



*Faculty of Engineering
and Computer Science*

ENGR 242/2 T STATICS

Fall 2015

Test 1 (October 7th, 2015)

Instructions:

1. Time allowed: **60 minutes**.
2. Answer all **four** questions.
3. Any missing data should be reasonably assumed with sufficient explanation.
4. Only non-programmable calculators are permitted.
5. Test includes **six** pages.
6. Write on both sides of the test, if needed.

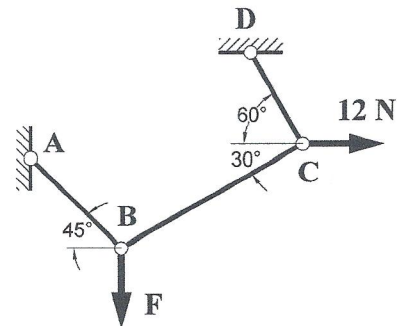
Name: *Solution of the Test*

Student ID:

Signature:

Question 1 (20 marks)

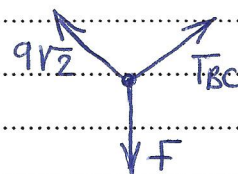
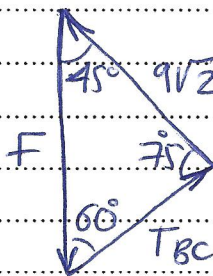
Determine the force F so that the tension in cable AB equals $9\sqrt{2}$ N.



point B is in equilibrium

$$R = \sum F = 0.0$$

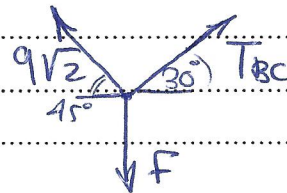
$$\frac{F}{\sin 75} = \frac{9\sqrt{2}}{\sin 60}$$



$$F = 14.2 \text{ N}$$

or

point B is in equilibrium



$$\sum F_x = 0.0 \quad T_{CB} \cos 30 = 9\sqrt{2} \cos 45$$

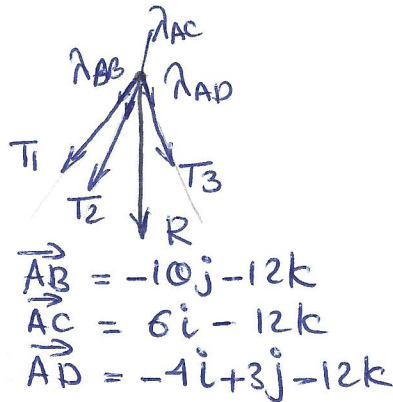
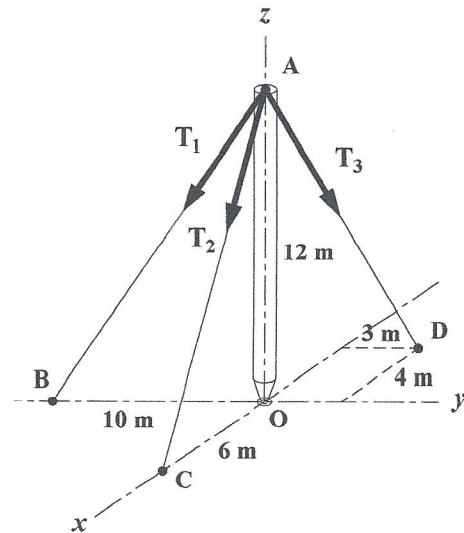
$$T_{CB} = 10.4 \text{ N}$$

$$\sum F_y = 0.0 \quad 9\sqrt{2} \sin 45 + 10.4 \sin 30 = F$$

$$F = 14.2 \text{ N}$$

Question 2 (30 Marks)

Three cable tensions T_1 , T_2 , and T_3 act at the top of the flagpole. Given that the resultant force for the three tensions is $\mathbf{R} = -400\mathbf{k}$ N, find the magnitudes of the cable tensions.



$$A(0, 0, 12)$$

$$B(10, 0, 0)$$

$$C(6, 0, 0)$$

$$D(-4, 3, 0)$$

$$\vec{AB} = -10\mathbf{j} - 12\mathbf{k}$$

$$\vec{AC} = 6\mathbf{i} - 12\mathbf{k}$$

$$\vec{AD} = -4\mathbf{i} + 3\mathbf{j} - 12\mathbf{k}$$

$$\lambda_{AB} = \frac{\vec{AB}}{AB} = \frac{-10\mathbf{j} - 12\mathbf{k}}{\sqrt{100+144}} = -0.64\mathbf{j} - 0.77\mathbf{k}$$

$$\lambda_{AC} = \frac{\vec{AC}}{AC} = \frac{6\mathbf{i} - 12\mathbf{k}}{\sqrt{36+144}} = 0.45\mathbf{i} - 0.9\mathbf{k}$$

$$\lambda_{AD} = \frac{\vec{AD}}{AD} = \frac{-4\mathbf{i} + 3\mathbf{j} - 12\mathbf{k}}{\sqrt{16+9+144}} = -0.31\mathbf{i} + 0.23\mathbf{j} - 0.92\mathbf{k}$$

$$\vec{T}_1 = T_1 \lambda_{AB} = (-0.64\mathbf{j} - 0.77\mathbf{k}) T_1 \text{ N}$$

$$\vec{T}_2 = T_2 \lambda_{AC} = (0.45\mathbf{i} - 0.9\mathbf{k}) T_2 \text{ N}$$

$$\vec{T}_3 = T_3 \lambda_{AD} = (-0.31\mathbf{i} + 0.23\mathbf{j} - 0.92\mathbf{k}) T_3 \text{ N}$$

$$\vec{R} = \vec{T}_1 + \vec{T}_2 + \vec{T}_3$$

$$(0.45 T_2 - 0.31 T_3)\mathbf{i} + (-0.64 T_1 + 0.23 T_3)\mathbf{j} + (0.77 T_1 - 0.9 T_2 - 0.92 T_3)\mathbf{k} = -400\mathbf{k}$$

$$R_x = 0 \quad R_y = 0 \quad R_z = -400$$

$$0.45 T_2 - 0.31 T_3 = 0 \quad \rightarrow \quad T_2 = 0.69 T_3 \quad \rightarrow \textcircled{1}$$

$$-0.64 T_1 + 0.23 T_3 = 0 \quad \rightarrow \quad T_1 = 0.36 T_3 \quad \rightarrow \textcircled{2}$$

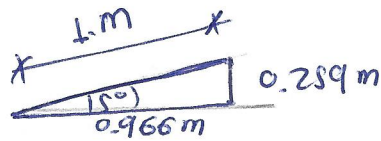
$$-0.77 T_1 - 0.9 T_2 - 0.92 T_3 = -400 \quad \rightarrow \textcircled{3}$$

From $\textcircled{1}$ & $\textcircled{2}$ in $\textcircled{3}$ get T_3, T_2, T_1 $1.8182 T_3 = 400$

$$T_3 = 220 \text{ N} \quad T_2 = 151.8 \text{ N} \quad T_1 = 79.2 \text{ N}$$

Question 3 (30 Marks)

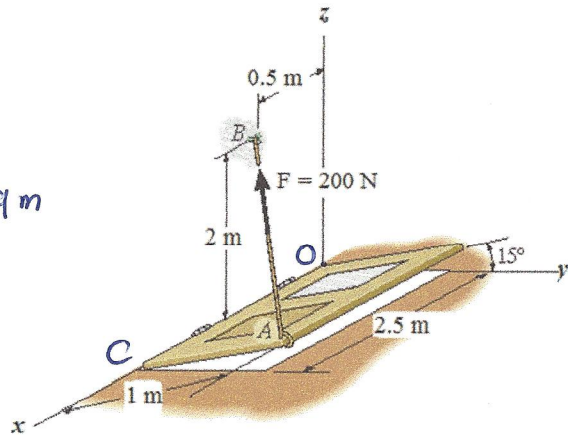
Determine the magnitude of the moment produced by the force $F = 200 \text{ N}$ about the hinged axis (the x axis) of the door.



$$A(2.5, 0.966, 0.289)$$

$$B(0.5, 0, 2.0)$$

$$C(2.5, 0, 0)$$



$$\vec{r}_{OB} = (0.5\mathbf{i} + 2\mathbf{k}) \text{ m}$$

$$\vec{AB} = -2\mathbf{i} - 0.966\mathbf{j} + 1.711\mathbf{k}$$

$$\hat{A}_{AB} = \frac{\vec{AB}}{AB} = \frac{1}{\sqrt{7.964}} (-2\mathbf{i} - 0.966\mathbf{j} + 1.711\mathbf{k})$$

$$= -0.708\mathbf{i} - 0.342\mathbf{j} + 0.617\mathbf{k}$$

$$\vec{F}_{AB} = F_{AB} \hat{A}_{AB} = 200(-0.708\mathbf{i} - 0.342\mathbf{j} + 0.617\mathbf{k})$$

$$= (-141.6\mathbf{i} - 68.4\mathbf{j} + 123.4\mathbf{k}) \text{ N}$$

Knowing that the unit vector of x axis is \mathbf{i} , the magnitude of the moment about x axis is

$$M_x = \mathbf{i} \cdot \vec{r}_{OB} \times \vec{F}_{AB}$$

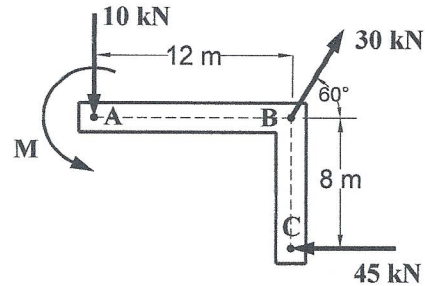
$$M_x = \begin{vmatrix} 1 & 0 & 0 \\ 0.5 & 0 & 2 \\ -141.6 & -68.4 & 123.4 \end{vmatrix} = 136.8 \text{ N}\cdot\text{m}$$

Note: \vec{r}_{CA} yields the same result.

Question 4 (20 Marks)

A couple of magnitude $M = 54 \text{ kN} \cdot \text{m}$ and three forces are applied as shown.

- (a) Find the resultant of this system of forces;
 (b) Locate the points where the line of action of the resultant intersects line AB and line BC.



(a)

$$R_x = 30 \cos 60^\circ - 45 = -30 \text{ kN}$$

$$R_y = 30 \sin 60^\circ - 10 = 15.98 \text{ kN}$$

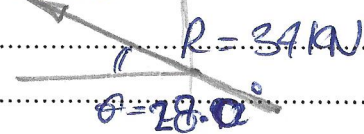
$$\vec{R} = R_x \mathbf{i} + R_y \mathbf{j}$$

$$= -30 \mathbf{i} + 15.98 \mathbf{j} \text{ N}$$

$$R = \sqrt{R_x^2 + R_y^2}$$

$$= 34 \text{ kN}$$

$$\tan \theta = \frac{R_y}{R_x} \Rightarrow \theta = 28.0^\circ$$



(b)

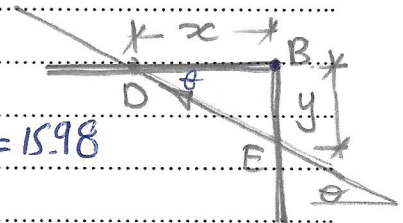
Equivalent force-couple at B

$$\sum M_B = 54 + 10 \times 12 - 45 \times 8 = -186 \text{ kN} \cdot \text{m} \quad (186 \text{ kN} \cdot \text{m})$$

R at point D

$$\sum M_B = 186 \text{ kN} \cdot \text{m} = R_y \cdot x \quad ; R_y = 15.98$$

$$x = 11.64 \text{ m}$$



R at point E

$$\sum M_B = 186 \text{ kN} \cdot \text{m} = R_x \cdot y \quad ; R_x = 30$$

$$y = 6.2 \text{ m}$$

For verification

$$\tan \theta = \frac{y}{x} = \frac{6.2 \text{ m}}{11.64 \text{ m}} \rightarrow \theta = 28^\circ \quad \underline{ok}$$