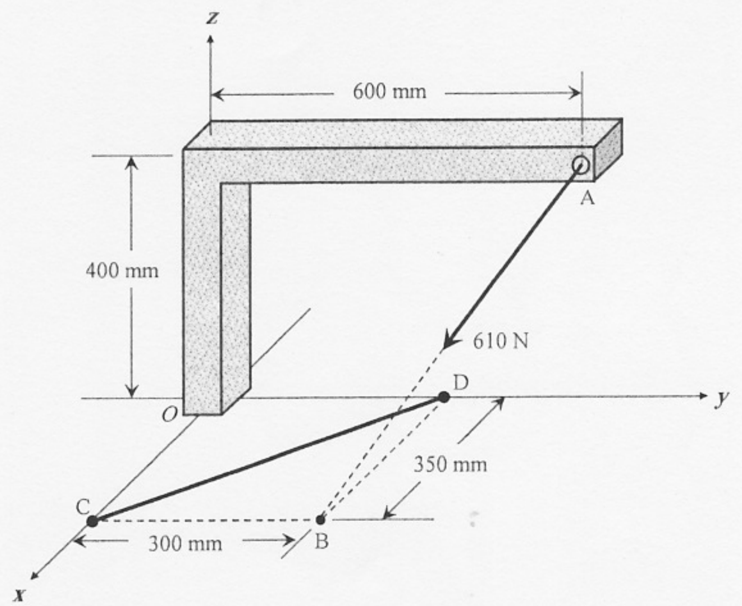
Good Luck

Problem 1A (12 Points)

The bracket, shown in the figure below, is subjected to a 610 N force (**F_{AB}**), Determine:

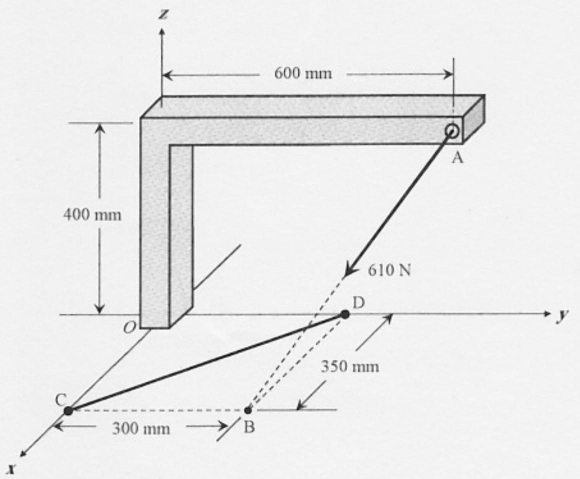
a) The moment of the force about an axis extending between **C** and **D**. Express the results as a Cartesian vector. **(10 Points)**

b) The perpendicular distance between the force (**F_{AB}**) and line **CD**. **(2 points)**



Problem 1A (12 Points):

A bracket is subjected to a 610 N force as shown in the figure.
(a) Determine the moment of the force about line CD and express it in Cartesian vector form. (**8 Points**)
b) Determine the distance between the force and line OC. (**4 points**)



Solution
a)

$$F = 610\left[\frac{350i - 300j - 400k}{\sqrt{(350)^2 + (-300)^2 + (-400)^2}}\right] = 349.8i - 299.8j - 399.8k \ [N]$$

$$u_{CD} = \frac{-350i + 300j}{\sqrt{(-350)^2 + (300)^2}} = -0.7593i + 0.6508j \quad [1 \text{ pts}]$$

$$M_C = \begin{vmatrix} i & j & k \\ 0 & 0.3 & 0 \\ 349.8 & -299.8 & -399.8 \end{vmatrix} = -119.94i - 104.94k \ [N.m]$$

[3pts]

$$M_{CD} = M_C \cdot u_{CD}$$

$$= (-119.94i - 104.9k) \cdot (-0.7593i + 0.6508j) = 91.07 \ N.m \quad [4pts]$$

Moment along line CD is

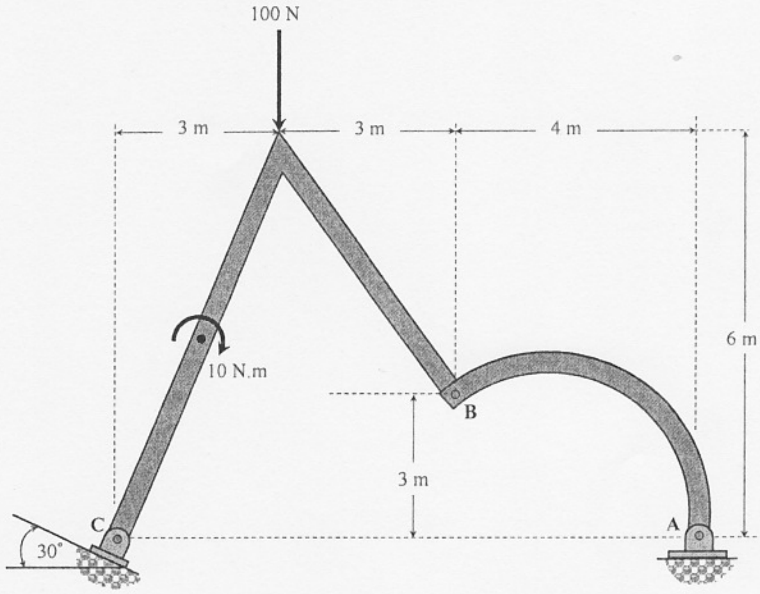
$$M_{CD} = M_{CD} \cdot u_{CD} = 91.07 \cdot (-0.7593i + 0.6508j)$$

$$= -69.1i + 59.3j \ Nm \quad [2 \text{ pts}]$$

b) $$d = \frac{M}{F} = \frac{91.07 \ N.m}{610 \ N} = \approx 0.15 \ m \quad [3 \text{ pts}]$$

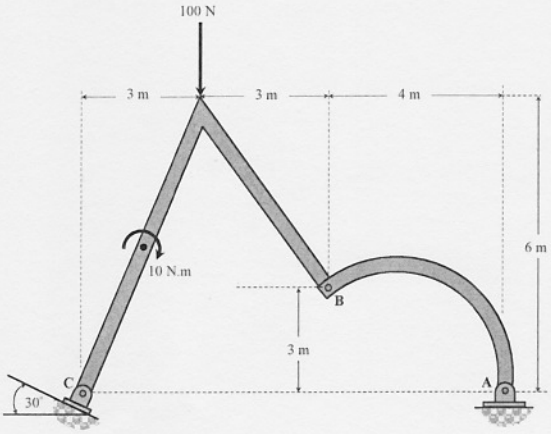
Problem 1B (13 Points)

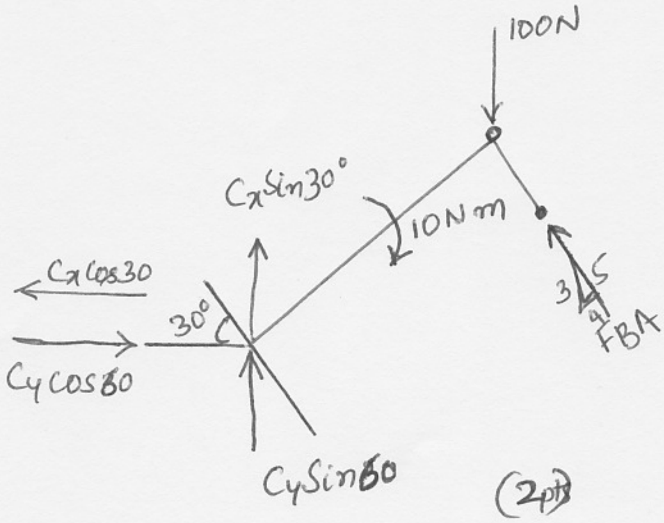
A 100 N force and a 10 N-m couple moment act on member **CB,** as shown in the figure below. Determine the horizontal and vertical components of reaction at the pins **A**, **B** and **C** required for equilibrium.



Problem #1B (13 Points)

A 100 N force and a 10 N-m couple act on member CB as shown below. Find the forces acting at C and B required for equilibrium.





SOLUTION

$\circlearrowleft^{+}\ \Sigma M_C = 0 \Rightarrow -10 - 100(3) + \frac{4}{5} F_{BA}(3) + \frac{3}{5} F_{BA}(6) = 0$ (3 pts)

$-50 - 1500 + 12 F_{BA} + 18 F_{BA} = 0$

$30 F_{BA} = 1550$

$F_{BA} = 51.67 N$ (2 pts)

$\overset{+}{\rightarrow}\ \Sigma F_x = 0 \Rightarrow -C_x \cos 30° + C_y \cos 60° - \left(\frac{4}{5}\right)(51.67) = 0$ — (1)

$+\uparrow\ \Sigma F_y = 0 \Rightarrow C_x \sin 30° + C_y \sin 60° + \left(\frac{3}{5}\right)(51.67) - 100 = 0$ — (2)

$-0.866 C_x + 0.5 C_y - 41.34 = 0$

$0.5 C_x + 0.866 C_y + 31.002 = 100$

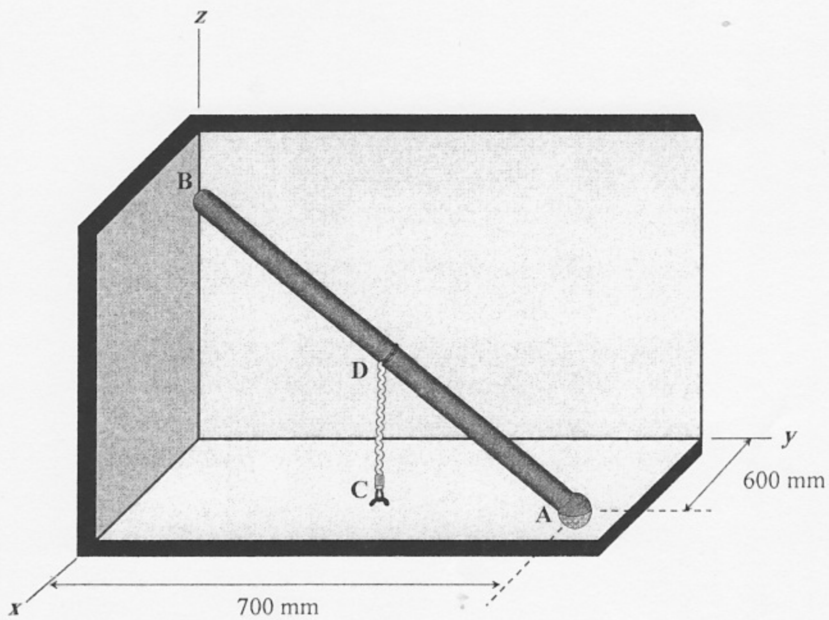
Solving these equations simultaneously, you get

$C_x = -1.29 N$ (3pts)

$C_y = 80.42 N$ (3pts)

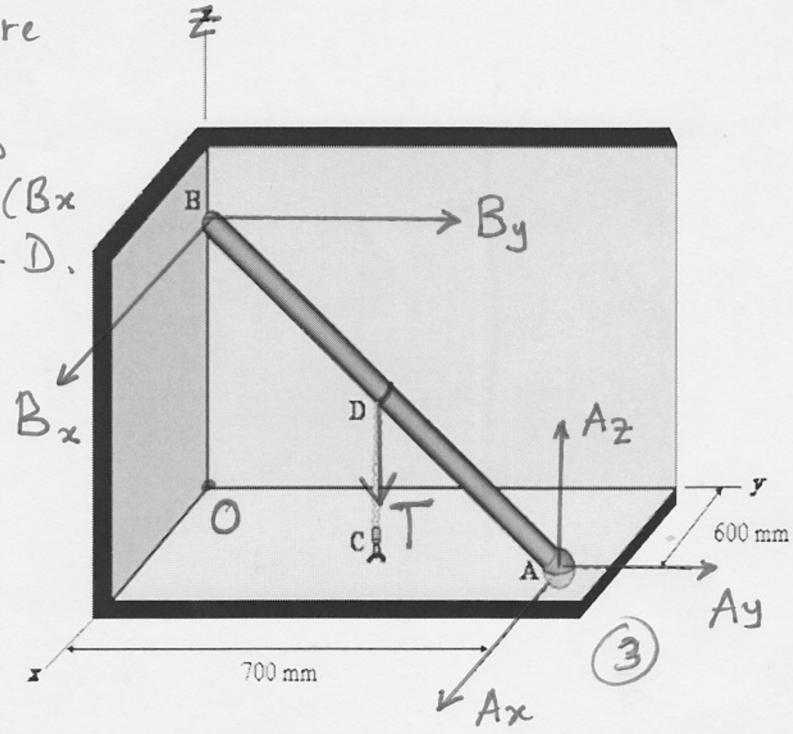
Problem 2 (25 Points)

The 1.1-m bar (**AB**) is supported by a ball and socket (**at A**) and two smooth walls (**at B**). If the tension in the vertical cable **CD** is 1 kN, determine the reactions at **A** and **B**. Point **D** is mid-way between points **A** and **B**.



Solution:

The FBD is shown, where There are 3 reactions at A One reaction at B, which is composed of two components (Bx and By) and one tention at D.



(3)

To determine ΣM_A, we have to determine the coordinates of A, D and B:

$$\overline{OA} = \sqrt{(0.6)^2 + (0.7)^2}$$

$$\hat{OAB} = \cos^{-1}\left(\frac{OA}{BA}\right)$$

$$= \cos^{-1}\left(\frac{\sqrt{(0.6)^2 + (0.7)^2}}{1.1}\right) = 33.1^\circ \quad (2)$$

Therefore, the coordinates of A is $(0.6, 0.7, 0)$ (0.5)

and of B is $(0, 0, 1.1 * \sin 33.1) = (0, 0, 0.6)$ (0.5)

$$\vec{r}_{AB} = \vec{r}_B - \vec{r}_A = -0.6\hat{i} - 0.7\hat{j} + 0.6\hat{k} \quad (2)$$

$$\vec{u}_{AB} = \frac{\vec{r}_{AB}}{r_{AB}} = \frac{\vec{r}_{AB}}{1.1} = -0.5455\hat{i} - 0.6364\hat{j} + 0.5455\hat{k} \quad (1)$$

$$\vec{r}_{AD} = \left(\frac{1.1}{2}\right)\vec{u}_{AB} = 0.55\,\vec{u}_{AB} = -0.300\hat{i} - 0.3500\hat{j} + 0.300\hat{k} \quad (2)$$

Now, considering the equation of equilibrium:

$$\Sigma \vec{M}_A = \vec{r}_{AB} \times \vec{B} + \vec{r}_{AD} \times \vec{T} = 0 \quad (3)$$

$$\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -0.6 & -0.7 & +0.6 \\ B_x & B_y & 0 \end{vmatrix} + \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -0.3 & -0.35 & +0.3 \\ 0 & 0 & -1 \end{vmatrix} \quad (3)$$

$$-0.6B_y\hat{i} + 0.6B_x\hat{j} - 0.6B_y\hat{k} + 0.7B_x\hat{k}$$

$$0.35\hat{i} - 0.3\hat{j} + 0k = 0$$

$$(-0.6B_y + 0.35)\hat{i} + (0.6B_x - 0.3)\hat{j} + (0.7B_x - 0.6B_y)\hat{k} = 0$$

Hence, $B_y = \frac{0.35}{0.6} = 0.58\ kN$ (1)

$B_x = \frac{0.3}{0.6} = 0.50\ kN$ (1)

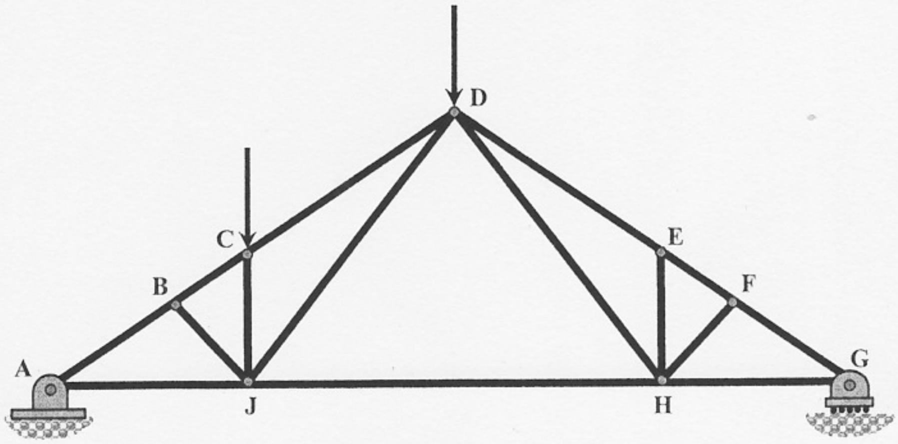
$\Sigma F_x = B_x + A_x = 0$, $\therefore A_x = -B_x = -0.50\ kN$ (2)

$\Sigma F_y = B_y + A_y = 0$, $\therefore A_y = -B_y = -0.58\ kN$ (2)

$\Sigma F_z = A_z - 1 = 0$, $\therefore A_z = 1\ kN$ (2)

Problem 3 (25 Points)

A. Find the zero force members by inspection in the truss below. Negative marks for each wrong answer.



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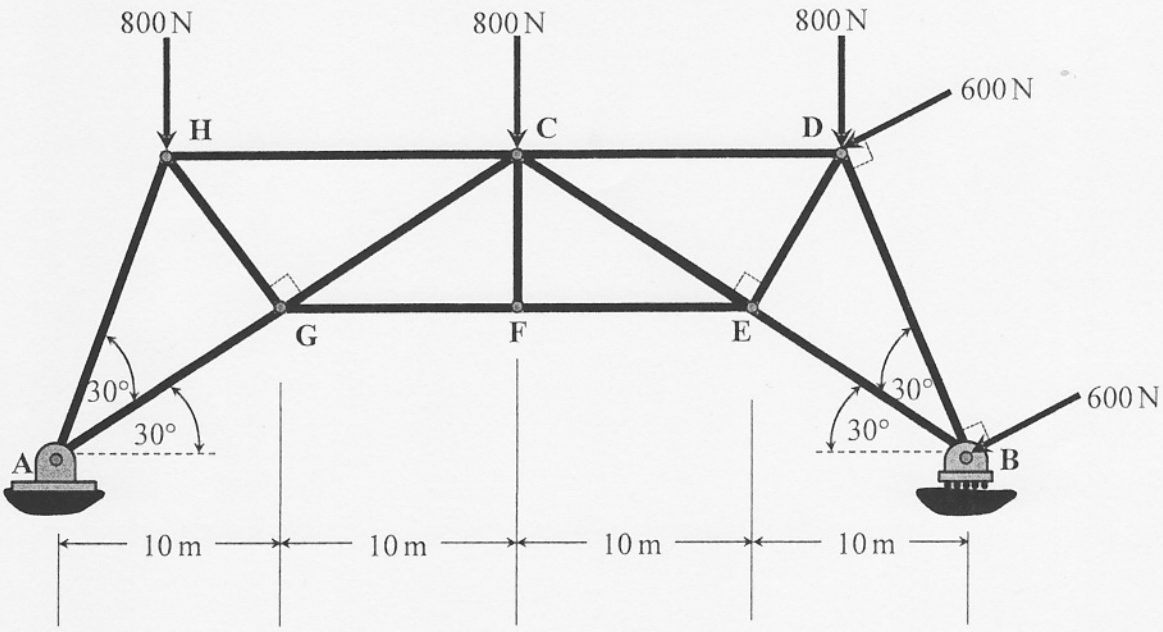
B. In the truss shown below that is supported by pin at **A** and roller at **B**, determine:

a) Reactions at the supports

b) Forces in members **CD**, **CE** and **GF** using the **Method of Sections**

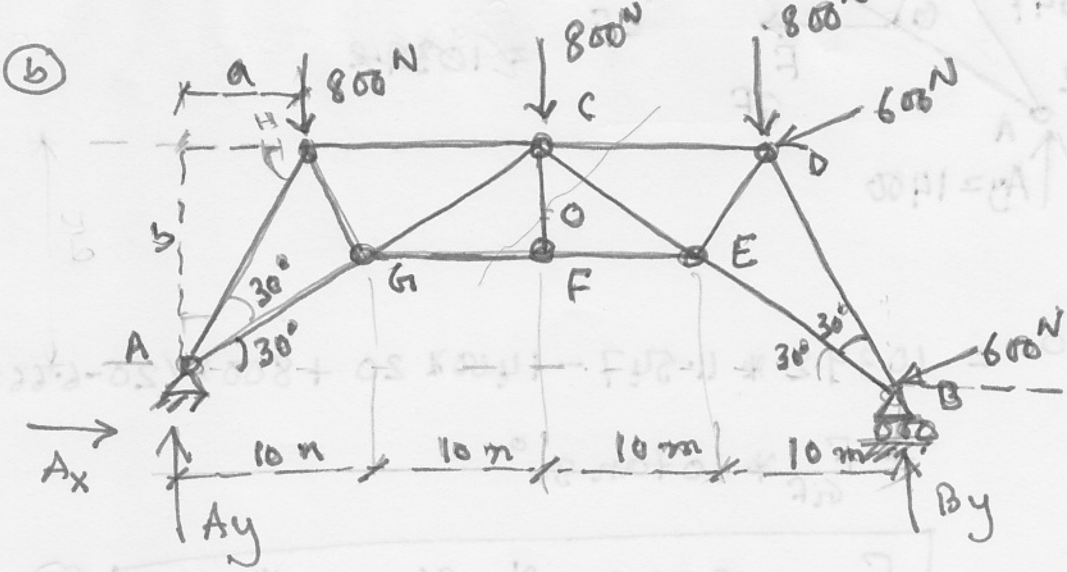


Solution

Q.3.

(a) BJ (1), FH (1), EH (1), DH (2)

(b)



$\tan 30^\circ = \frac{b}{20} \Rightarrow b = 11.547\ m$

$a = 11.547 \tan 30^\circ = 6.667\ m$

$\circlearrowleft \Sigma M_A = 0 = B_y * 40 - 600 \sin 30^\circ * 40 + 600 \cos 30^\circ * 11.547 - 600 \sin 30^\circ * (40 - 6.667) - 800 * (40 - 6.667) - 800 * 20 - 800 * 6.667$

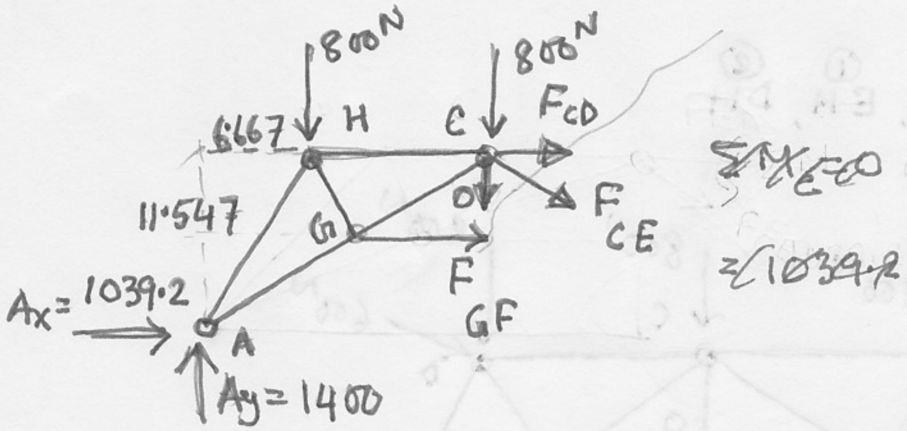
$\boxed{B_y = 1600^N\ (\uparrow)}$ (3)

$\Sigma F_y = 0 = A_y - 800 - 800 - 800 - 600 \sin 30^\circ - 600 \sin 30^\circ + 1600$

$\Rightarrow \boxed{A_y = 1400^N}\ (\uparrow)$ (3)

$\Sigma F_x = 0 = A_x - 600 \cos 30^\circ - 600 \cos 30^\circ$

$\Rightarrow \boxed{A_x = 1039.2^N}\ (\rightarrow)$ (2)



$\circlearrowleft + \Sigma M_C = 0 = 1039.2 * 11.547 - 1400 * 20 + 800 * (20 - 6.667)$

$+ F_{GF} * 10 \tan 30^\circ$

$$\boxed{F_{GF} = 923.87^N \cong 924^N \ (T)}$$ (4)

$\Sigma f_y = 0 = 1400 - 800 - 800 - F_{CE} \sin 30^\circ$

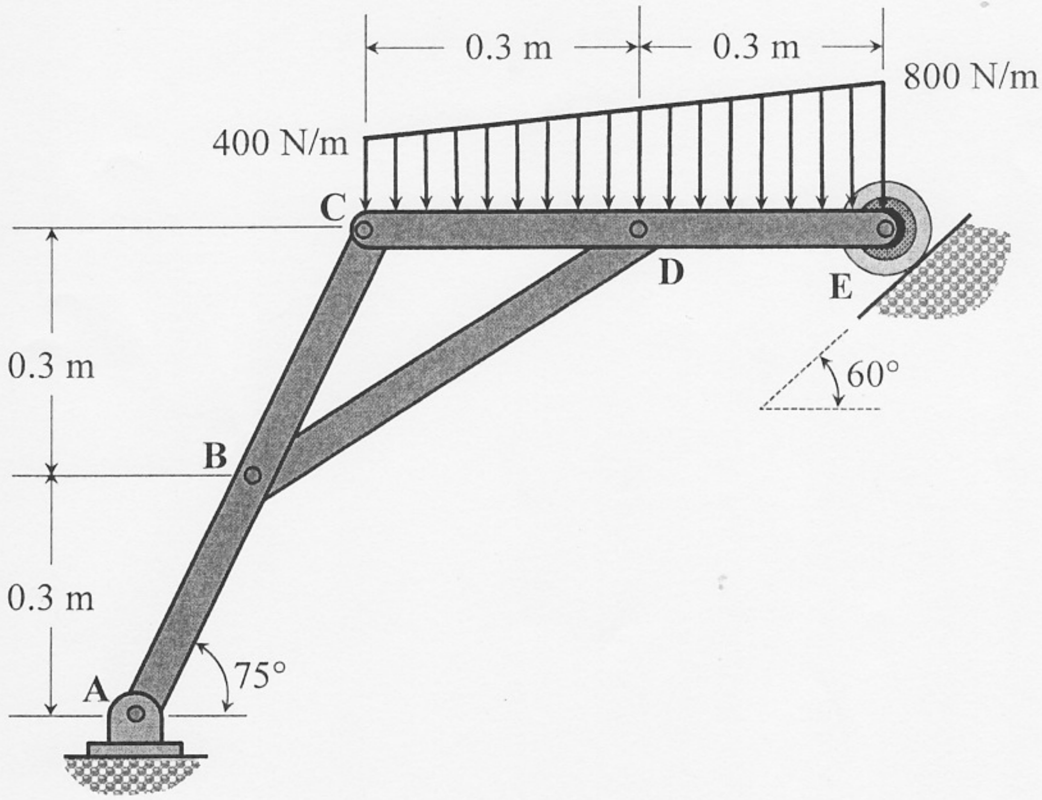
$F_{CE} = -400^N = 400^N \ (C)$ (4)

$\Sigma f_x = 0 = 1039.2 + 924 - 400 \cos 30^\circ + F_{CD}$

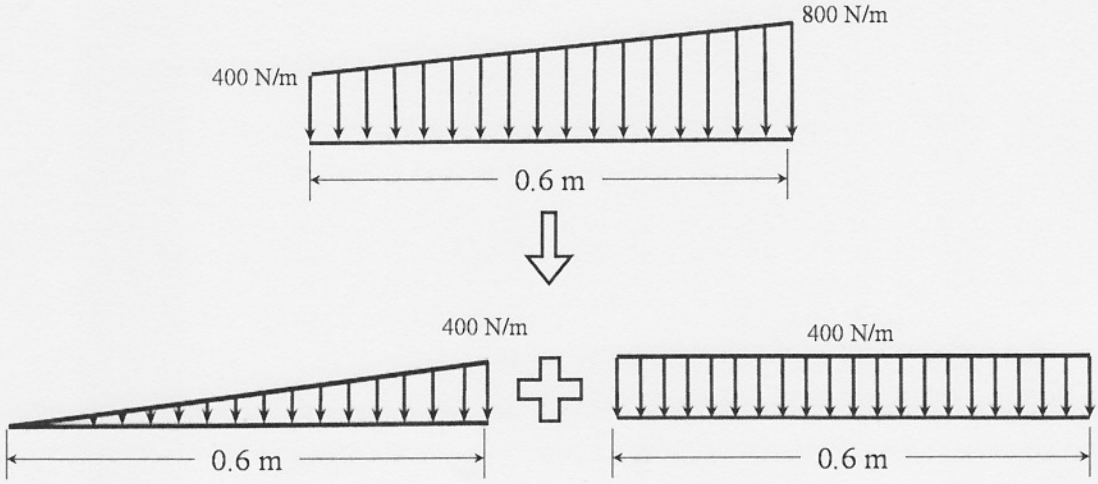
$F_{CD} = -1616.8^N = 1617^N \ (C)$ (4)

Problem 4 (25 Points)

The frame shown below is composed of 3 members (**ABC**, **CDE**, and **BD**) and supported by a pin at **A** and a roller at **E**. Determine the horizontal and vertical components of reaction at **A**, **B**, **C**, **D** and **E**.



Solution:



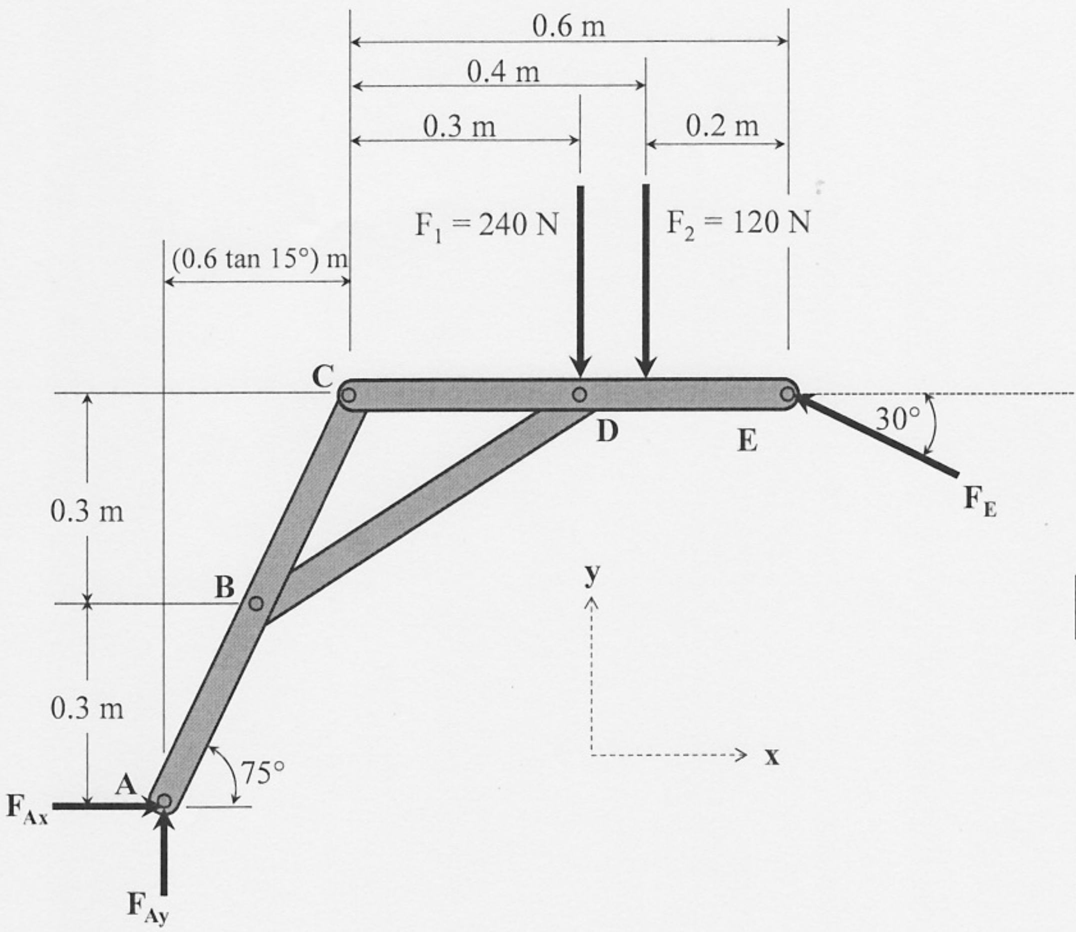
2

F_2 = 1/2 (400 N/m)(0.6 m)
= 120 N

$\overline{x}_2$ = 1/3 (0.6 m)
= 0.2 m

F_1 = (400 N/m)(0.6 m)
= 240 N

$\overline{x}_1$ = 1/2 (0.6 m)
= 0.3 m



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<u>From the FBD for the complete frame:</u>

$\circlearrowleft + \quad \sum M_A = F_E \cos 30° (0.6) + F_E \sin 30° (0.6 + 0.6 \tan 15°) - 240 (0.3 + 0.6 \tan 15°) - 120 (0.4 + 0.6 \tan 15°) = 0$

$0.520 F_E + 0.380 F_E - 110.585 - 67.292 = 0$ **3**

$\mathbf{F_E = 197.63\ N\ (\nwarrow)}$

$\xrightarrow{+} \quad \sum F_x = F_{Ax} - F_E \cos 30° = 0$

$F_{Ax} = 197.63 \cos 30°$ **3**

$\mathbf{F_{Ax} = 171.15\ N\ (\rightarrow)}$

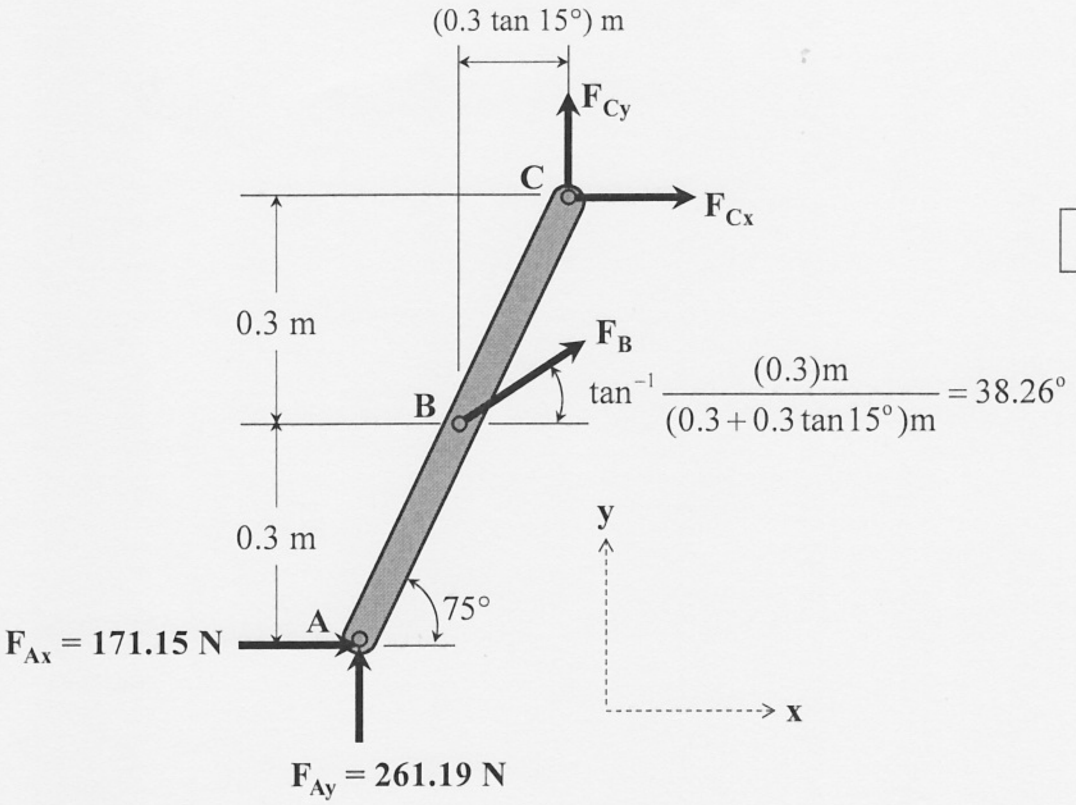
$+\uparrow \quad \sum F_y = F_{Ay} + F_E \sin 30° - 240 - 120 = 0$

$F_{Ay} = -197.63 \sin 30° + 360$ **3**

$\mathbf{F_{Ay} = 261.19\ N\ (\uparrow)}$

$\mathbf{F_A = [(171.15)^2 + (261.19)^2]^{0.5} = 312.3\ N}$

Member BD is a two force member. Therefore, the line of action of force F_B is known as shown on the FBD for member ABC:



3

From the FBD for member ABC:

$\curvearrowleft +$ $\sum M_C = F_B \cos 38.26° (0.3) - F_B \sin 38.26° (0.3 \tan 15°) + 171.15 (0.6) - 261.19 (0.6 \tan 15°) = 0$ **3**

$0.236\, F_B - 0.050\, F_B + 102.690 - 41.991 = 0$

$\mathbf{F_B = -326.34\ N = 326.34\ N\ (\swarrow)}$

$\xrightarrow{+}$ $\sum F_x = F_{Cx} - (326.34 \cos 38.26°) + 171.15 = 0$ **3**

$\mathbf{F_{Cx} = 85.10\ N\ (\rightarrow)}$

$+\uparrow$ $\sum F_y = F_{Cy} - (326.34 \sin 38.26°) + 261.19 = 0$ **3**

$\mathbf{F_{Cy} = -59.11\ N = 59.11\ N\ (\downarrow)}$

$\mathbf{F_C = [(85.10)^2 + (-59.11)^2]^{0.5} = 103.61\ N}$