TEST 2
Spring 2015
(14 April, 2015)
CIE200 – STATICS
CLOSED BOOK, 75 MINUTES

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NOTES

- 3 problems (11 pages).
- All your answers should be provided on the question sheets.
- Two extra sheets is provided at the end.
- Ask for additional sheets if you need more space.
- Some answers may require much less than the space provided.
- ***Do not*** use the back of the sheets for answers.
- ***Every FBD needed for the solution of a problem should be clearly shown.***
- ***Points will be deducted for any missing/ incomplete/incorrect FBD.***
- ***Points will be deducted for answers not supported by proper calculations.***

YOUR COMMENT(S)

DO NOT WRITE IN THE SPACE BELOW

MY COMMENT(S)

YOUR GRADE

Problem I:	30 /30
Problem II:	40 /40
Problem III	30 /30

TOTAL: 100 /100

Problem I: *(30 points)*

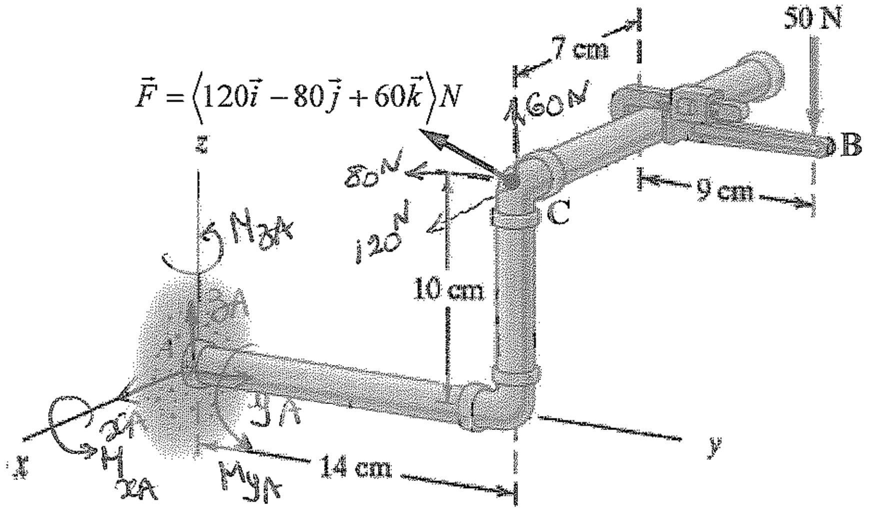

Figure I

The rigid pipe system is fixed at A, and subjected to the forces shown in **Figure I**.

1. Use vector approach, determine the reactions at the fixed support A. *(12 points).*
2. Use scalar Approach, Re-compute the three components Mx, My, and Mz at A due to the two forces, and compare with question 1. *(6 points)*
3. Determine the magnitude and direction of the moments at A. *(6 points)*
4. Determine the projected component of the moment at A about an axis extending between points A and C. Express the result as Cartesian vector. *(6 points)*

Note: FBD must be included

Calculations and/or Diagrams:

Reactions at A:

$\swarrow^{+} \Sigma F_x = 0 \Rightarrow x_A + 120 = 0 \Rightarrow x_A = -120\,KN$

$\boxed{x_A = 120\,KN \nearrow}$

$\overset{+}{\rightarrow} \Sigma F_y = 0 \Rightarrow y_A - 80 = 0 \Rightarrow \boxed{y_A = 80\,KN \rightarrow}$

$+\uparrow \Sigma F_z = 0 \Rightarrow z_A + 60 - 50 = 0 \Rightarrow \boxed{z_A = -10\,KN = 10\,KN \downarrow}$

Coordinates A(0,0,0) C(0, 14, 10) B(-7, 23, 10)

$\vec{r}_{AC} = \vec{r}_C = \{0\vec{i} + 14\vec{j} + 10\vec{k}\}cm$

$\vec{r}_{AB} = \vec{r}_B = \{-7\vec{i} + 23\vec{j} + 10\vec{k}\}cm$

Calculations and/or Diagrams:

$$\vec{F}_B = \{0\vec{i} + 0\vec{j} - 50\vec{k}\}^N$$

$$\vec{M}_A = \vec{r}_{AC} \times \vec{F}_C + \vec{r}_{AB} \times \vec{F}_B$$

$$= \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 0 & 14 & 10 \\ 120 & -80 & 60 \end{vmatrix} + \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ -7 & 23 & 10 \\ 0 & 0 & -50 \end{vmatrix}$$

$$= \{1640\vec{i} + 1200\vec{j} - 1680\vec{k}\} + \{-1150\vec{i} - 350\vec{j} + 0\vec{k}\}$$

$$\Rightarrow \vec{M}_A = \{490\vec{i} + 850\vec{j} - 1680\vec{k}\}^{N.cm}$$

$+\sum M_x = 0 \Rightarrow M_{xA} + 490 = 0 \Rightarrow$ $\boxed{M_{xA} = -490 \text{ N.cm} = 490 \text{ N.cm}}$

$+\sum M_y = 0 \Rightarrow M_{yA} + 850 = 0 \Rightarrow$ $\boxed{M_{yA} = -850 \text{ N.cm} = 850 \text{ N.m}}$

$+\sum M_z = 0 \Rightarrow M_{zA} - 1680 = 0 \Rightarrow$ $\boxed{M_{zA} = 1680 \text{ N.cm}}$

2. Scalar Approach

$+\sum M_x = 0 \Rightarrow M_{xA} + 80(10) + 60(14) - 50(23) \Rightarrow$ $\boxed{M_{xA} = -490 \text{ N.cm} = 490 \text{ N.m}}$

$\sum M_y = 0 \Rightarrow M_{yA} + 120(10) - 50(7) = 0 \Rightarrow$ $\boxed{M_{yA} = -850 \text{ N.cm}} = 850 \text{ N.cm}$

$\sum M_z = 0 \Rightarrow M_{zA} - 120(14) = 0 \Rightarrow$ $\boxed{M_{zA} = 1680 \text{ N.cm}}$

Same as Q1. ok.

3. Magnitude:

$$M_A = \sqrt{(-490)^2 + (-850)^2 + (1680)^2} \Rightarrow M_A = 1945.5 \text{ N.cm}$$

Direction: $\cos\alpha = \frac{M_{xA}}{M_A} = \frac{-490}{1945.5}$ $\boxed{\alpha = 104.59^\circ}$

$\cos\beta = \frac{M_{yA}}{M_A} = \frac{-850}{1945.5}$ $\boxed{\beta = 115.9^\circ}$

$\cos\gamma = \frac{M_{zA}}{M_A} = \frac{1680}{1945.5}$ $\boxed{\gamma = 30.28^\circ}$

EXTRA SHEET 1: Continued from page ______

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Calculations and/or Diagrams:

4. $M_{A/AC} = M_A \cdot \vec{u}_{AC}$

$\vec{u}_{AC} = \dfrac{0\vec{i} + 14\vec{j} + 10}{\sqrt{(0)^2 + (14)^2 + (10)^2}} = 0\vec{i} + 0.814\vec{j} + 0.581\vec{k}$

$\Rightarrow M_{A/AC} = \{490\vec{i} - 850\vec{j} + 1680\vec{k}\} \cdot \{0\vec{i} + 0.814\vec{j} + 0.581\vec{k}\}$

$\Rightarrow \boxed{M_{A/AC} = +284.18 \text{ N.cm}}$

In cartesian vector:

$\vec{M}_{A/AC} = M_{A/AC}\,\vec{u}_{AC} = +284.18\{0\vec{i} + 0.814\vec{j} + 0.581\vec{k}\}$

$\Rightarrow \boxed{\vec{M}_{A/AC} = \{0\vec{i} + 231.3\vec{j} + 165.1\vec{k}\} \text{ N.cm}}$

Problem II: *(40 points)*

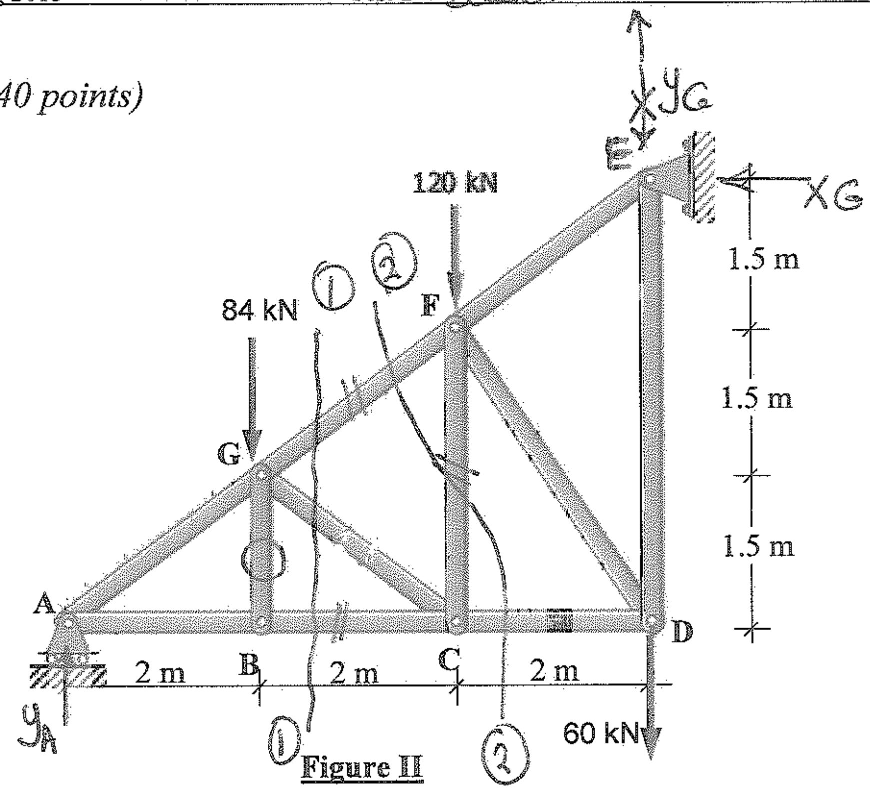


Figure II

For the truss shown in **Figure II**:

1- Determine the external reactions at the roller support A and the pin at E *(5 points)*
2- Determine the force in members BC, GF, FC ***using the section method***. Also solve for the force on members AB, and AG using the appropriate method of analysis. *(30 points)*.
3- Indicate Zero-force members. *(5points)*.

Calculations and/or Diagrams:

1- Reactions:

$\overset{+}{\rightarrow} \sum F_x = 0 \Rightarrow \boxed{X_G = 0}$

$+\circlearrowleft \sum M_A = 0 \Rightarrow -84(2) - 120(4) - y_G(6) - 60(6) = 0 \Rightarrow y_G = -168 \text{ KN}$

$\Rightarrow \boxed{y_G = 168 \text{ KN} \uparrow}$

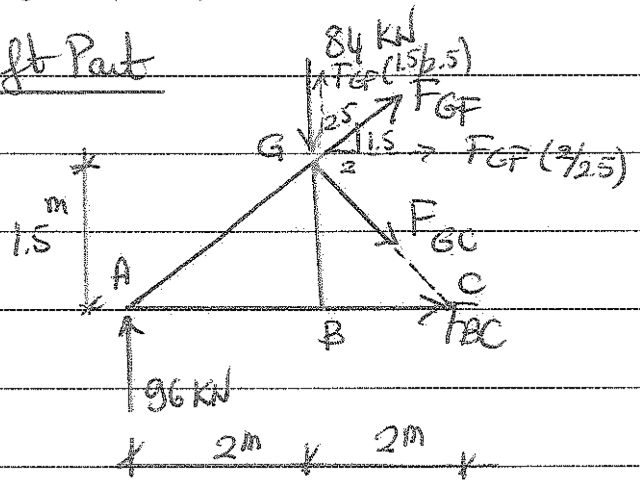
$+\circlearrowleft \sum M_G = 0 \Rightarrow 120(2) + 84(4) - y_A(6) = 0 \Rightarrow \boxed{y_A = 96 \text{ KN} \uparrow}$

Check!

$+\uparrow \sum F_y = 0 \Rightarrow 96 - 84 - 120 + 168 - 60 = 0$ ✓ o.K.

Calculations and/or Diagrams (cont'd):

* Sec ①-① left Part

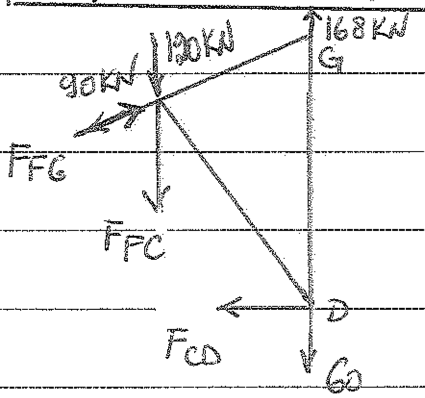


$+\circlearrowleft \Sigma M_G = 0 \Rightarrow F_{BC}(1.5) - 96(2) = 0 \Rightarrow$ $\boxed{F_{BC} = 128\,KN\ (T)}$

$+\circlearrowleft \Sigma M_C = 0 \Rightarrow -96(4) + 84(2) - F_{GF}\left(\frac{2}{2.5}\right)(1.5) - F_{GF}\left(\frac{1.5}{2.5}\right)(2) = 0$

$\Rightarrow \boxed{F_{GF} = -90\,KN = 90\,KN\ (C)}$

* Sec ②-② Right Part



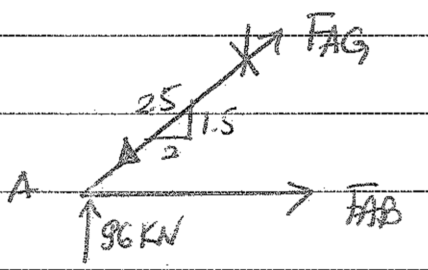
$+\uparrow \Sigma F_y = 0 \Rightarrow 90 \times \frac{1.5}{2.5} - F_{FC} - 60 + 168 - 120 = 0$

$\Rightarrow \boxed{F_{FC} = 42\,KN\ (T)}$

* Method of Joint:
* Equilibrium at A

$+\uparrow \Sigma F_y = 0 \Rightarrow 96 + F_{AG}\left(\frac{1.5}{2.5}\right) = 0$

$\Rightarrow \boxed{F_{AG} = -160\,KN\ (C)}$



$\xrightarrow{+} \Sigma F_x = 0 \Rightarrow -160\left(\frac{2}{2.5}\right) + F_{AB}$

$\boxed{F_{AB} = 128\,KN\ (T)}$

Calculations and/or Diagrams (cont'd):

Problem III: *(30 points)*

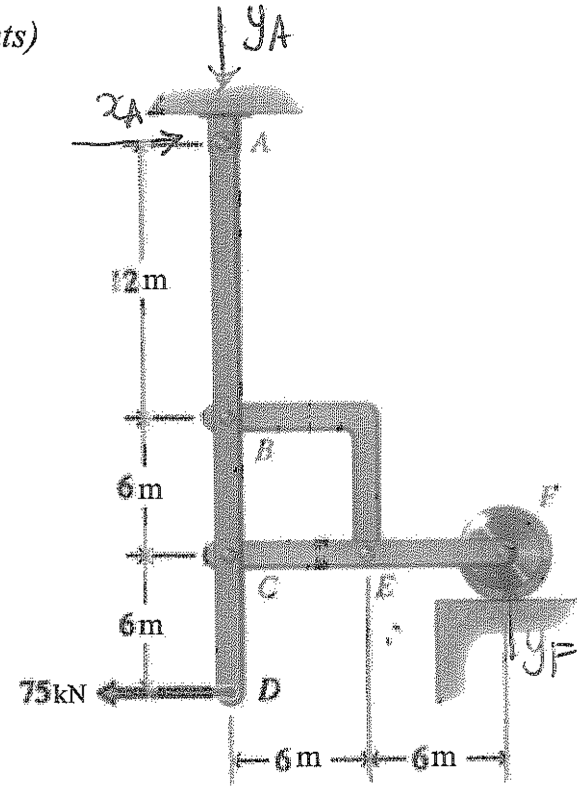


Figure III

The frame shown in **Figure III** is composed of three members **AD**, **BE** and **CF**, connected by pins at **B**, **C** and **E**.

1. Determine the external reactions at pin support A and roller F, and the internal forces of the frame at points B, C and E. *(30 points)*

Calculations and/or Diagrams:

Whole Frame:

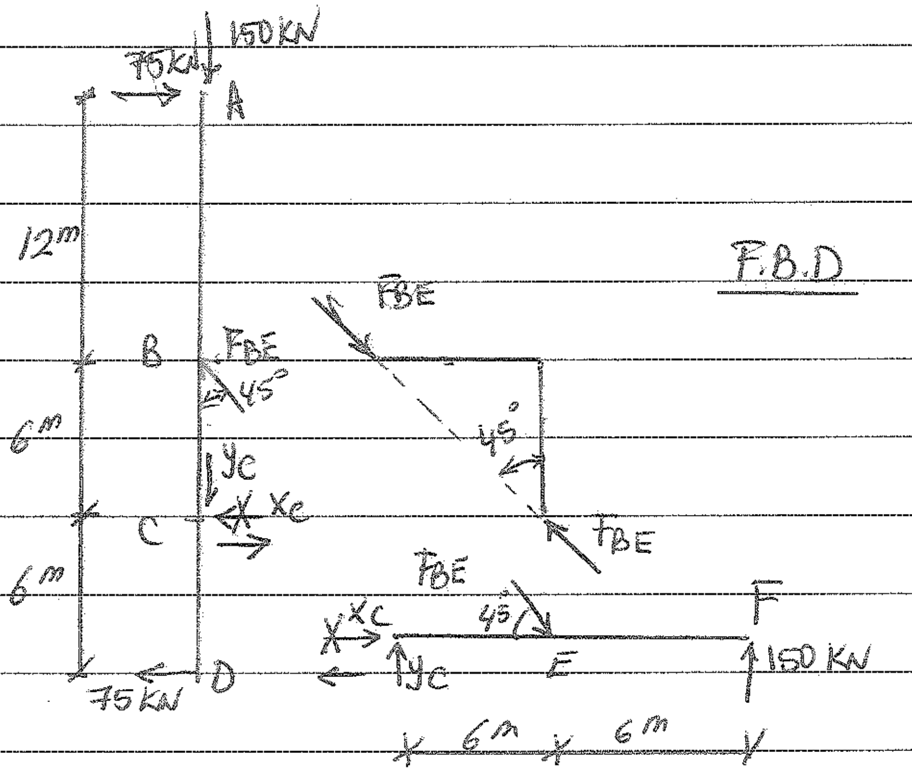
$\xrightarrow{+} \Sigma F_x = 0 \Rightarrow x_A - 75 = 0 \Rightarrow$ $\boxed{x_A = 75\,kN \rightarrow}$

$+\circlearrowleft \Sigma M_A = 0 \Rightarrow -75(24) + y_F(12) = 0 \Rightarrow$ $\boxed{y_F = 150\,kN \uparrow}$

$+\circlearrowleft \Sigma M_F = 0 \Rightarrow -75(6) + 75(18) + y_A(12) = 0 \Rightarrow$ $\boxed{y_A = 150\,kN \downarrow}$

check! $+\uparrow \Sigma F_y = 0 \Rightarrow -150 + 150 = 0$ ✓ o.k.

Calculations and/or Diagrams (cont'd):



Part CF

$+\circlearrowleft \Sigma M_C = 0 \Rightarrow -F_{BE}\sin 45(6) + 150(12) = 0 \Rightarrow$ $F_{BE} = 424.264$ kN ↘

$\xrightarrow{+} \Sigma F_x = 0 \Rightarrow x_C + 424.264\cos 45 = 0 \Rightarrow x_C = -300$ KN

$\therefore$ $x_C = 300$ KN ←

$+\uparrow \Sigma F_y = 0 \Rightarrow y_C - 424.264\sin 45 + 150 = 0 \Rightarrow$ $y_C = 150$ KN ↑

Part AD: check!

$\xrightarrow{+} \Sigma F_x = 0 \Rightarrow -75 + 75 - 424.264\sin 45 + 300 = 0$ ✓ OK.

$+\uparrow \Sigma F_y = 0 \Rightarrow -150 + 424.264\cos 45 - 150 = 0$ ✓ OK

EXTRA SHEET 2: Continued from page ____

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Calculations and/or Diagrams: