King Saud University
College of Engineering
Department of Civil Engineering

GE 201 Statics
First Semester 1433-34 H
Monday: 27-12-1433
Time: 90 Min

FIRST MID TERM EXAM

Name (in Arabic): ....

Student No.: ....

Section / Instructor: ....

Model Solution

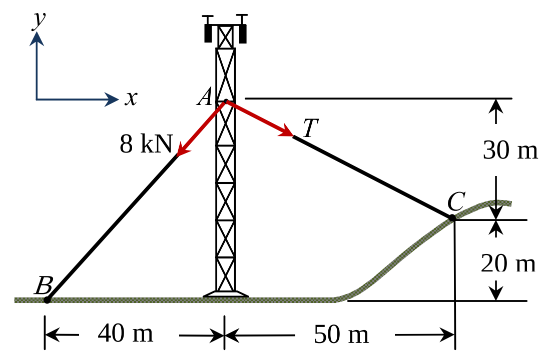
Q. No.	Max. Marks	Marks Obtained
1	10	
2	10	
3	10	
Total	30	

Question # 1(a) (6 Marks)

The cables *AB* and *AC* are attached to the top of the transmission tower as shown in the figure.
If the tension in cable *AB* is 8 kN, determine

a) The required tension *T* in the cable *AC* such that the resultant (R) of the two cable tensions is along y-axis.

b) The magnitude of the resultant force *R*.



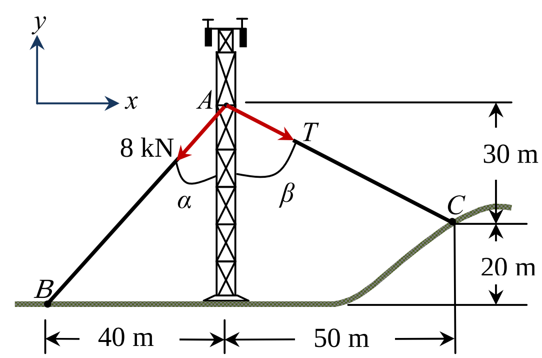
Solution

The angles α and β can be obtained from the above figure as

$$\alpha = \tan^{-1}\left(\frac{40}{50}\right) = 38.7^\circ; \text{and } \beta = \tan^{-1}\left(\frac{50}{30}\right) = 59^\circ$$

The angle $\gamma = 180^\circ - (\alpha + \beta) = 180^\circ - (38.7^\circ + 59^\circ) = 82.3^\circ$

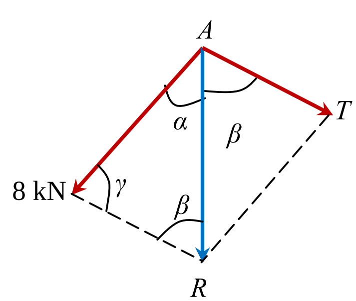
Applying sine law on the second figure yields,



$$\frac{T}{\sin\alpha} = \frac{R}{\sin\gamma} = \frac{8}{\sin\beta} \Rightarrow \frac{T}{\sin 38.7^\circ} = \frac{R}{\sin 82.3^\circ} = \frac{8}{\sin 59^\circ}$$

$$\Rightarrow \frac{T}{\sin 38.7^\circ} = \frac{8}{\sin 59^\circ} \Rightarrow T = 5.83 \text{ kN} \qquad \textit{Ans.}$$

$$\text{Similarly, } \frac{R}{\sin 82.3^\circ} = \frac{8}{\sin 59^\circ} \Rightarrow R = 9.25 \text{ kN} \qquad \textit{Ans.}$$



(3 marks)

(3 marks)

Alternatively,

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

$$\overset{+}{\rightarrow} R_x = \sum F_x = T\sin\beta - 8\sin\alpha = T\sin 59^\circ - 8\sin 38.7^\circ = 0$$

$$\Rightarrow T = 5.83 \text{ kN} \qquad \textit{Ans.}$$

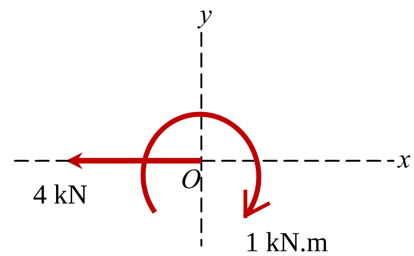
$$\overset{+}{\uparrow} R_y = \sum F_y = -T\cos\beta - 8\cos\alpha = -5.83\cos 59^\circ - 8\cos 38.7^\circ$$

$$\Rightarrow R = R_y = -9.25 \text{ kN} \qquad \textit{Ans.}$$

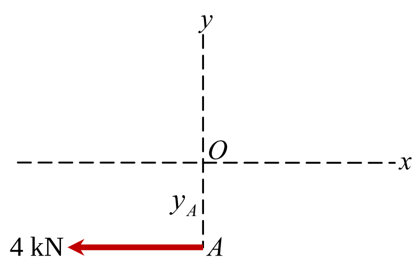
Student name		Marks obtained for Q.1	page 2/4
Student number			

Question # 1(b) (2 Marks)

Replace the force-couple system at point O by a single force. Specify the y-coordinate through which the line of action of this single force passes.



Solution



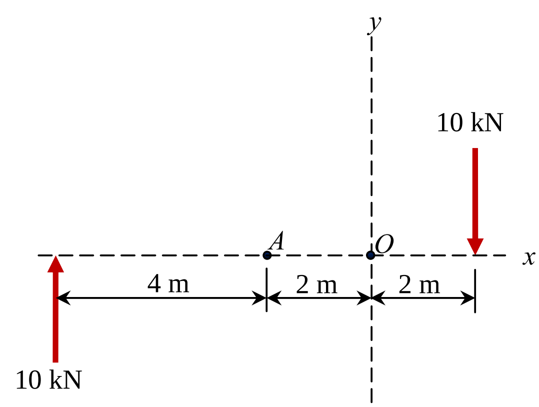
$$y_A = -\frac{M}{R_x} = -\left(\frac{-1}{-4}\right) = -0.25\,\text{m} \qquad Ans.$$

(2 marks)

Question # 1(c) (2 Marks)

Compute the moment of the two 10-kN forces about the

a) Point O; and
b) Point A.



Solution

The two 10-kN forces are forming a couple. As couple moment is independent of the moment centers, the moment produced by the two 10-kN forces about points O and A will be the same.

Therefore, $M_O = M_A = Fd = -10 \times 8 = -80\,\text{kN.m (CW)}$ $\quad Ans.$

(2 marks)

Student name		Marks obtained for Q.2	page 3/4
Student number			

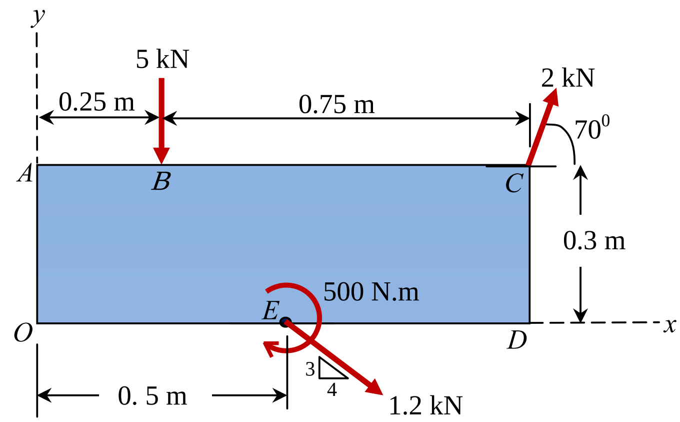
Question ≠ 2 (10 Marks)

For the force-system shown in the figure:

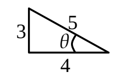
i. Replace the three forces and one couple by an equivalent force-couple system (R and M) at point O.

ii. Determine the direction of R.

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



Solution



(i)

$$\overset{+}{\rightarrow} R_x = \sum F_x = 2\cos 70^{\circ} + 1.2\cos\theta = 2\cos 70^{\circ} + 1.2 \times (4/5) = 1.64 \text{ kN} \rightarrow$$ **(1 mark)**

$$\overset{+}{\uparrow} R_y = \sum F_y = -5 + 2\sin 70^{\circ} - 1.2\sin\theta = -5 + 2\sin 70^{\circ} - 1.2 \times (3/5) = -3.84 \text{ kN} \downarrow$$ **(1 mark)**

$$\text{Therefore, } R = \sqrt{R_x^2 + R_y^2} = \sqrt{(1.64)^2 + (-3.84)^2} = 4.18 \text{ kN} \qquad \textit{Ans.}$$ **(1 mark)**

$$CCW(+) M_O = -5 \times 0.25 - 2\cos 70^{\circ} \times 0.3 + 2\sin 70^{\circ} \times 1.0 - 1.2\sin\theta \times 0.5 - \left(\frac{500}{1000}\right)$$ **(3 marks)**

$$\Rightarrow M_O = -1.25 - 0.205 + 1.879 - 1.2 \times (3/5) \times 0.5 - 0.5 = -0.44 \text{ kN.m (CW)} \qquad \textit{Ans.}$$

(ii)

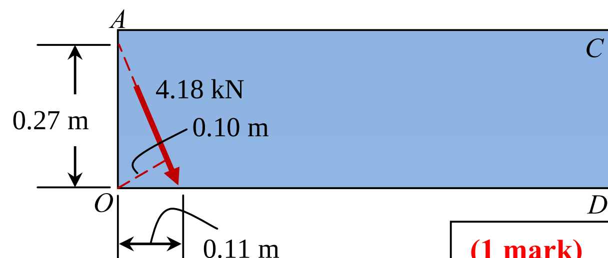
$$\theta = \tan^{-1}\left(\frac{R_y}{R_x}\right) = \tan^{-1}\left(\frac{-3.84}{1.64}\right) = -66.9^{0} \qquad \textit{Ans.}$$ **(1 mark)**

(iii)

$$|M_O| = Rd \Rightarrow d = \frac{|M_O|}{R} = \frac{0.44}{4.18} = 0.10 \text{ m}$$

$$x - \text{intercept}, x = \frac{M_O}{R_y} = \frac{-0.44}{-3.84} = 0.11 \text{ m} \qquad \textit{Ans.}$$ **(1 mark)**

$$y - \text{intercept}, y = -\frac{M_O}{R_x} = -\frac{-0.44}{1.64} = 0.27 \text{ m} \qquad \textit{Ans.}$$ **(1 mark)**



x

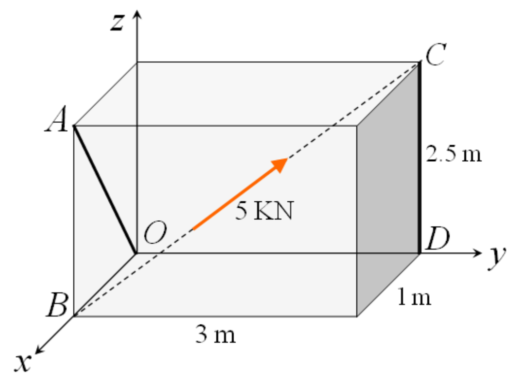
(1 mark)

Student name		Marks obtained for Q.3	
Student number			

Question # 3 (10 Marks)

A force of 5 kN is acting along the line *BC* as shown in the figure. Determine the following:

(i) The moment about point *O* ($\boldsymbol{M_O}$).
(ii) The moment about line *OA* ($\boldsymbol{M_{OA}}$).
(iii) The moment about line *CD* ($\boldsymbol{M_{CD}}$).



Solution

The coordinates of points *O*, *A*, *B* and *C* are: *O*(0, 0, 0); *A*(1, 0, 2.5); *B*(1, 0, 0) and *C*(0, 3, 2.5) **(1 mark)**

(i) $\vec{M}_O = \vec{r}_{OB} \times \vec{F}$, where $\vec{r}_{OB} = \vec{i}$ and $\vec{F} = 5\vec{u}_{BC} = 5\left(\dfrac{-\vec{i} + 3\vec{j} + 2.5\vec{k}}{\sqrt{(-1)^2 + (3)^2 + (2.5)^2}}\right) = -1.24\vec{i} + 3.72\vec{j} + 3.1\vec{k}$ kN **(2 marks)**

Therefore, $\vec{M}_O = \vec{r}_{OB} \times \vec{F} = \vec{i} \times \left(-1.24\vec{i} + 3.72\vec{j} + 3.1\vec{k}\right) = -3.1\vec{j} + 3.72\vec{k}$ kN.m *Ans.* **(2 marks)**

And the magnitude of $\vec{M}_O$ is, $M_O = \left|\vec{M}_O\right| = \sqrt{(-3.1)^2 + (3.72)^2} = 4.84$ kN.m *Ans.*

(ii) $M_{OA} = \vec{M}_O \cdot \vec{u}_{OA}$, where $\vec{u}_{OA}$ is the unit vector along the line *OA*.

$$\vec{u}_{OA} = \frac{\vec{r}_{OA}}{\left|\vec{r}_{OA}\right|} = \frac{\vec{i} + 2.5\vec{k}}{\sqrt{1^2 + 2.5^2}} = 0.371\vec{i} + 0.928\vec{k}$$ **(1 mark)**

Therefore, $M_{OA} = \vec{M}_O \cdot \vec{u}_{OA} = \left(-3.1\vec{j} + 3.72\vec{k}\right) \cdot \left(0.371\vec{i} + 0.928\vec{k}\right) = 3.45$ kN.m *Ans.* **(2 marks)**

The above moment can be expressed in a vector form as

$\vec{M}_{OA} = M_{OA}\vec{u}_{OA} = 3.45\left(0.371\vec{i} + 0.928\vec{k}\right) = 1.28\vec{i} + 3.20\vec{k}$ kN.m *Ans.*

(iii) Since the line of action of the force is passing through the line *CD*, the moment of the force about line *CD* will be zero. That is, $M_{CD} = 0$ *Ans.* **(2 marks)**