TEST 2 – SOLUTION
Fall 2016
(17 November, 2016)
CIE200 – STATICS
CLOSED BOOK, 75 MINUTES

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NOTES

- 3 problems (10 pages).
- All your answers should be provided on the question sheets.
- **One extra sheet 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:	40 /40
Problem II:	35 /35
Problem III	25 /25
TOTAL:	100 /100

Problem I: *(40 points)*

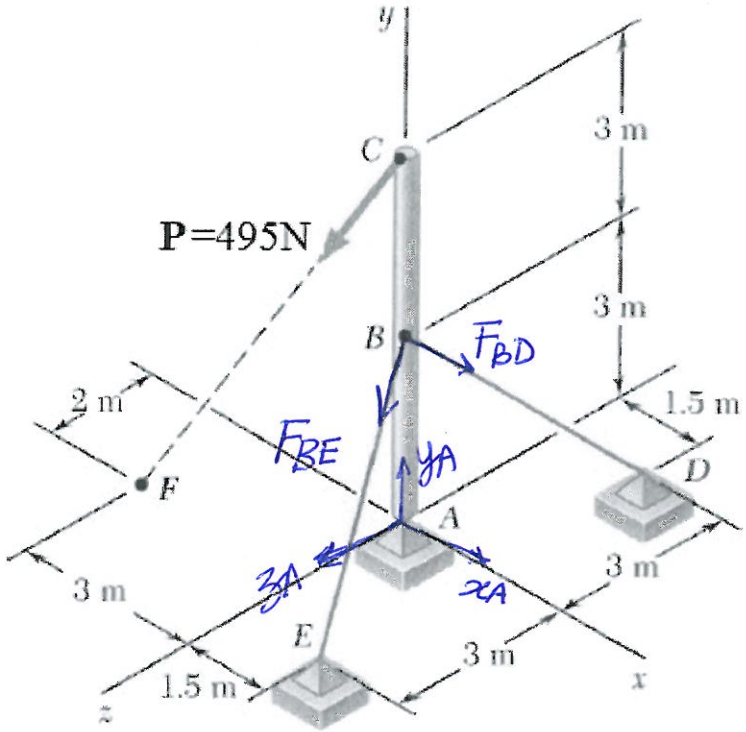


Figure I

The 6-m pole ABC is acted upon by a force **P**= 495N, as shown in the **Figure I**. The pole is held by a ball-and-socket joint (Pin) at A and by two cables BD and BE.

1. Determine the tension in each cable and the reactions at A.

Note: FBD must be included

Calculations and/or Diagrams:

$B(0,3,0)$ $C(0,6,0)$ $D(1.5,0,-3)$ $E(1.5,0,3)$

$F(-3,0,2)$

$$\vec{P} = 495\left\{\frac{-3\vec{i}-6\vec{j}+2\vec{k}}{\sqrt{(-3)^2+(-6)^2+(2)^2}}\right\} = \{-212.14\vec{i}-424.29\vec{j}+141.43\vec{k}\}\ N$$

$$\vec{F}_{BD} = F_{BD}\left\{\frac{1.5\vec{i}-3\vec{j}-3\vec{k}}{\sqrt{(1.5)^2+(-3)^2+(-3)^2}}\right\} = \left\{\frac{1}{3}F_{BD}\vec{i}-\frac{2}{3}F_{BD}\vec{j}-\frac{2}{3}F_{BD}\vec{k}\right\}$$

Calculations and/or Diagrams:

$$\vec{F}_{BE} = F_{BE}\left\{\frac{1.5\vec{i} - 3\vec{j} + 3\vec{k}}{\sqrt{(1.5)^2+(-3)^2+(3)^2}}\right\} = \frac{1}{3}F_{BE}\vec{i} - \frac{2}{3}F_{BE}\vec{j} + \frac{2}{3}F_{BE}\vec{k}$$

$$\vec{A} = \{x_A\vec{i} + y_A\vec{j} + z_A\vec{k}\}$$

$$\vec{M}_A = \vec{r}_{AB} \times \{\vec{F}_{BE} + \vec{F}_{BD}\} + \vec{r}_{AC} \times \vec{P}$$

where:

$$\vec{r}_{AB} = \{\vec{r}_B = 0\vec{i} + 3\vec{j} + 0\vec{k}\}^m \quad \& \quad \vec{r}_{AC} = \vec{r}_C = \{0\vec{i} + 6\vec{j} + 0\vec{k}\}$$

$\vec{i}$	$\vec{j}$	$\vec{k}$		$\vec{i}$	$\vec{j}$	$\vec{k}$
0	3	0	+	0	6	0
$\frac{1}{3}(F_{BD}+F_{BE})$	$-\frac{2}{3}(F_{BD}+F_{BE})$	$\frac{2}{3}(F_{BE}-F_{BD})$		-912.14	-424.29	141.34

$$= \left(2F_{BE} - 2F_{BD} + 848.04\right)\vec{i} - (0)\vec{j} + \left(-F_{BD} - F_{BE} + 1272.84\right)\vec{k}$$

$$\rightarrow \Sigma M_{x_A} = 2F_{BE} - 2F_{BD} + 848.04 = 0$$

$$\rightarrow F_{BE} = F_{BD} - 424.02 \quad \text{--- Eq (1)}$$

$$+\circlearrowleft \Sigma M_{B_{OA}} = 0 \rightarrow -F_{BD} - F_{BE} + 1272.84 = 0 \quad \text{--- Eq (2)}$$

Substitute Eq (1) in (2)

$$\rightarrow \boxed{F_{BD} = 848.43\ N}$$

$$\boxed{F_{BE} = 424.41\ N}$$

Calculations and/or Diagrams:

$\pm \rightarrow \sum F_x = 0 \Rightarrow x_A - 212.14 + \frac{1}{3}(848.43) + \frac{1}{3}(424.41) = 0$

$x_A = -212.14\ N = 919.14\ N \leftarrow$

$+\uparrow \sum F_y = 0 \Rightarrow y_A - 424.29 - \frac{2}{3}(848.43) - \frac{2}{3}(424.41)$

$\Rightarrow y_A = 1272.85\ N$

$+\swarrow \sum F_z = 0 \Rightarrow z_A + 141.43 - \frac{2}{3}(848.43) + \frac{2}{3}(424.41)$

$\Rightarrow z_A = 141.25\ N$

Problem II: *(35 points)*

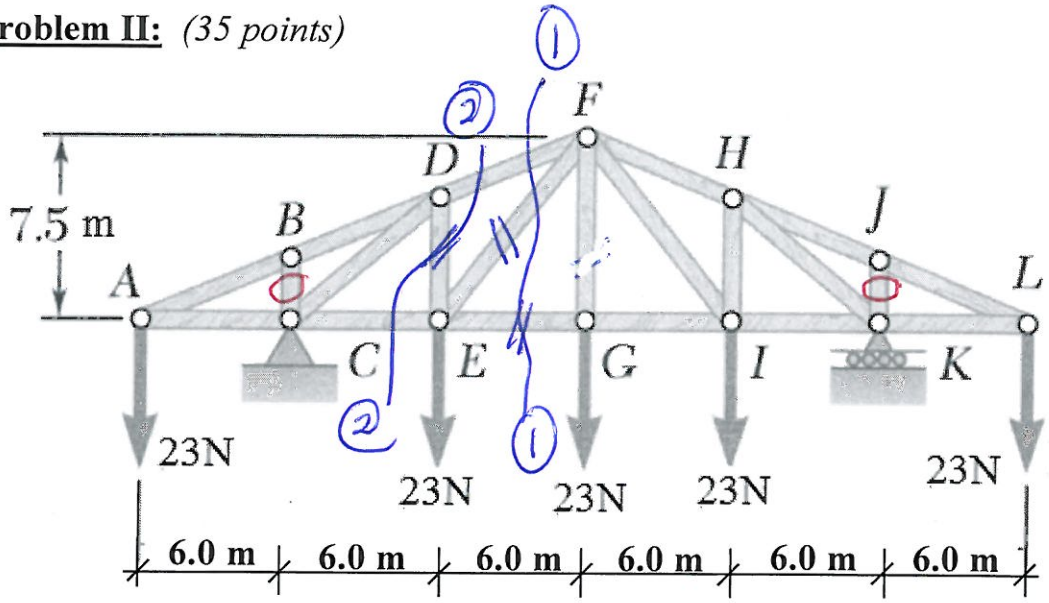


Figure II

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

1) Determine the force in members **EG**, **EF** and **ED**, indicate whether the members are tension or compression. *(25 points)*
2) Indicate Zero-force members. *(10 points)*

Note: FBD must be included

Calculations and/or Diagrams:

1. Reaction at C

$+\circlearrowleft \sum M_K = 0 \Rightarrow -23(6) + 23(6+12+18+30) - y_C(24) = 0$

$\Rightarrow \boxed{y_C = 57.5\,kN \uparrow}$

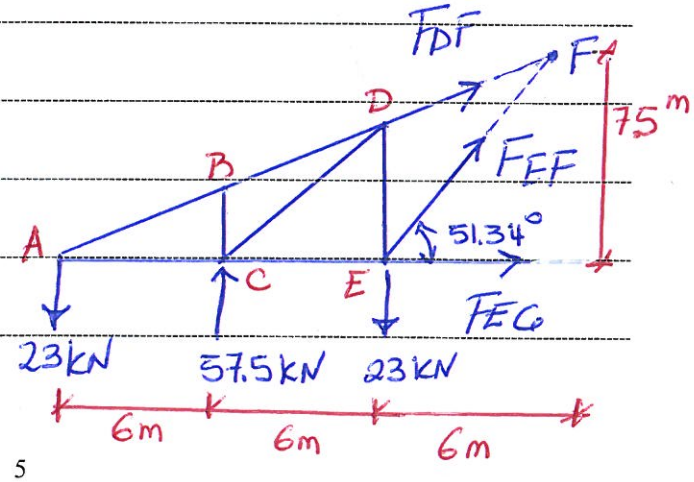
$\pm \sum F_x = 0 \Rightarrow \boxed{x_C = 0}$

Sec ① ① A → ①

$+\circlearrowleft \sum M_F = 0$

$23(18) - 57.5(12) + 23(6) + F_{EG}(7.5) = 0$

$\Rightarrow \boxed{F_{EG} = 18.4\,kN\,(T)}$

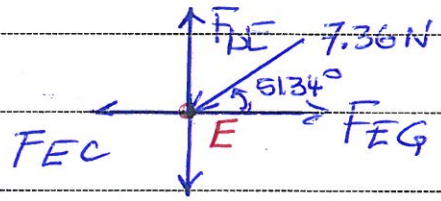


Calculations and/or Diagrams (cont'd):

$+\circlearrowleft \Sigma M_A = 0 \rightarrow 57.5(6) - 23(12) + F_{EF}\sin 51.34(12) = 0$

$\Rightarrow \boxed{F_{EF} = -7.36\,N = 7.36\,N\,(C)}$

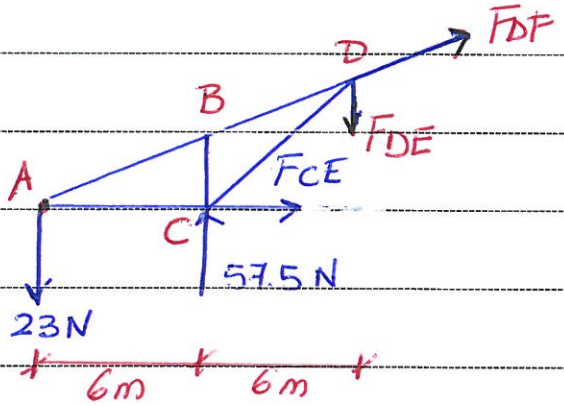
Equilibrium at E



$+\uparrow \Sigma F_y = 0 \rightarrow F_{DE} - 7.36\sin 51.34 - 23 = 0$

$\Rightarrow \boxed{F_{DE} = 28.75\,N\,(T)}$

Or, use Sec ① – ②:



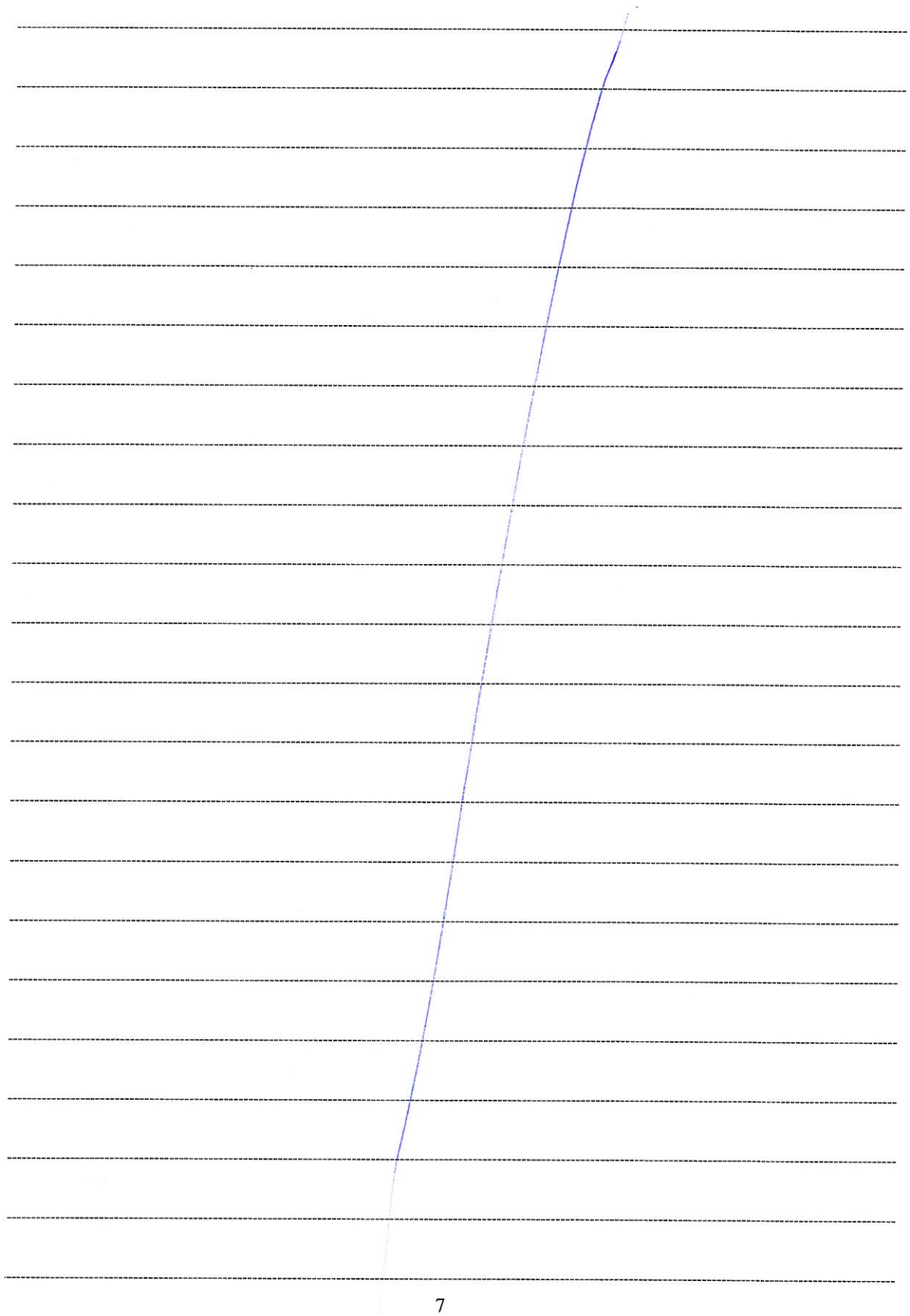
$+\circlearrowleft \Sigma M_A = 0$

$-F_{DE}(12) + 57.5(6) = 0$

$\boxed{F_{DE} = 28.75\,N\,(T)}$

2. Zero-force members: JK & BC

Calculations and/or Diagrams (cont'd):



Problem III: *(25 points)*

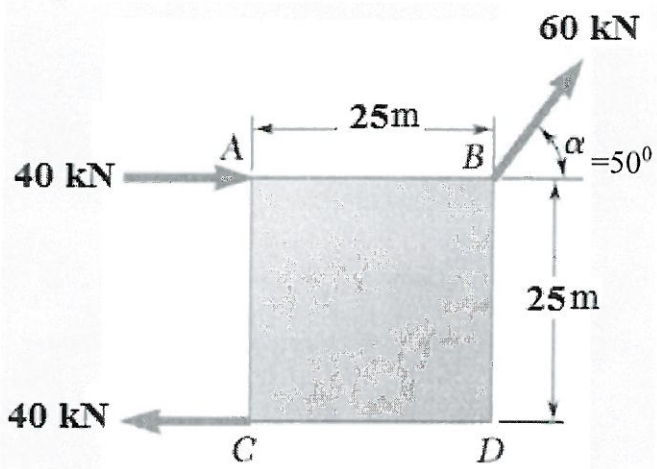


Figure III

For the loading shown in **Figure III**, replace the given loads by a single force applied:

1. on line **AB.**
2. on line **AC**.

In each case specify its location measured from point **A**.

Calculations and/or Diagrams:

1 Resultant force:

$+\rightarrow \Sigma F_x = 0 \Rightarrow 60\cos 50 = F_{Rx} = 38.57\,kN \rightarrow$

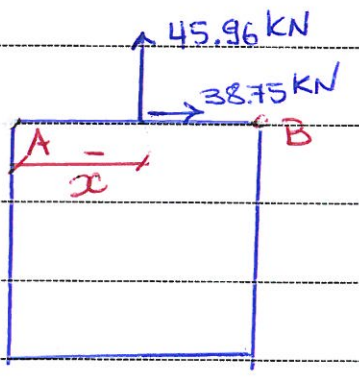
$+\uparrow \Sigma F_y = 0 \Rightarrow F_{Ry} - 60\sin 50 = 45.96\,kN \uparrow$ } $F_R = 60\,kN$

$\tan\theta = \left|\frac{F_{Ry}}{F_{Rx}}\right| \Rightarrow \theta = 50^\circ$

$+\circlearrowleft \Sigma M_A = 0 \Rightarrow$

$-40(25) + 60\sin 50(25) = 45.96\,\bar{x}$

$\Rightarrow \boxed{\bar{x} = 3.24\ m}$



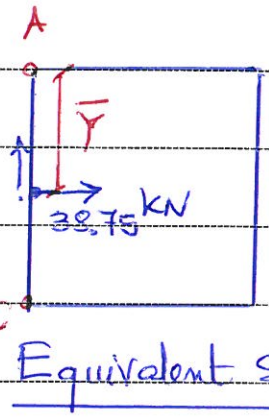
Equivalent system

Calculations and/or Diagrams (cont'd):

$+\circlearrowleft \Sigma M_A = 0 \rightarrow$

$-40(25) + 60\sin 50(25) = 38.75\,\bar{y}$

$\bar{y} = 3.85\ m$



Equivalent System

EXTRA SHEET 1: Continued from page _____

Name: _____ **ID#:** _____

Calculations and/or Diagrams: