THE UNIVERSITY OF MANITOBA

Date: Saturday, December 14, 2002 | **Page No: 1 of 5**
Department & Course No: 130.135 | **Time: 1:30**
Paper No: 416 | **Duration: 2 Hours**
Examination: Engineering Statics | **Examiner: Drs: R.Hutchinson & A. Shah**
Place: FR Kennedy Gold Gym | **Seats: 172 - 356**

PRINT LAST NAME

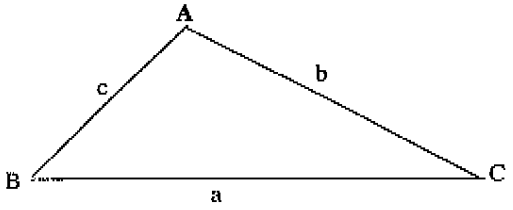
PRINT GIVEN NAME

STUDENT NUMBER

SEAT NUMBER

Problem	Marks
1	
2	
3	
4	
TOTAL	40

- **There are four questions. All questions of equal value.**
- **Straight edge is required. Two decimal accuracy is expected**
- **Work directly on the examination paper.**
- **CLOSED BOOK. Textbooks, notes, problems are NOT permitted.**
- **Calculators are permitted.**
- **Wherever necessary FBD must be drawn.**
- **Write at the back of the previous page.**



$$a^2 = b^2 + c^2 - 2bc\cos A$$

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

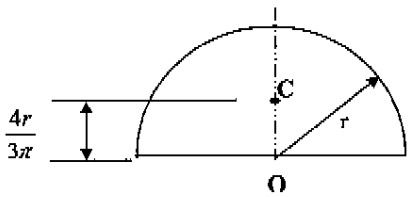
$$\vec{P} \times \vec{Q} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ P_x & P_y & P_z \\ Q_x & Q_y & Q_z \end{vmatrix} = \hat{i}(P_yQ_z - P_zQ_y) - \hat{j}(P_xQ_z - P_zQ_x) + \hat{k}(P_xQ_y - P_yQ_x)$$

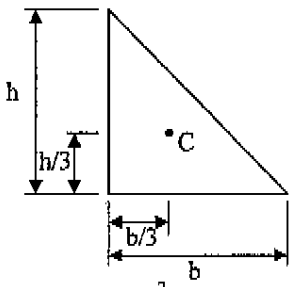
$$V = |\vec{V}| = \sqrt{V_x^2 + V_y^2 + V_z^2}$$

$$\cos\theta_x = \frac{V_x}{V}, \cos\theta_y = \frac{V_y}{V}, \cos\theta_z = \frac{V_z}{V}$$

$$\vec{M} = \vec{r} \times \vec{F}$$

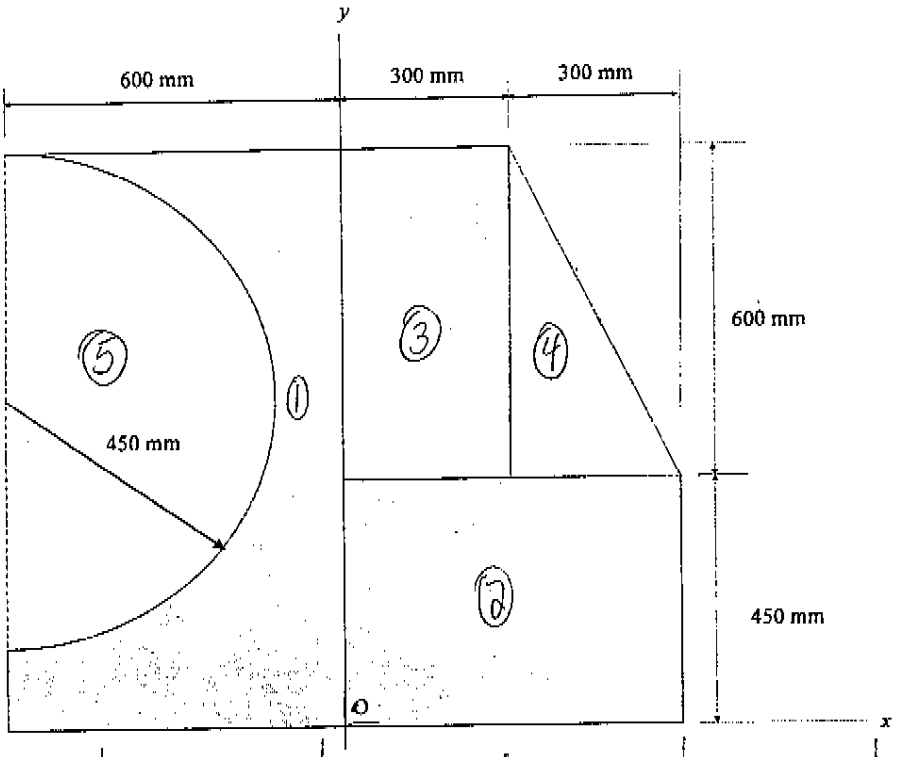
$$M_{OL} = \vec{\lambda}_{OL} \bullet \vec{M}_O$$





Area of a circle = πr^2

Question 1:
Locate the centroid $(\bar{x}, \bar{y})$ of the shaded plane area shown in the figure.



	Area	$\bar{x}$	$\bar{y}$	$\bar{x}A$	$\bar{y}A$
(1) +	$0.63m^2$	$-0.3m$	$0.525m$	$-0.189m^3$	$0.331\ m^3$
(2) +	$0.27m^2$	$0.3m$	$0.225m$	$0.081m^3$	$0.0608m^3$
(3) +	$0.18m^2$	$0.15m$	$0.75m$	$0.027m^3$	$0.135m^3$
(4) +	$0.09m^2$	$0.4m$	$0.65m$	$0.036m^3$	$0.0585m^3$
(5) −	$-0.318m^2$	$-0.409m$	$0.6m$	$0.130\ m^3$	$-0.191\ m^3$
Σ	$0.852m^2$ ✓			$0.085m^3$ ✓	$0.394m^3$ ✓

$$\bar{X} = \frac{\Sigma \bar{x}A}{\Sigma A} = \frac{0.085}{0.852} = 0.1m = 100mm$$ ✓

$$\bar{Y} = \frac{\Sigma \bar{y}A}{\Sigma A} = \frac{0.394}{0.852} = 0.462m = 462mm$$ ✓

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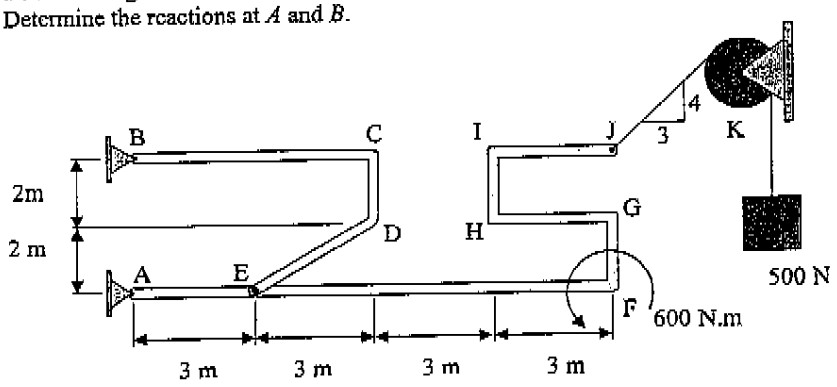
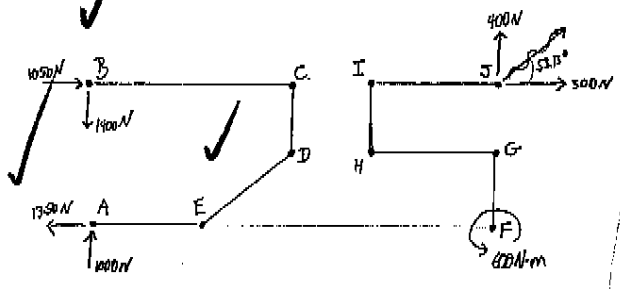
Question 2:
A frame is made up of two rigid members, *BCDE* and *AEFGHIJ* pinned together at *E*. A cable is attached at *J*. The cable passes over a simple frictionless pulley at *K* and supports a 500 N weight as shown in the figure. A couple of magnitude 600 N.m is applied at *F*. Determine the reactions at *A* and *B*.





$J_x = 500N(\cos 53.13) = 300N$
$J_y = 500N(\sin 53.13) = 400N$

entire Frame

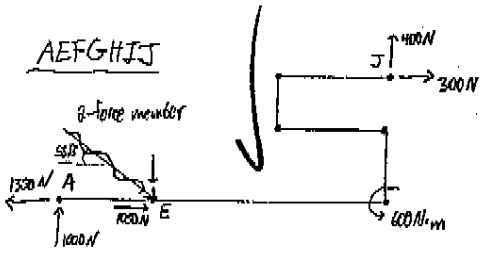
$\Sigma M_A = 0, \quad (B_x \times 4) + (400 \times 12) - (300 \times 4) + 600 = 0$

$B_x = -1050N \leftarrow$ (re-draw)

$B_x = 1050N \rightarrow$

$\Sigma F_x = 0, \quad (300) + (1050) - A_x = 0$

$A_x = 1350N \leftarrow$



$\Sigma F_y = 0, \quad (1000 + 400 - B_y = 0)$

$B_y = 1400N \downarrow$

$\Sigma M_E = 0, \quad (A_y \times 3) + 600 + (400 \times 9) - (300 \times 4) = 0$

$A_y = -1000N \downarrow$ (re-draw)

$A_y = 1000N \uparrow$

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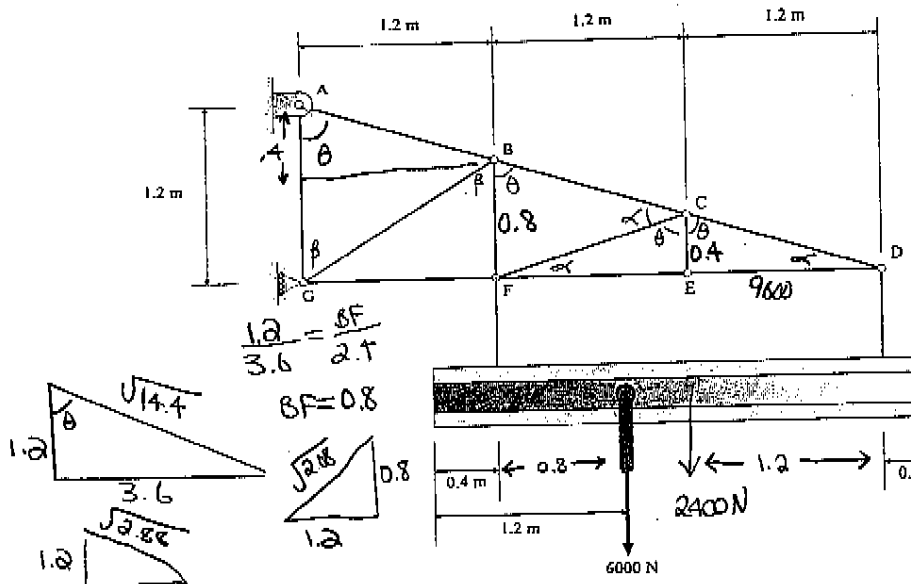
Question 3:
An overhead crane consists of an I-beam supported by a simple truss as shown in the figure. If the uniform I-beam weighs 2400 N and carries a weight of 6000 N, find the force in each member of the truss. State whether each member is in tension or compression.



$\alpha = 18.43°$

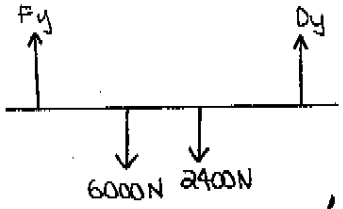
$\frac{1.2}{3.6} = \frac{CE}{1.2}$

$CE = 0.4$

$\frac{1.2}{3.6} = \frac{BF}{2.4}$

$BF = 0.8$

I-Beam



$\Sigma M_D \circlearrowleft = 0$

$-F_y(2.4) + 6000(1.6) + 2400(1.2) = 0$

$F_y = 5200\ N \uparrow (T)$

$\Sigma F_y = 0$

$5200 - 6000 - 2400 + D_y = 0$

$D_y = 3200N \uparrow (T)$

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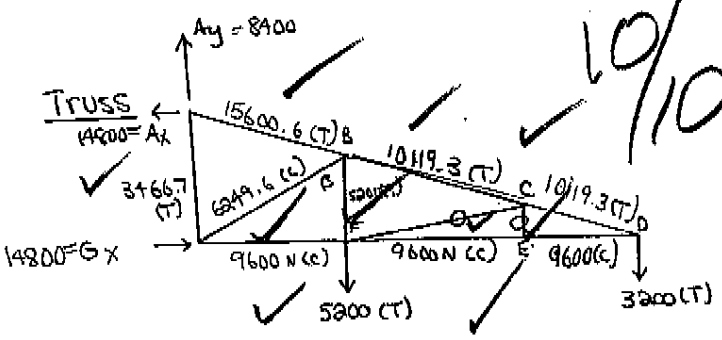
Truss



$\Sigma M_A \circlearrowleft = 0$

$G_x(1.2) - (5200)(1.2) - (3200)(3.6) = 0$

$G_x = 14800\ N \rightarrow$

$\Sigma F_x = 0$

$G_x - A_x = 0$

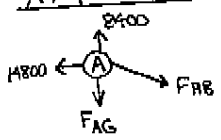
$14800 - A_x = 0 \quad \therefore A_x = 14800N \leftarrow$

$\Sigma F_y = 0$

$A_y - 5200 - 3200 = 0$

$A_y = 8400\ N \uparrow$

At point A:



$\Sigma F_x = 0$

$-14800 + F_{AB}\left(\frac{3.6}{\sqrt{14.4}}\right) = 0$

$F_{AB} = 15600.56979^{N}\ (T)$

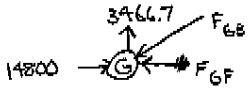
$\Sigma F_y = 0$

$8400 - F_{AG} - (15600.6)\left(\frac{1.2}{\sqrt{14.4}}\right) = 0$

$F_{AG} = 3466.67\ N\ (T)$

$\beta =$

At point G:



$\Sigma F_y = 0$

$3466.7 - F_{GB}\left(\frac{0.8}{\sqrt{2.88}}\right) = 0$

$F_{GB} = 6249.620211\ N\ (C)$

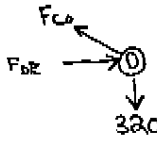
$\Sigma F_x = 0$

$14800 - F_{GF} - \left(\frac{1.2}{\sqrt{2.88}}\right)(6249.6) = 0$

$F_{GF} = 9600\ N\ (C)$

← MORE

At point D:



$\Sigma F_y = 0$

$-3200 + F_{CD}(\sin 18.43^\circ) = 0$

$F_{CD} = 10119.28851$ N (T)

$\Sigma F_x = 0$

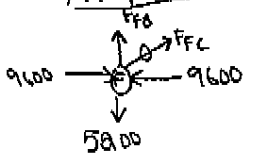
$F_{DE} - \cos 18.43^\circ (10119.3) = 0$

$F_{DE} = 9600$ N

At point E:

$F_{FE} = 9600$ N (C)

At point F:



$\Sigma F_x = 0$

$9600 - 9600 + F_{FC}(\cos 0) = 0$

$F_{FC} = 0$

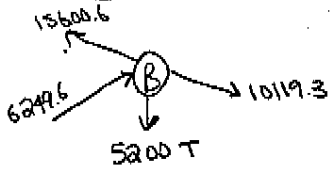
$\Sigma F_y = 0$

$F_{FB} = 5200$ N (T)

At point C:

$\therefore F_{BC} = 10119.3$ N (T) as well

Check at point B:



$\Sigma F_y = 0$:

$0 = -5200 + 15600.6\left(\frac{4}{\sqrt{1.6}}\right) - 10119.3\left(\frac{0.4}{\sqrt{1.6}}\right) + 6249.6\left(\frac{0.8}{\sqrt{2.08}}\right)$

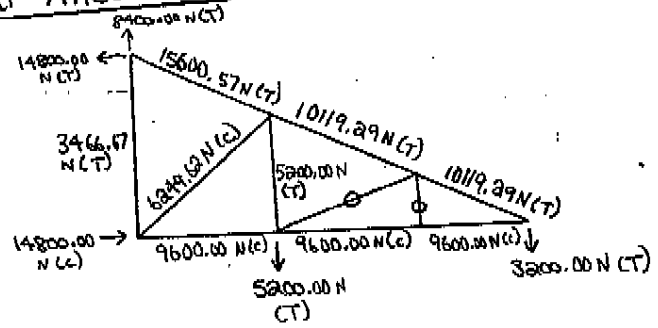
$0 = 0$ ✓

$\Sigma F_x = 0$

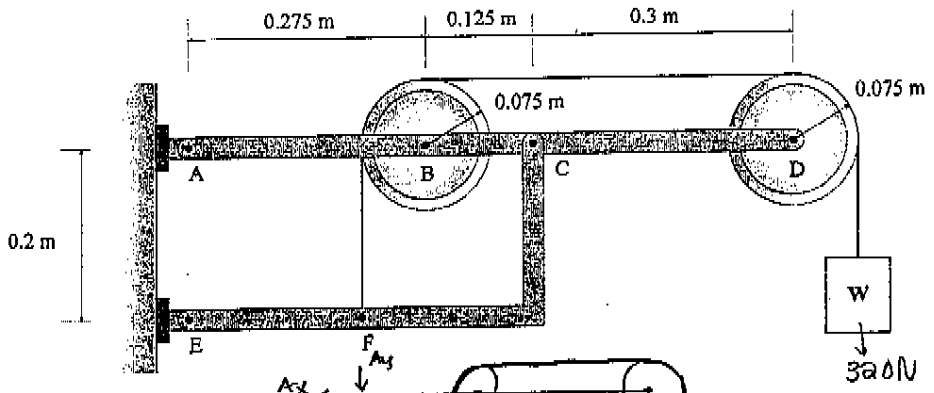
$\left(\frac{1.2}{\sqrt{2.08}}\right)(6249.6) - \left(15600.6\right)\left(\frac{1.2}{\sqrt{1.6}}\right) + (10119.3)\left(\frac{1.2}{\sqrt{1.6}}\right) = 0$

$0 = 0$ ✓

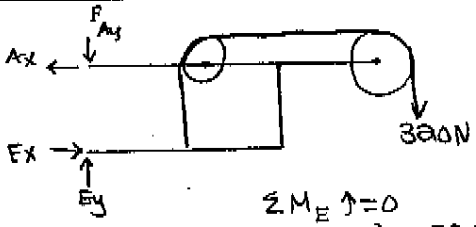
Final Answer:



Question 4:
For the figure shown, determine the components of the forces on member *ABCD* when weight $W = 320$ N.



For the system:

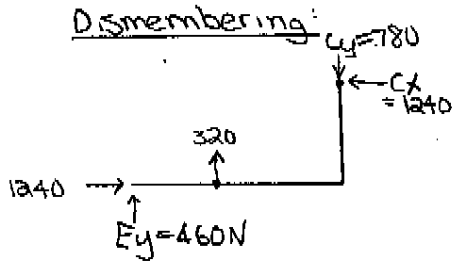


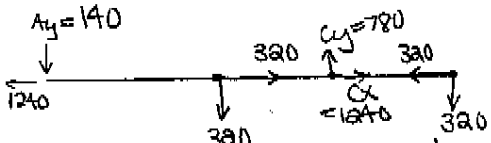
$\Sigma M_E \circlearrowleft = 0$
$A_x(0.2) - 320(.775) = 0$
$A_x = 1240$ N ← ✓

$\Sigma F_x = 0$
$E_x - 1240 = 0$ ✓
$E_x = 1240$ N →

$\Sigma F_y = 0$
$E_y - A_y - 320 = 0$
$460 - A_y - 320 = 0$
$A_y = 140$ N

Dismembering:





(member ABCD)

Member EFC:

$\Sigma M_C \circlearrowleft = 0$
$-E_y(.4) + 1240(.2) - 320(.2) = 0$
$E_y = 460$ N

$\Sigma F_y = 0$
$460 + 320 - C_y = 0$
$C_y = 780$ N

$\Sigma F_x = 0$
$1240 - C_x = 0$
$C_x = 1240$

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Check: (member ABCD)

$\Sigma F_y = 0$
$-140 - 320 + 780 - 320 = 0$
$0 = 0$ ✓

$\Sigma F_x = 0$
$-1240 + 320 + 1240 - 320 = 0$
$0 = 0$

$\Sigma M_A \circlearrowleft = 0$
$-320(.275) + 780(.4) - 320(.7) = 0$
$0 = 0$ ✓

Final Answer:

member ABCD: