King Saud University
College of Engineering
Department of Civil Engineering

GE 201 Statics
Second Semester 1433-34 H
Monday: 6-5-1434
Time: 90 Min

FIRST MID TERM EXAM
(SOLUTION)

Name (in Arabic): …………………………………....

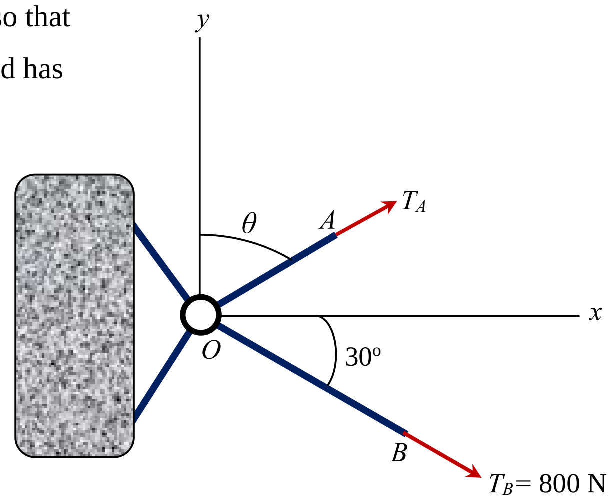
Student No.: ………………………………………..

Section / Instructor: ……………………………........

Q. No.	Max. Marks	Marks Obtained
1	10	
2	10	
3	10	
Total	30	

Question # 1(a) (5 Marks)

Determine the magnitude of force T_A and its direction θ so that the resultant force is directed along the positive x axis and has a magnitude of 1250 N.



Solution

The force T_A can be obtained by applying the cosine law on ΔOAC:

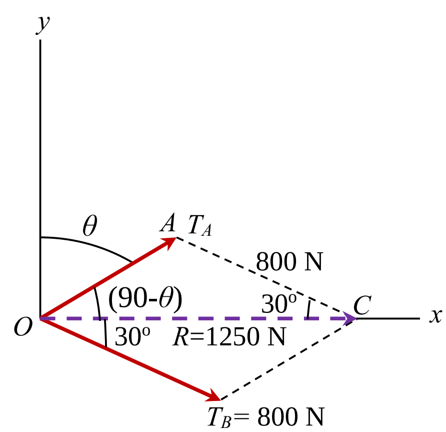
$$c = \sqrt{\left(a^2 + b^2 - 2ab\cos C\right)}$$

$$\Rightarrow T_A = \sqrt{\left(800^2 + 1250^2 - 2\times 800\times 1250\times \cos 30^\circ\right)}$$

$$\Rightarrow T_A = 685.9 \text{ N} \quad Ans.$$

Applying the sine law on ΔOAC, we have

$$\frac{\sin(90-\theta)}{800} = \frac{\sin 30^\circ}{685.9} \Rightarrow \sin(90-\theta) = 0.583 \Rightarrow \theta = 54.33^\circ \quad Ans.$$



Alternatively,

Note $R_y = 0$ and $R_x = R$

$$\overset{+}{\uparrow} R_y = \sum F_y = -800\sin 30^\circ + T_A\cos\theta = 0 \quad \Rightarrow T_A = \frac{400}{\cos\theta}$$

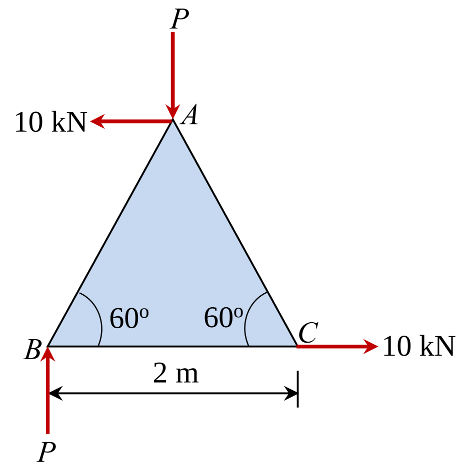
$$\overset{+}{\rightarrow} R_x = \sum F_x = T_A\sin\theta + 800\cos 30^\circ = 1250$$

$$\Rightarrow \frac{400}{\cos\theta}\sin\theta + 692.82 = 1250 \Rightarrow 400\tan\theta = 557.18$$

$$\Rightarrow \theta = 54.33^\circ \quad \text{and} \quad T_A = \frac{400}{\cos\theta} = 685.9 \text{ N} \qquad Ans.$$

Question # 1(b) (2.5 Marks)

Calculate the value of the force P that makes the resulting moment equals to zero.

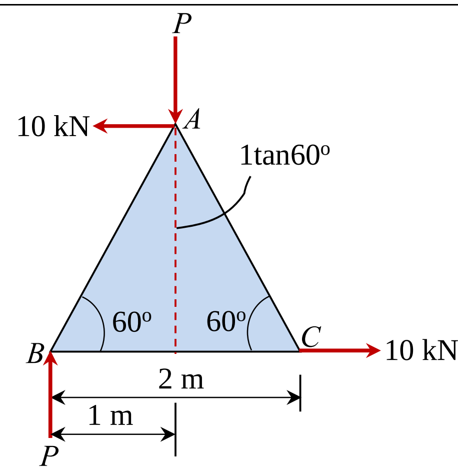


Solution

The given four forces form the two couples.

$$M_t = 10 \times 1 \tan 60^\circ - P \times 1 = 0$$

$$\Rightarrow P = 10 \tan 60^\circ = 17.3 \text{ kN} \qquad Ans.$$



Question # 1(c) (2.5 Marks)

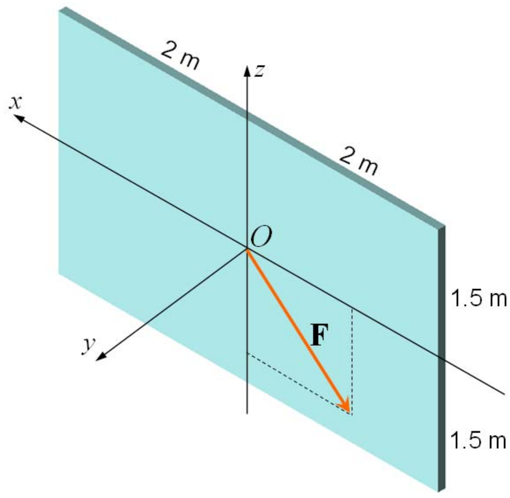
Determine the scalar projection of the force $\mathbf{F} = -10\mathbf{i} - 8\mathbf{k}$ kN on the x-, y- and z-axes.

Solution

$$\text{Projection of the force on } x\text{-axis} = F_x = \mathbf{F}.\mathbf{i} = -10 \text{ kN} \qquad Ans.$$

$$\text{Projection of the force on } y\text{-axis} = F_y = \mathbf{F}.\mathbf{j} = 0 \text{ kN} \qquad Ans.$$

$$\text{Projection of the force on } z\text{-axis} = F_z = \mathbf{F}.\mathbf{k} = -8 \text{ kN} \qquad Ans.$$



Student name		Marks obtained for Q.2	
Student number			

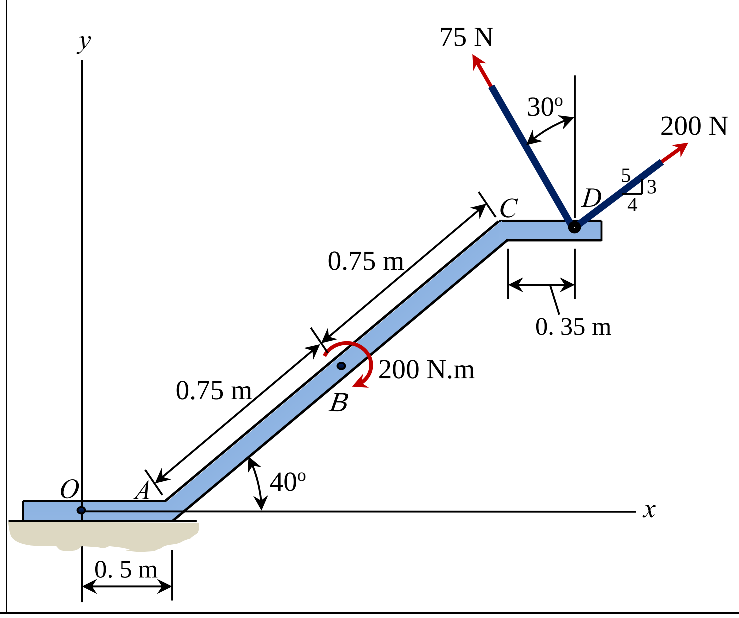
Question ≠ 2 (10 Marks)

For the force-system shown in the figure:

i. Replace the two forces and one couple by an equivalent force-couple system (R and M) at point O.

ii. Determine the direction of R.

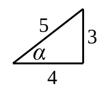
iii. Sketch the single resultant force R that represents the force-couple system alone and find its intersection with the x- and y-axes.



Solution

$\cos\alpha = 4/5 = 0.8$

$\sin\alpha = 3/5 = 0.6$



(i)

$$\overset{+}{\rightarrow} R_x = \sum F_x = 200\cos\alpha - 75\sin 30^\circ = 200\times 0.8 - 75\sin 30^\circ = 122.5\text{ N}\rightarrow$$

$$\overset{+}{\uparrow} R_y = \sum F_y = 200\sin\alpha + 75\cos 30^\circ = 200\times 0.6 + 75\cos 30^\circ = 184.9\text{ N}\uparrow$$

Therefore, $R = \sqrt{R_x^2 + R_y^2} = \sqrt{(122.5)^2 + (184.9)^2} = 221.8\text{ N}$ *Ans.*

$$CCW(+) M_O = 75\times\cos 30^\circ\times(0.5 + 1.5\cos 40^\circ + 0.35) + 75\sin 30^\circ\times 1.5\sin 40^\circ$$
$$+ 200\sin\alpha\times(0.5 + 1.5\cos 40^\circ + 0.35) - 200\cos\alpha\times 1.5\sin 40^\circ - 200$$

$\Rightarrow M_O = 51.6\text{ kN.m (CCW)}$ *Ans.*

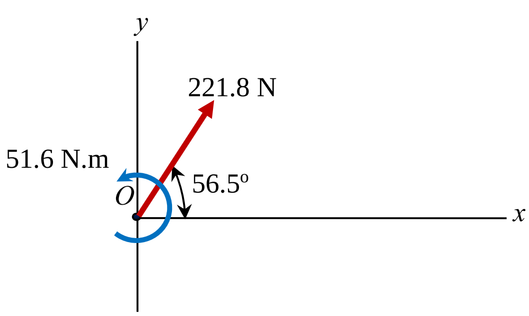
(ii)

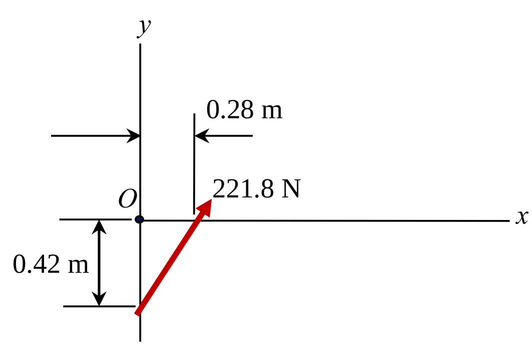
$$\theta = \tan^{-1}\left(\frac{R_y}{R_x}\right) = \tan^{-1}\left(\frac{184.9}{122.5}\right) = 56.5^0$$ *Ans.*

(iii)

$$x-\text{intercept}, x = \frac{M_O}{R_y} = \frac{51.6}{184.9} = 0.28\text{ m}$$ *Ans.*

$$y-\text{intercept}, y = -\frac{M_O}{R_x} = -\frac{51.6}{122.5} = -0.42\text{ m}$$ *Ans.*





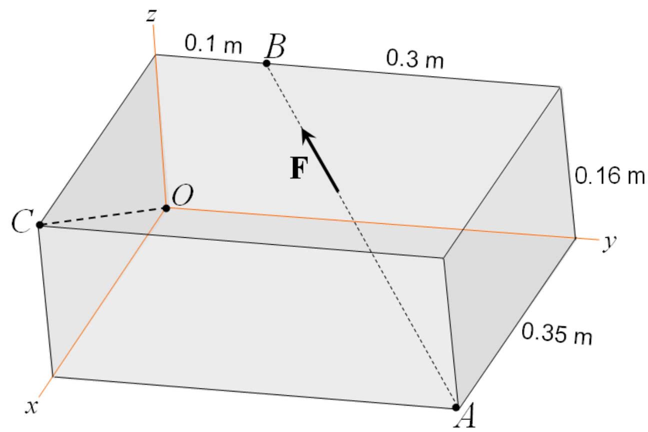
Student name		Marks obtained for Q.3	
Student number			

Question # 3 (10 Marks)

The force F = 976 N is acting along the line AB as shown in the figure. Determine the following:

(i) The *magnitude* of the moment about line OC (M_{OC}), and express it in vector form ($\mathbf{M}_{OC}$).

(ii) The moment about point B.



Solution

The coordinates of points O, A, B and C are: $O(0, 0, 0)$; $A(0.35, 0.4, 0)$; $B(0, 0.1, 0.16)$ and $C(0.35, 0, 0.16)$

(i) $\vec{M}_O = \vec{r}_{OB} \times \vec{F}$, where

$$\vec{r}_{OB} = (0-0)\vec{i} + (0.1-0)\vec{j} + (0.16-0)\vec{k} = 0.1\vec{j} + 0.16\vec{k}$$

$$\vec{F} = 976\vec{n}_{AB} = 976\left(\frac{(0-0.35)\vec{i} + (0.1-0.4)\vec{j} + (0.16-0)\vec{k}}{\sqrt{(0-0.35)^2 + (0.1-0.4)^2 + (0.16-0)^2}}\right) = -700\vec{i} - 600\vec{j} + 320\vec{k} \text{ N}$$

Therefore,

$$\vec{M}_O = \vec{r}_{OB} \times \vec{F} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 0 & 0.1 & 0.16 \\ -700 & -600 & 320 \end{vmatrix} \Rightarrow \vec{M}_O = 128\vec{i} - 112\vec{j} + 70\vec{k} \text{ N.m}$$

$M_{OC} = \vec{M}_O \cdot \vec{n}_{OC}$, where $\vec{n}_{OC}$ is the unit vector along the line OC.

$$\vec{n}_{OC} = \frac{(0.35-0)\vec{i} + (0-0)\vec{j} + (0.16-0)\vec{k}}{\sqrt{\left((0.35-0)^2 + (0-0)^2 + (0.16-0)^2\right)}} = \frac{0.35\vec{i} + 0.16\vec{k}}{\sqrt{0.35^2 + 0.16^2}} = 0.91\vec{i} + 0.42\vec{k}$$

Therefore, $M_{OC} = \vec{M}_O \cdot \vec{n}_{OC} = \left(128\vec{i} - 112\vec{j} + 70\vec{k}\right) \cdot \left(0.91\vec{i} + 0.42\vec{k}\right) = 145.9 \text{ N.m}$ *Ans.*

The above moment can be expressed in a vector form as

$\vec{M}_{OC} = M_{OC}\vec{n}_{OC} = 145.9\left(0.91\vec{i} + 0.42\vec{k}\right) = 132.8\vec{i} + 61.3\vec{k}$ N.m *Ans.*

(ii) Since the line of action of the force is passing through the point B, the moment of the force about point B will be zero. That is, $M_B = 0$ *Ans.*