King Fahd University of Petroleum & Minerals

Department of Civil and Environmental Engineering

CE 201 – Statics

Semester: 151
Examination: First Major
Date (Day): October 10, 2015 (Sunday)
Time: 07:00 – 09:00 p.m.

Section	1	2	3	4	5	6	7	8
Instructor	Al-Malack	Al-Malack	Vohra	Al-Osta	Al-Attas	Essa	Al-Amoudi	Chowdhury
Time	07:00	08:00	08:00	09:00	10:00	11:00	13:10	07:00
Tick								

Student's Name :	
Student's ID :	

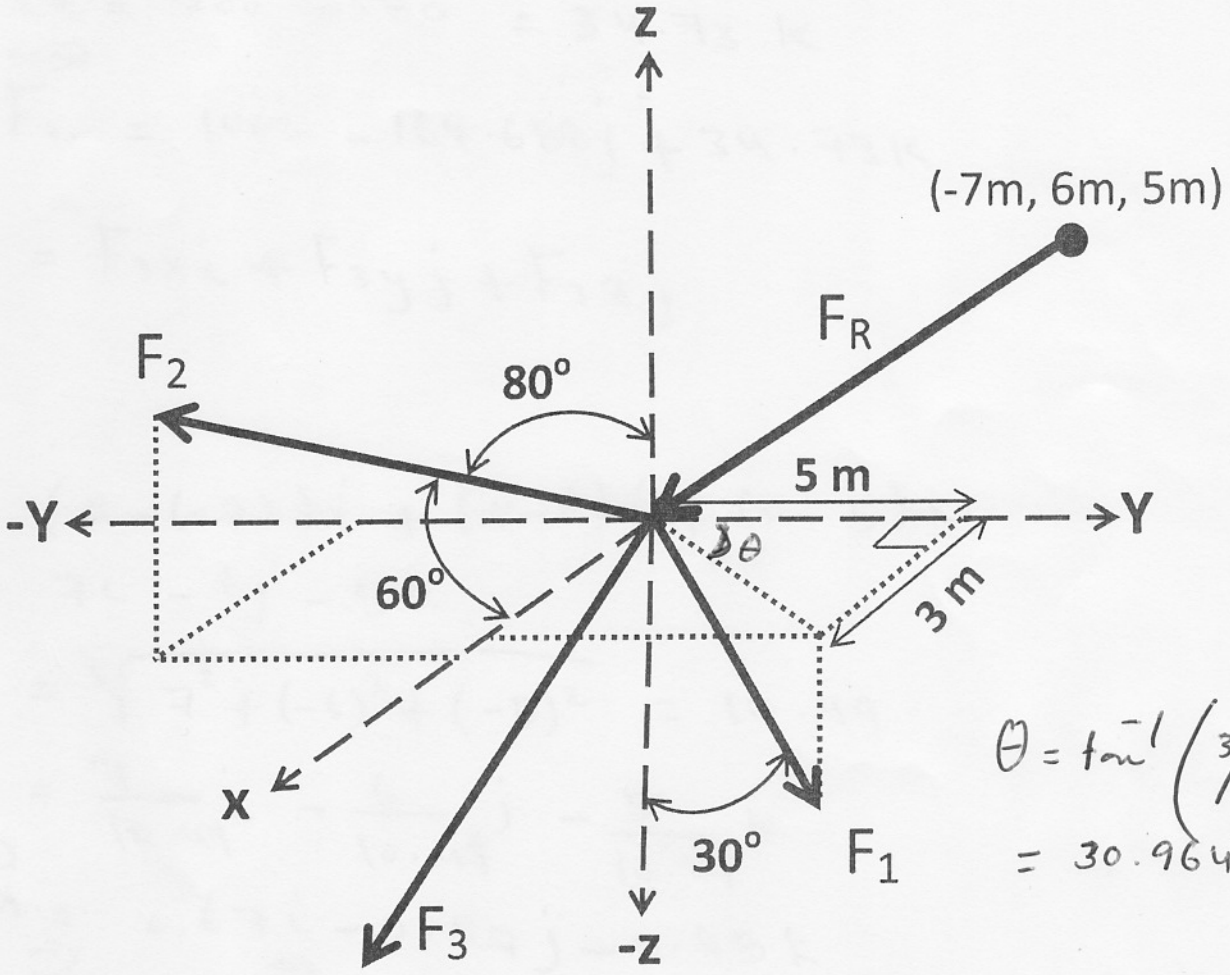
Problem	Assigned Grade	Earned Grade
1	25 (Points)	
2	25 (Points)	
3	25 (Points)	
4	25 (Points)	
Total	100 (Points)	

Good Luck

Problem 1 (25 Points)

Using Cartesian Vector Formulation, Find the magnitude and directional angles of F_3 of the forces shown in the figure if:

- $F_1 = 100$ kN;
- $F_2 = 200$ kN;
- The resultant force F_R of the F_1, F_2 and $F_3 = 400$ kN



$\theta = \tan^{-1}\left(\frac{3}{5}\right)$

$= 30.964°$

F_1:

$F_{1z} = -100 \cos 30 = -86.603k$

$F_1' = 100 \sin 30 = 50$

$F_{1x} = 50 * \sin 30.964 = 25.725i$

$F_{1y} = 50 \times \cos 30.96 = 42.88j$

$\Rightarrow F_1 = 25.725i + 42.875j - 86.603k$

F_2 :-

$\because \cos^2 60 + \cos^2 \beta + \cos^2 80 = 1$

$\Rightarrow \beta = 31.96^\circ$ or $\beta = 148.04^\circ$

By inspection: $\beta = 148.04^\circ$

$\Rightarrow F_{2x} = 200\cos 60 = 100\,i$

$F_{2y} = 200\cos 148.04 = -169.688\,j$

$F_{2z} = 200\cos 80 = 34.73\,k$

$\Rightarrow \vec{F_2} = 100i - 169.688j + 34.73k$

$\vec{F_3} = F_{3x}i + F_{3y}j + F_{3z}j$

F_R:

$\vec{r} = (0-(-7))i + (0-6)j + (0-5)k$

$r = 7i - 6j - 5k$

$|r| = \sqrt{7^2 + (-6)^2 + (-5)^2} = 10.49$

$\Rightarrow \vec{u} = \frac{7}{10.49}i - \frac{6}{10.49}j - \frac{5}{10.49}k$

$\vec{u} = 0.67i - 0.57j - 0.48k$

$\Rightarrow \vec{F_R} = 400\vec{u} = 266.97i - 228.83j - 190.69k$

$\because \sum F = \vec{F_R} = \vec{F_1} + \vec{F_2} + \vec{F_3}$

$266.97i - 228.83j - 190.69k = (25.725 + 100 + F_{3x})i$

$+ (42.875 + 169.688 + F_{3y})j$

$+ (-86.603 + 34.73 + F_{3z})k$

$\Rightarrow F_{3x} = 141.245 \text{ kN}$

$F_{3y} = -102.02 \text{ kN}$

$F_{3z} = -138.82 \text{ kN}$

Magnitude of F_3

$\Rightarrow |F_3| = \sqrt{141.245^2 + (-102.02)^2 + (-138.82)^2} = 222.77 \text{ kN}$

Directional angles of F_3

$\Rightarrow \alpha = \cos^{-1}\left(\frac{141.245}{222.77}\right) = 50.65^\circ$

$\beta = \cos^{-1}\left(\frac{-102.02}{222.77}\right) = 117.25^\circ$

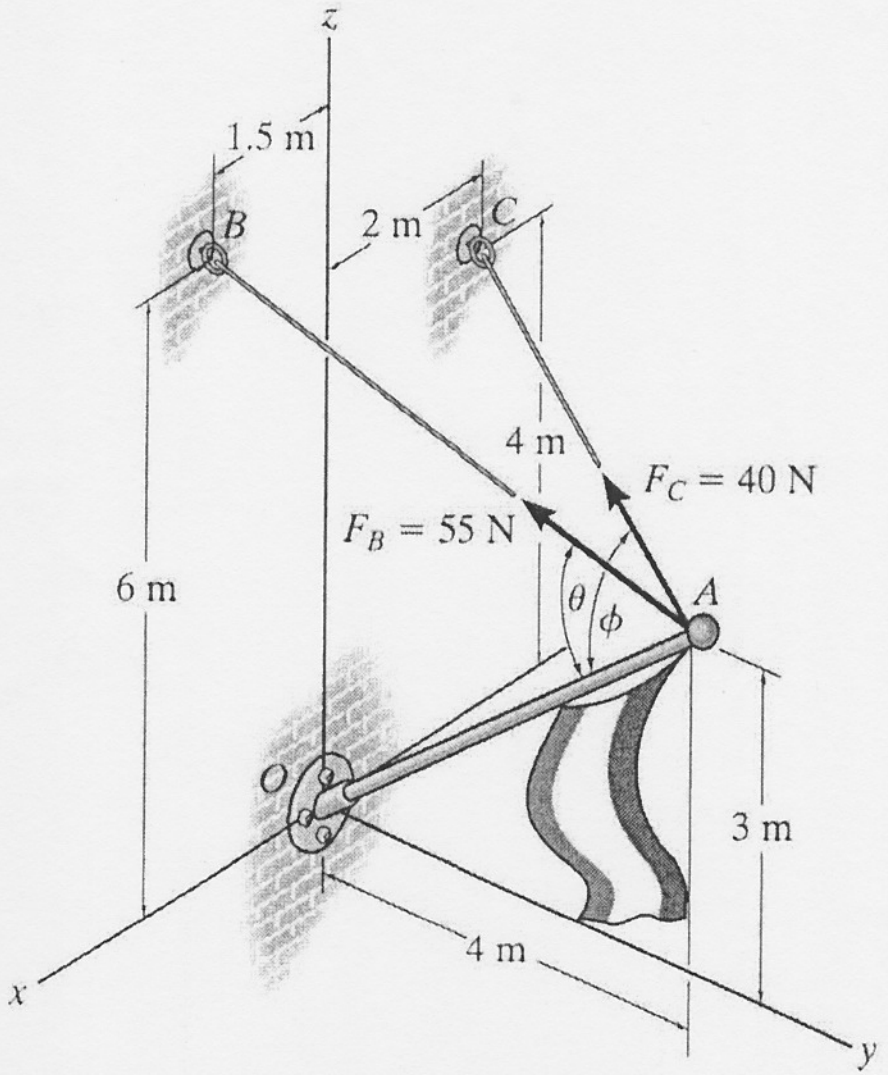
$\gamma = \cos^{-1}\left(\frac{-138.82}{222.77}\right) = 128.55^\circ$

Problem 2 (25 Points)

For the figure shown below:

Use the **DOT PRODUCT** to determine the angles θ between the axes OA of the flag pole and cable AB.

Use the **DOT PRODUCT** to determine the projection of force $\mathbf{F_B}$ along cable **AC**



Answer:

3 Coordinates of points A, B and C are:

O = (0, 0, 0) m

A = (0, 4, 3) m

B = (1.5, 0, 6) m

C = (–2, 0, 4) m

4 The force exerted by cables AB:

$\mathbf{F_B} = F_B\,\mathbf{u_{AB}}$

$$\mathbf{u}_{AB} = \frac{\mathbf{r}_{AB}}{r_{AB}}$$

$\mathbf{r_{AB}} = (1.5 - 0)\,i + (0 - 4)\,j + (6 - 3)\,k = [1.5\,i - 4\,j + 3\,k]$ m

$r_{AB} = \sqrt{1.5^2 + 4^2 + 3^2} = 5.22$ m

$$\mathbf{u}_{AB} = \frac{1.5}{5.22}i - \frac{4}{5.22}j + \frac{3}{5.22}k$$

$$\mathbf{F}_B = 55\left(\frac{1.5}{5.22}i - \frac{4}{5.22}j + \frac{3}{5.22}k\right) = [15.80i - 42.15j + 31.61k]\,\text{N}$$

4 The force exerted by cables AC:

$\mathbf{F_C} = F_C\,\mathbf{u_{AC}}$

$$\mathbf{u}_{AC} = \frac{\mathbf{r}_{AC}}{r_{AC}}$$

$\mathbf{r_{AC}} = (-2 - 0)\,i + (0 - 4)\,j + (4 - 3)\,k = [-2\,i - 4\,j + 1\,k]$ m

$r_{AC} = \sqrt{2^2 + 4^2 + 1^2} = 4.58$ m

$$\mathbf{u}_{AC} = -\frac{2}{4.58}i - \frac{4}{4.58}j + \frac{1}{4.58}k$$

$$\mathbf{F}_{AC} = 40\left(-\frac{2}{4.58}i - \frac{4}{4.58}j + \frac{1}{4.58}k\right) = [-17.47i - 34.93j + 8.73k]\,\text{N}$$

4 The position vector of the flag pole:

$\mathbf{r_{AO}} = (0-0)\,i + (0-4)\,j + (0-3)\,k = [0\,i - 4\,j - 3\,k]$ m

$r_{AO} = \sqrt{0^2 + 4^2 + 3^2} = 5$ m

1. The angle θ between the forces exerted by cables AB and AC using **DOT PRODUCT**.

3 $\mathbf{F_B} \bullet \mathbf{r_{AO}} = F_B\ r_{AO}\ \cos\theta$

$(15.80i - 42.15j + 31.61k) \bullet (0i - 4j - 3k) = (55)(5)\cos\theta$

$[(15.80)(0)] + [(-42.15)(-4)] + [(31.61)(-3)] = (55)(5)\cos\theta$

2 $\theta = \cos^{-1}\left(\frac{73.77}{275}\right) = 74.44^{\circ}$

2. The magnitude of the projection of $\mathbf{F_B}$ along the cable AC using the **DOT PRODUCT**.

3 Projection of $\mathbf{F_B}$ along the cable AC = $\mathbf{F_B} \bullet \mathbf{u_{AC}}$

$$= 55\left(\frac{1.5}{5.22}i - \frac{4}{5.22}j + \frac{3}{5.22}k\right) \bullet \left(-\frac{2}{4.58}i - \frac{4}{4.58}j + \frac{1}{4.58}k\right)$$

$$= [(15.80)(-0.44)] + [(-42.15)(-0.87)] + [(31.61)(0.22)]$$

2 $= 36.67$ N

Problem 3 (25 Points)

In the figure shown below, If tensions in Cables BC and BE are:

$T_{BC} = 0.35$ kN

$T_{BE} = 0.22$ kN

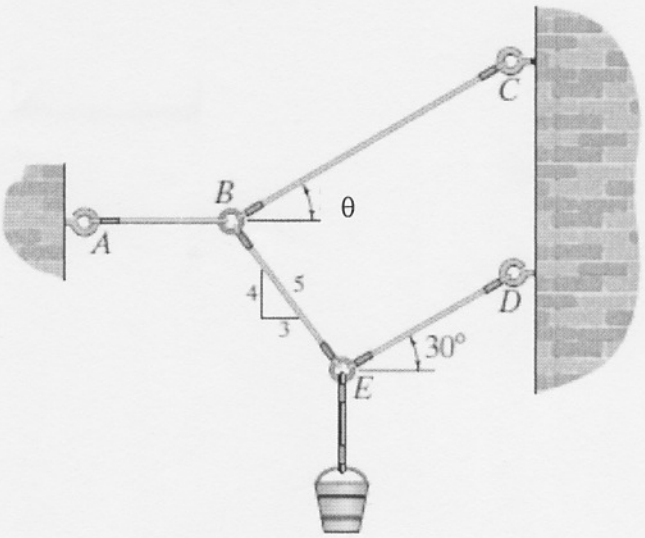
Find:

A. T_{AB}

B. T_{ED}

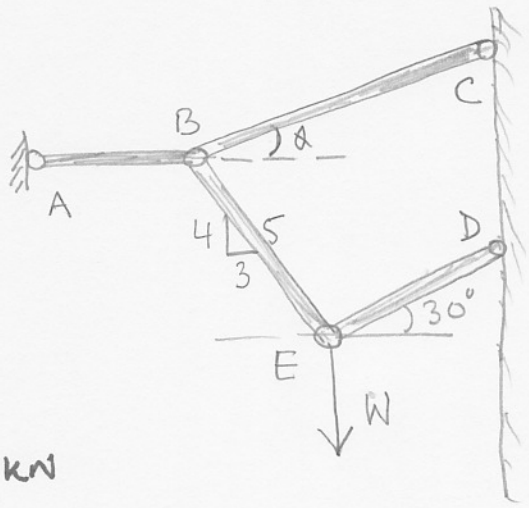
C. Weight of the bucket

D. Angle θ



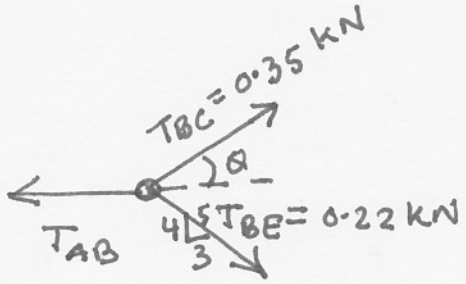
Q.3

The tensions in cables BC and BE are 0.35 kN and 0.22 kN respectively.



Solution:

Joint B

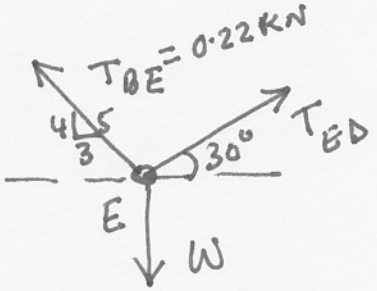


$$\Sigma f_x = 0 = -T_{AB} + 0.35\cos\alpha + \frac{3}{5} * 0.22$$

$$\Sigma f_y = 0 = 0.35\sin\alpha - \frac{4}{5} * 0.22 \Rightarrow \boxed{\alpha = 30.2^\circ}$$

$$\therefore \boxed{T_{AB} = 0.434 \text{ kN}}$$

Joint E:



$$\Sigma f_x = 0 \Rightarrow \frac{3}{5} * 0.22 + T_{ED}\cos 30^\circ \Rightarrow \boxed{T_{ED} = 0.152 \text{ kN}}$$

$$\Sigma f_y = 0 = T_{ED}\sin 30^\circ - W + T_{BE} * \frac{4}{5}$$

$$\Rightarrow W = 0.252 \text{ kN}$$

$$\therefore m = 252/9.81$$

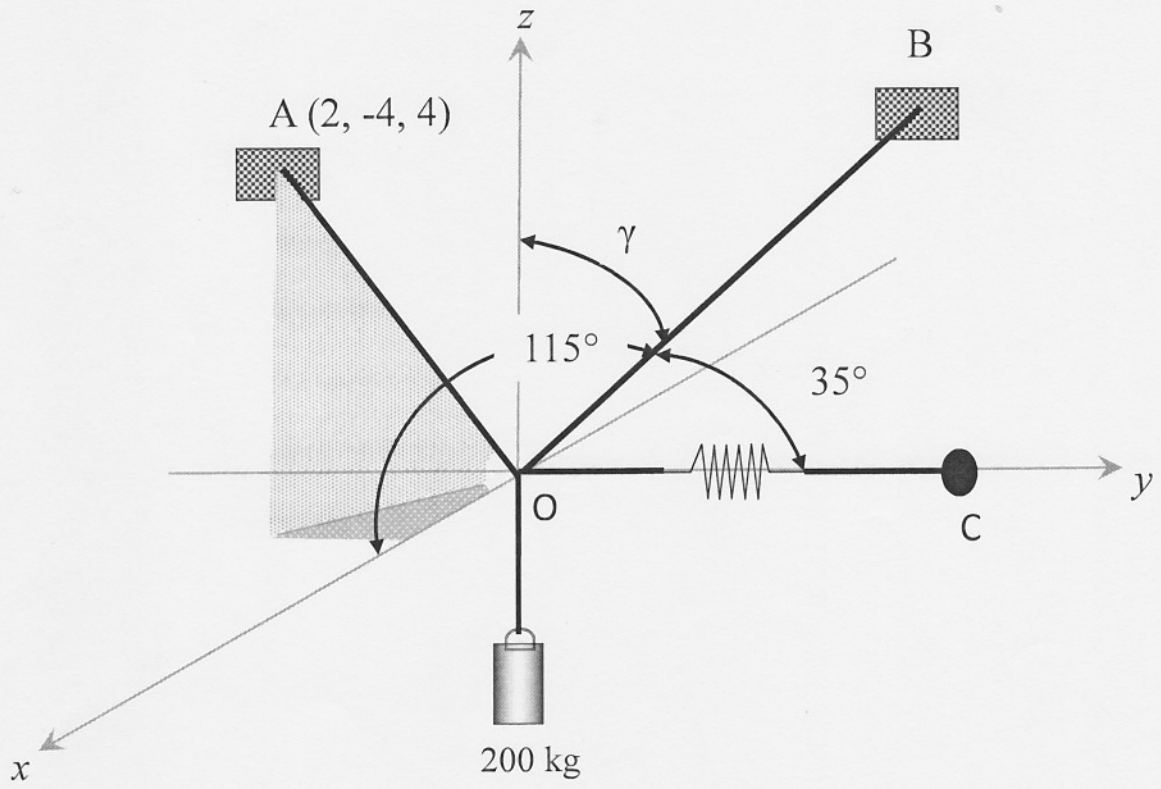
$$\therefore \boxed{m = 26 \text{ kg}}$$

Problem 4 (25 Points)

The system shown below is supporting a mass of 200 kg. The spring OC has stiffness k value of 0.7 kN/m. Determine:

A. Tensions in cables OA and OB.

B. Stretch of spring OC.



Q 4

→ $W = mg = 1962\ N$

$\bar{W} = \{-1962\,k\}\ N$

→ $\bar{F}_{OC} = \{F_{OC}\,j\}\ N = \{700\,s\,j\}\ N$

→ $\bar{F}_{OB} = F_{OB}\cos\alpha\,i + F_{OB}\cos\beta\,j + F_{OB}\cos\gamma\,k$

$\cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1$

$\gamma = \pm 0.387$

$= 67.2°$ or $112.76°$

By inspection $\gamma = 67.2°$

$\therefore \bar{F}_{OB} = -0.423\,F_{OB}\,i + 0.819\,F_{OB}\,j + 0.388\,F_{OB}\,k$

→ $\bar{F}_{OA} = F_{OA}\,\bar{U}_{OA} = F_{OA}\,\dfrac{\bar{r}_{OA}}{r_{OA}}$

$\bar{r}_{OA} = 2i - 4j + 4k$

$r_{OA} = \sqrt{2^2 + (-4)^2 + (4)^2} = 6\ m$

$\therefore \bar{F}_{OA} = 0.333\,F_{OA}\,i - 0.667\,F_{OA}\,j + 0.667\,F_{OA}\,k$

→ $\Sigma F_x = -0.423\,F_{OB} + 0.333\,F_{OA} = 0$

$\Sigma F_y = F_{OC} + 0.819\,F_{OB} - 0.667\,F_{OA} = 0$

$\Sigma F_z = 0.388\,F_{OB} + 0.667\,F_{OA} - 1962 = 0$

Solving gives $F_{OC} = 44.902\ N$

$F_{OB} = 1588.3\ N$

$F_{OA} = 2017.6\ N$

→ $s = \dfrac{F_{OC}}{700} = 0.064\ m$