THE UNIVERSITY OF MANITOBA

Date : Tuesday, December 19, 2000
Department & Course No : 130.135
Examination: Engineering Statics
Paper No : 538
Place : Room 229 Engineering
Seat Numbers: 1 - 203

Page No : 1 of 5
Time : 9:00 a.m.
Duration : 2 Hours
Examiners : J. Frye, D. Polyzois, and A. Shah

PRINT STUDENT NAME IN FULL

STUDENT SIGNATURE

STUDENT NUMBER

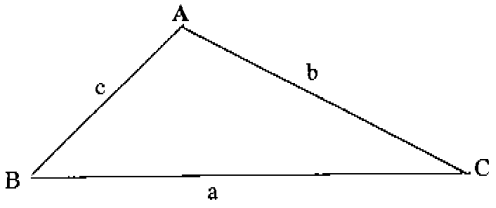
SEAT NUMBER

Problem	Marks
1	
2	
3	
4	
TOTAL	50

Instructor: _____ **Section No.:** _____

Notes:

- **There are FOUR questions.**
- **CLOSED BOOK. Textbooks, notes, problems NOT permitted.**
- **Calculators are permitted.**
- **All questions are of equal value.**
- **STRAIGHT EDGE IS REQUIRED.**



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

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

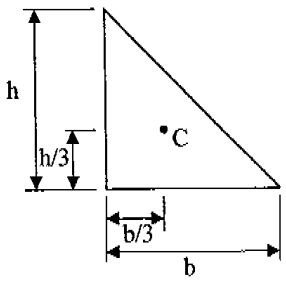
$$\vec{P} \times \vec{Q} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ P_x & P_y & P_z \\ Q_x & Q_y & Q_z \end{vmatrix} = \hat{i}(P_yQ_z - P_zQ_y) - \hat{j}(P_xQ_z - P_zQ_x) + \hat{k}(P_xQ_y - P_yQ_x)$$

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

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

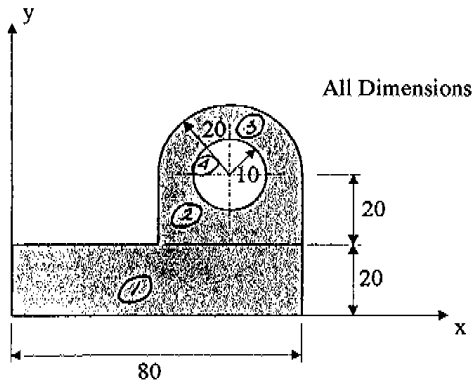
$$\vec{M} = \vec{r} \times \vec{F}$$

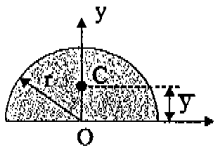
$$M_{OL} = \vec{\lambda}_{OL} \bullet \vec{M}_O$$



Question 1:

Determine the centroid of the composite shape having a circular hole as shown in the Figure below.





$\bar{y} = 4r/3\pi$

$A = \pi r^2/4$

$\bar{y} = \frac{4r}{3\pi} = \frac{4}{3}\frac{(20)}{\pi} = 8.488$

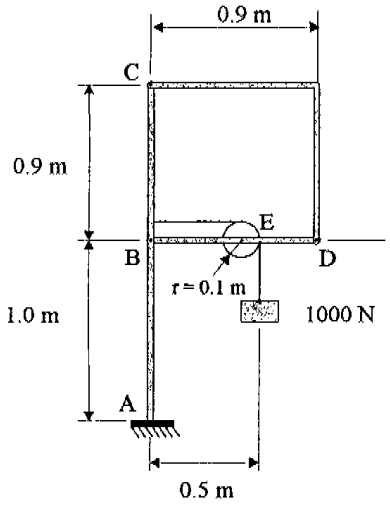
SHAPE	Area	$\bar{x}$	$\bar{y}$	$A\bar{x}$	$A\bar{y}$
① Rect.	1600	40	10	64 000	16 000
② Rect	800	60	30	48 000	24 000
③ ½ Circle	628	60	48.49	37 680	30451.7
④ Circle	-314	60	40	-18840	-12 560
	Σ = 2714			Σ = 130840	Σ = 57891.7

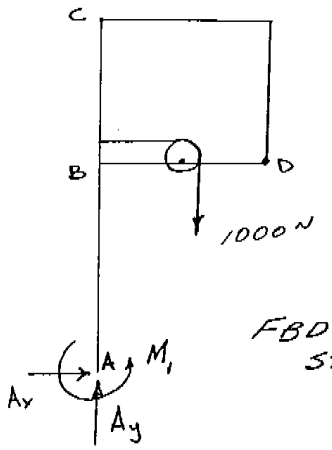
$\bar{x} = \frac{130840}{2714} = 48.2 \text{ mm}$

$\bar{y} = \frac{57891.7}{2714} = 21.33 \text{ mm}$

Question 2:

For the frame shown, determine the components of all forces acting on member *ABC* and show them on a **separate** diagram.





FBD Entire Structure

$\Sigma F_x = 0 \rightarrow+$ $\quad A_x = 0$ ①

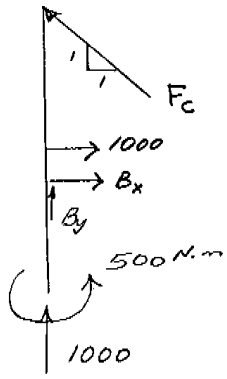
$\Sigma F_y = 0 \uparrow+$ $\quad A_y - 1000 = 0$ ②

$A_y = +1000\ N \therefore A_y = 1000\ N \uparrow$

$\Sigma M_A = 0$ ↻+ $\quad -1000(0.5) + M_1 = 0$

$M_1 = +500\ N.m \therefore M_1 = 500\ N.m$ ↻

NOTE: CD is a 2-Force Member



FBD Member ABC

$\Sigma F_x = 0 \rightarrow+$ $\quad -0.707F_C + 1000 + B_x = 0$ ①

$\Sigma F_y = 0 \uparrow+$ $\quad 0.707F_C + B_y + 1000 = 0$ ②

$\Sigma M_B = 0$ ↻+

$500 - 1000(0.1) + 0.707F_C(0.9) = 0$ ③

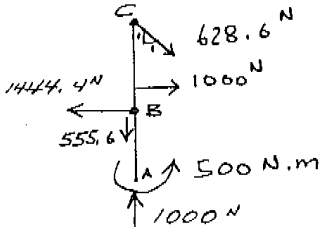
$F_C = \dfrac{-400}{0.707(0.9)} = -628.6\ N$ ↑ Direction in FBD Assumed Incorrectly

$\therefore F_C = 628.6\ N$ ↙

From ① $\quad -0.707(-628.6) + 1000 + B_x = 0$

$B_x = -1444.4\ N$ ← Direction in FBA Assumed Incorrectly

$\therefore B_x = 1444.4\ N \leftarrow$



From ② $\quad 0.707(-628.6) + B_y + 1000 = 0$

$B_y = -555.6\ N$ Dir. Assumed Inc.

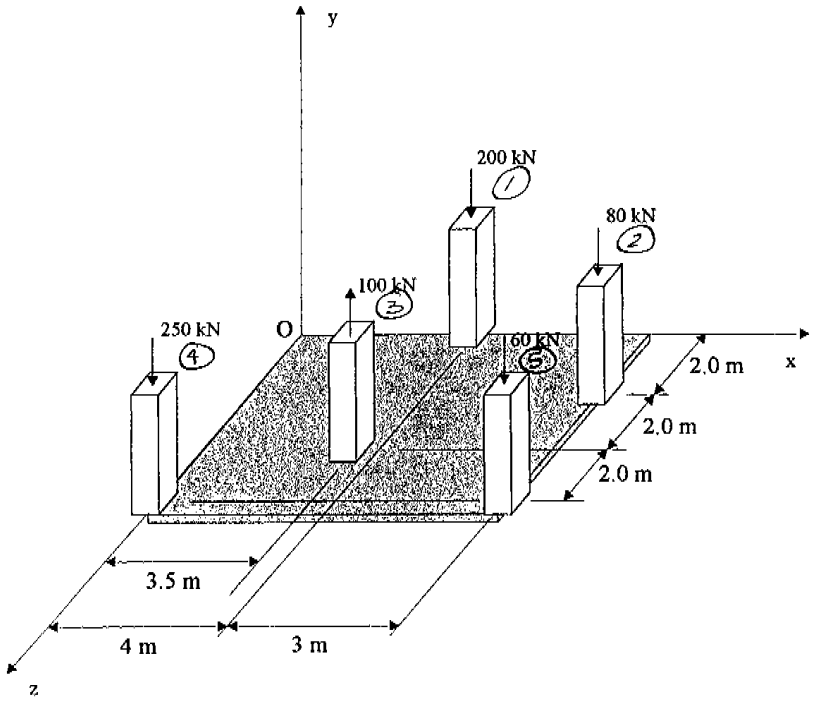
$\therefore B_y = 555.6\ N \downarrow$

Check $\Sigma M_A = 0$ ↻

$+1444.4(1) - 1000(1.1) + 500 - 0.707(628.6)(1.9) = 0$ ✓

Question 3:

A concrete pad supports five column loads as shown. Determine the resultant and the point of application of the five loads.



LOAD	$\vec{P}$	$\vec{r}$	$\vec{r} \times \vec{P}$
①	$-200\hat{j}$	$4\hat{i}$	$-800\hat{k}$
②	$-80\hat{j}$	$7\hat{i}+2\hat{k}$	$-560\hat{k}+160\hat{i}$
③	$+100\hat{j}$	$3.5\hat{i}+4\hat{k}$	$+350\hat{k}-400\hat{i}$
④	$-250\hat{j}$	$6\hat{k}$	$+1500\hat{i}$
⑤	$-60\hat{j}$	$7\hat{i}+6\hat{k}$	$-420\hat{k}+360\hat{i}$

$\Sigma \; -490\hat{j}$ $\qquad \vec{M} = -1430\hat{k}+1620\hat{i}$

$$(\bar{x}\hat{i}+\bar{z}\hat{k})\times(-490\hat{j}) = -1430\hat{k}+1620\hat{i}$$

$$-490\bar{x}\hat{k}+490\bar{z}\hat{i} = -1430\hat{k}+1620\hat{i}$$

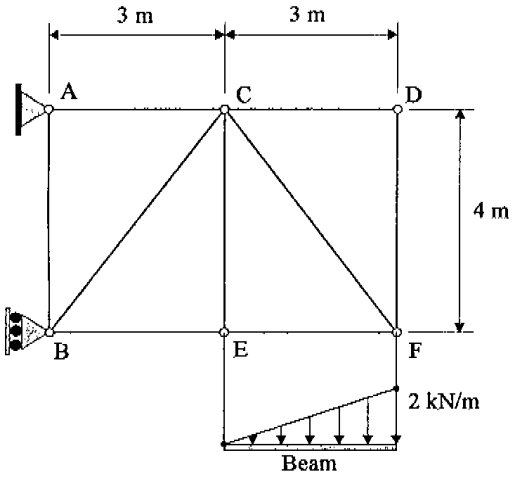
$$\bar{x} = \frac{1430}{490} = 2.92\,m$$

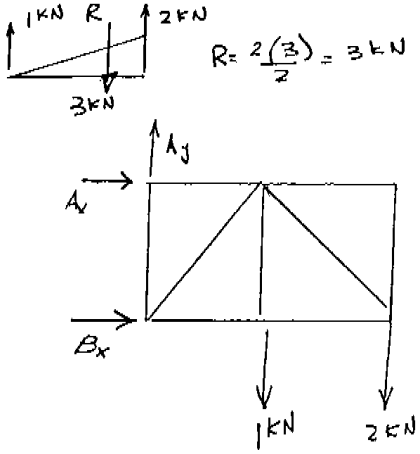
$$\bar{z} = \frac{1620}{490} = 3.31\,m$$

Question 4:

The truss shown supports a beam attached by cables at *E* and *F*. The beam carries a distributed load.

Determine the forces in all members of the truss. **Show your results on a separate figure OR in tabular form and state whether the forces are in TENSION or COMPRESSION.**





$\Sigma F_y = 0 \uparrow +$

$A_y - 3 = 0$

$A_y = +3^{KN} \therefore A_y = 3^{KN} \uparrow$

$\Sigma M_B = 0 \circlearrowleft$

$-A_x(4) - 1(3) - 2(6) = 0$

$A_x = -\frac{15}{4} = -3.75^{KN}$

$\therefore A_x = 3.75^{KN} \leftarrow$

$\Sigma F_x = 0 \rightarrow +$

$-3.75 + B_x = 0 \quad \therefore B_x = +3.75^{KN}$

$B_x = 3.75^{KN} \rightarrow$