King Fahd University of Petroleum & Minerals
DEPARTMENT OF CIVIL ENGINEERING

CE 201 STATICS (092)

Second Major Examination

Tuesday 11/5/2010
7:00 p.m. → 9:00 p.m.

Name : ***Solved by the instructors who put the problems (Coordinated course)***
I.D. # : ……………………

SECTION:

Question	Points	Grade
1	10	
2	18	
3	25	
4	22	
5	25	
TOTAL	**100**	

Good luck !

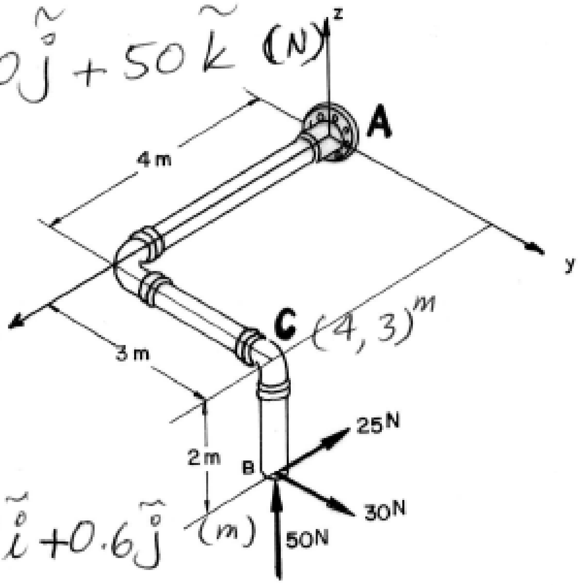
Question # 1 (10 points)

In the pipe assembly shown below:-

(2 points) A) Express the force at point (B) in Cartesian vector form.

(6 points) B) Determine the magnitude of the moment of the force at (B) about axis (AC).

(2 points) C) Express the moment in part (B) above in Cartesian vector form.



(2)

A) $\underset{\sim}{F} = -25\underset{\sim}{i} + 30\underset{\sim}{j} + 50\underset{\sim}{k}$ (N)

B) $\underset{\sim}{r}_{AC} = 4\underset{\sim}{i} + 3\underset{\sim}{j}$

(2) $|r_{AC}| = 5^{m}$

$$\underset{\sim}{u}_{AC} = \frac{\underset{\sim}{r}_{AC}}{|\underset{\sim}{r}_{AC}|} = 0.8\underset{\sim}{i} + 0.6\underset{\sim}{j}$$

$r_{CB} = -2\underset{\sim}{k}$

(2) $$|\underset{\sim}{M}^{F}_{AC}| = \underset{\sim}{u}_{AC} \cdot \underset{\sim}{r}_{CB} \times \underset{\sim}{F}$$

$$= \left|\begin{array}{ccc|cc} 0.8 & 0.6 & 0 & 0.8 & 0.6 \\ 0 & 0 & -2 & 0 & 0 \\ -25 & 30 & 50 & -25 & 30 \end{array}\right|$$

(2)

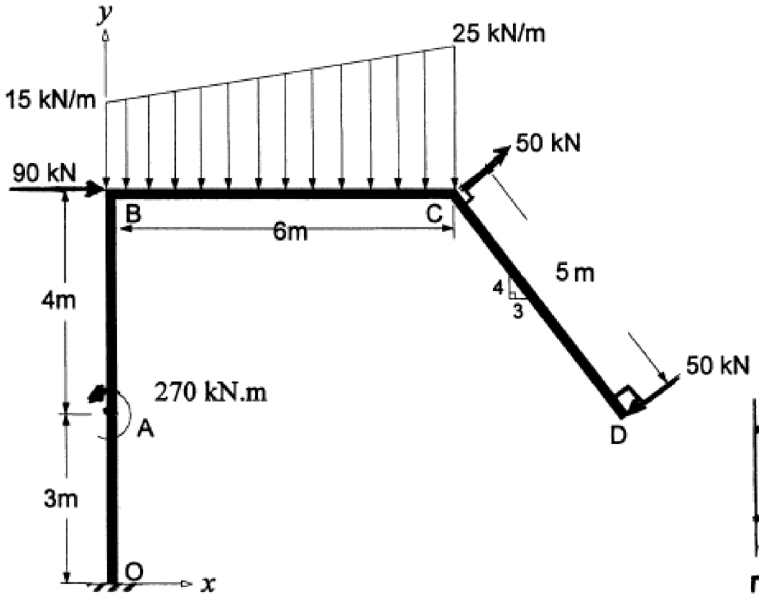
$$= +30 + 48 = 78^{\,N \cdot m}$$

C)

(2) $$M^{F}_{AC} = |\underset{\sim}{M}^{F}_{AC}|\, \underset{\sim}{u}_{AC} = 62.4\underset{\sim}{i} + 46.8\underset{\sim}{j}^{\;N \cdot m}$$

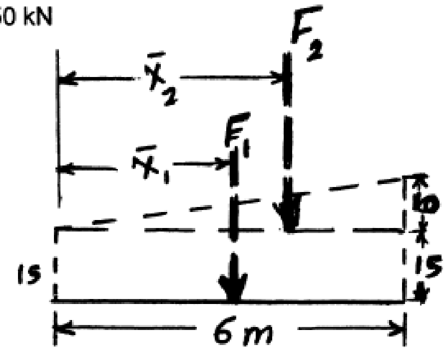
Question # 2 (18 points)

Replace the loads shown in the figure below by an ***equivalent force and couple moment*** acting at point O.



(pts.)

Solution:



Note the 50-kN couple $\Rightarrow$

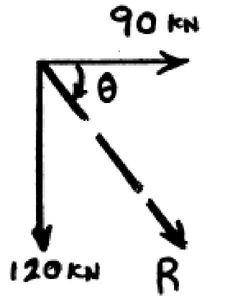
(2) $M_{couple} = -50(5) = 250$ kN.m ↻

(1) $F_1 = 15(6) = 90$ kN ↓

(1) $\bar{x}_1 = 6/2 = 3$ m

(2) $F_2 = 10(6)/2 = 30$ kN ↓

(2) $\bar{x}_2 = \frac{2}{3}(6) = 4$ m



(1) $\Sigma F_x = 90$ kN →

(1) $\Sigma F_y = 90 + 30 = 120$ kN ↓

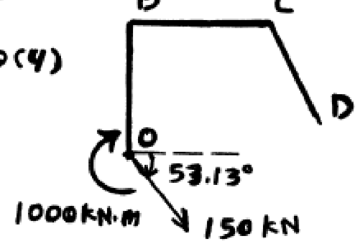
(2) $R = \sqrt{(90)^2 + (120)^2} \Rightarrow \boxed{R = 150 \text{ kN}}$

(2) $\tan\theta = -\frac{120}{90} \Rightarrow \boxed{\theta = -53.13° = 53.13° ↻}$

$\circlearrowleft + \; \Sigma M = -250 + 270 - 90(7) - 90(3) - 30(4)$

(4) $\Rightarrow \boxed{M = -1000 = 1000 \text{ kN.m} ↻}$

As shown



Question # 3 (25 points)

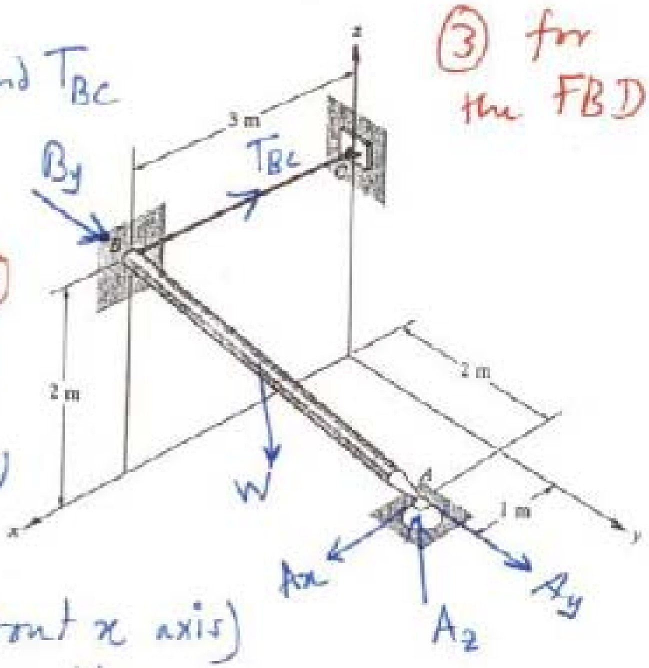
The uniform rod (AB) has a mass of (5) kg, and is supported by a ball-and-socket at (A), a rope (BC), and is resting on a smooth wall at (B). Determine the support reactions at A, B & C.

The unknowns are

A_x, A_y, A_z, B_y and T_{BC}

3 for the FBD

$W = 5 * 9.81 = 49.1$ N



$\Sigma F_x = 0$, $A_x = T_{BC}$ 2

$\Sigma F_y = 0$, $A_y = -B_y$ 2

$\Sigma F_z = 0$, $A_z = W = 49.1$ N 4

4 $\Sigma M_x = 0$ (moment about x axis)

$$-B_y(2) + A_z(2) - \overset{W}{49.1}\left(\frac{0+2}{2}\right) = 0$$

Since $A_z = 49.1$ N 2 $\therefore B_y = 24.6$ N

$\Sigma F_y = 0$, 1 $A_y = -B_y = -24.6 \text{ N} = 24.6 \text{ N} \leftarrow$

4 $\Sigma M_y = 0$, $-A_z(1) + 49.1\left(\frac{1+3}{2}\right) - T_{BC}(2) = 0$

Since $A_z = 49.1$ N 2 $\therefore T_{BC} = 24.6$ N

$\Sigma F_x = 0$, 1 $A_x = T_{BC} = 24.6$ N

To check the results:

$\Sigma M_z = 0$, $B_y(3) - A_x(2) + A_y(1) = 0$

$\therefore 24.6(3) - 24.6(2) + (-24.6)(1) = 0$

The solution is correct

Vector Analysis

Coordinates $A(1,2,0)$, $B(3,0,2)$ and $D(2,1,1)$

3 marks for FBD shown in the scalar analysis

Forces are shown in the figure:

$W = 5(9.81) = 49.1\,N$

1 $B_y\hat{i}$, $T_{BC}(-\hat{j})$, $W(-\hat{k})$

$A_x\hat{i}$, $A_y\hat{j}$ and $A_z\hat{k}$

Equations of Force Equilibrium

2 $A_x = T_{BC}$

2 $A_y = -B_y$

4 $A_z = W = 49.1\,N$

1 $\vec{r}_{AB} = 2\hat{i} - 2\hat{j} + 2\hat{k}$, 1 $\vec{r}_{AD} = \hat{i} - \hat{j} + \hat{k}$

Taking moments of all forces about A:

$$\Sigma\vec{M}_A = \vec{r}_{AB} \times \vec{B}_y + \vec{r}_{AB} \times \vec{T}_{BC} + \vec{r}_{AD} \times (\overset{W}{-49.1\hat{k}})$$

$$2\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -2 & 2 \\ 0 & B_y & 0 \end{vmatrix} + 2\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -2 & 2 \\ -T_{BC} & 0 & 0 \end{vmatrix} + 2\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & -1 & 1 \\ 0 & 0 & -49.1 \end{vmatrix} = 0$$

$$[-2B_y\hat{i} + 2B_y\hat{k}] + [-2T_{BC}\hat{j} - 2T_{BC}\hat{k}] + [49.1\hat{i} + 49.1\hat{j}] = 0$$

$\therefore -2B_y + 49.1 = 0 \rightarrow B_y = 24.6\,N$ 1

$\therefore -2T_{BC} + 49.1 = 0 \rightarrow T_{BC} = 24.6\,N$ 1

$\therefore 2B_y - 2T_{BC} = 0 \rightarrow B_y = T_{BC} = 24.6\,N$ 1

From the force equilibrium above:

$A_x = T_{BC} = 24.6\,N$ 1

$A_y = -B_y = -24.6\,N$ (-ve y-axis) 1

$$\rightarrow \Sigma\vec{M}_A = \vec{r}_{AB} \times (\vec{B}_y + \vec{T}_{AB}) + \vec{r}_{AD} \times (-49.1\hat{k})$$

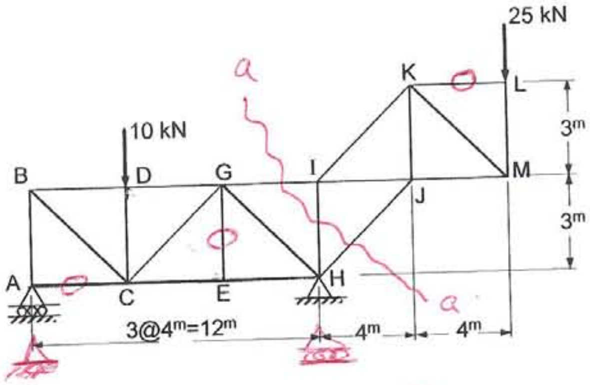
Question # 4 (22 points)

In the truss shown below:-

(4 points) A) Identify the zero-force members.

(10 points) B) Determine the force in member (MJ) by the joint method.

(8 points) C) Determine the force in member (IH) by the section method.
(Note: use one section and one equation).



(A) Zero-force members: KL (1) Point
EG (1) Point
AC (2) Points

Total 4 Points
- for others

(B) Force in MJ (Joint Method) 10 points

(3) Joint (L)

25 kN, 0, L, FLM

$\Sigma F_y = 0$

$F_{LM} - 25 = 0$

$F_{LM} = 25$ kN (Compression)

(4) Joint (M)

F_{KM}, 25 kN, F_{JM}, M, 53.1, 4, 3, 5, 36.9°

(4) $\Sigma F_y = 0 \uparrow +$ $\quad -25 + \frac{3}{5} F_{KM} = 0 \rightarrow F_{KM} = 25 \times \frac{5}{3} = 41.67$ kN

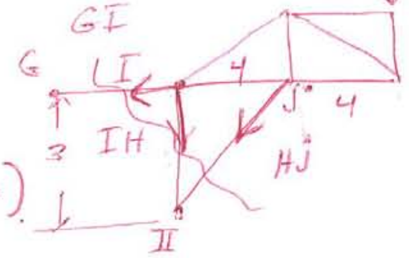
$\Sigma F_x = 0 \xrightarrow{+}$ $\quad F_{JM} - \frac{4}{5}(41.67) = 0 \quad \therefore F_{MJ} = 33.33$ kN (C)

25 kN

(C) $\Sigma M_J = 0$ ↺+

(8) $IH(4) - 25(4) = 0$

$\therefore IH = 25$ kN (Tension)

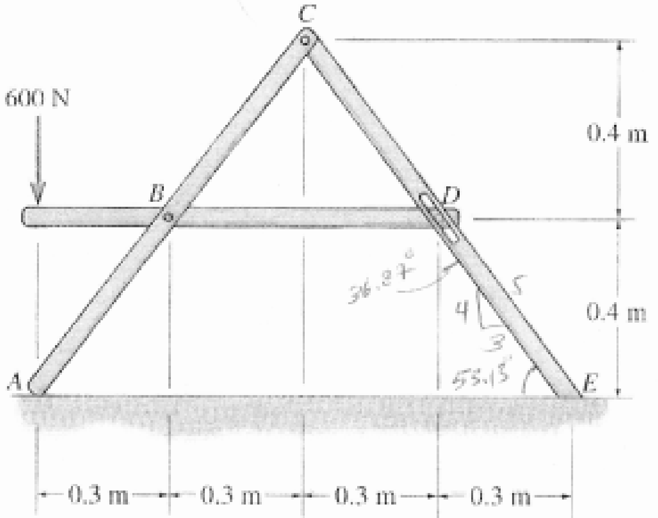


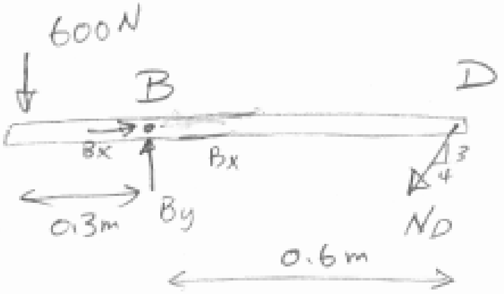
IF MORE EQUATIONS ARE USED

(−3)

Question # 5 (25 points)

For the frame shown below, determine the fixed support reaction at (E) and the smooth surface reaction at A. Note that the pin attached to member (BD) passes through a smooth slot at (D).





(3)

For Member BD

$\circlearrowleft + \sum M_B = 0$;

$600 * 0.3 - \frac{3}{5} N_D * 0.6 = 0$

$\Rightarrow \boxed{N_D = 180/(1.8/5) = 500\,N}$

(2)

$\xrightarrow{+} \sum F_x = 0$; $+B_x - \frac{4}{5} * 500 = 0 \Rightarrow \boxed{B_x = +400\,N}$ (2)

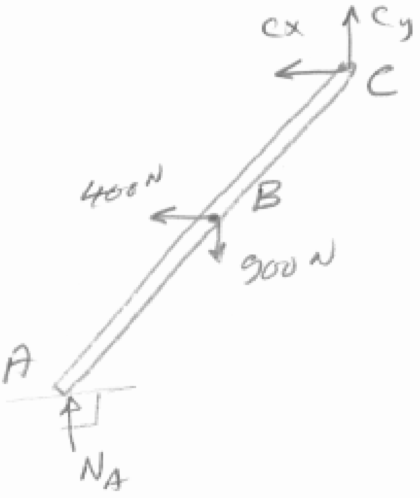
$+\uparrow \sum F_y = 0$; $-600 + B_y - \frac{3}{5} * 500 = 0$ (2)

$\Rightarrow \boxed{B_y = 900\,N}$

Check $\circlearrowleft \sum M_D = 0$; $600 * 0.9 - 900 * 0.6 = 0$ ok

Problem # 5 2/2

For Member CBA



2

$$\circlearrowleft + \sum M_C = 0; \quad +900 * 0.3 - 400 * 0.4 - N_A * 0.6 = 0$$

$$\Rightarrow \boxed{N_A = 183.33\,N} \quad 2$$

2

$$+\uparrow \sum F_y = 0; \quad 183.33 - 900 + C_y = 0 \Rightarrow \boxed{C_y = 716.67\,N}$$

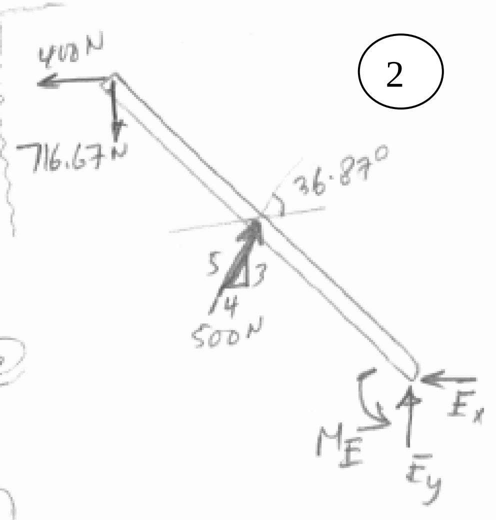
$$\xrightarrow{+} \sum F_x = 0; \quad -400 - C_x = 0 \Rightarrow \boxed{C_x = -400\,N}$$

2

Check !

$$\circlearrowleft + \sum M_A = 0; \quad \underbrace{-900 * 0.3}_{-270} + \underbrace{400 * 0.4}_{+160} + \underbrace{716.67}_{+430} \underbrace{- 400 * 0.8}_{-320} \overset{?}{=} 0 \quad \text{OK}$$

For Member CDF



2

$$\circlearrowleft + \sum M_E = 0; \quad -500 * 0.5 + 400 * 0.8 + 716.67 * 0.6 + M_E = 0$$

$$\Rightarrow \boxed{M_E = -500\,N \cdot m} \quad 2$$

$$+\uparrow \sum F_y = 0; \quad -716.67 + 300 + E_y = 0$$

$$\Rightarrow \boxed{E_y = 416.67\,N} \quad 2$$

$$\xrightarrow{+} \sum F_x = 0; \quad -400 + 400 - E_x = 0$$

$$\Rightarrow \boxed{E_x = 0} \quad 2$$

Can also be obtained From $\sum F_x$ for the entire Rigid Body