*Ministry of Higher Education*

**Delta Higher Institute for Eng. & Tech**

**Engineering Mechanics** First term 2011/2012

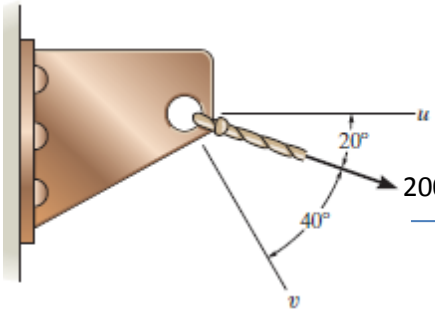
**Total mark**: 60 points **Time**: Three hours

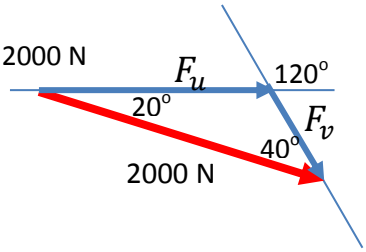
**Final Exam**

**Answer the following questions.**

**Question 1:** ( *6 points*)

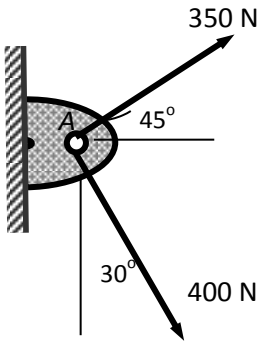
Resolve the 2000 N force shown Figure into components acting along the u and v axes and determine the magnitudes of these components.




$$\frac{F_u}{\sin 40} = \frac{2000}{sin120} \rightarrow F_u = 1484.5\ N$$

$$\frac{F_v}{\sin 20} = \frac{2000}{sin120} \rightarrow F_v = 790\ N$$




**Question 2**: (*6 points*):

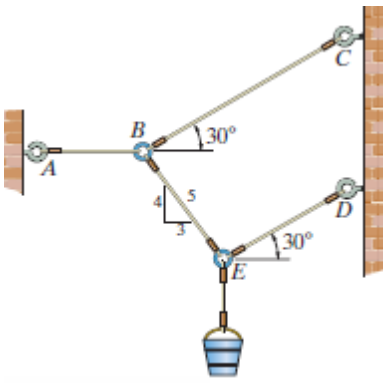
Determine the magnitude and direction of the two forces shown in Figure.

$$\rightarrow \sum F_x = 350\cos 45 + 400\sin 30 = 447.5\ N$$

$$\uparrow \sum F_y = 350\sin 45 - 400\cos 30 = -90\ N$$

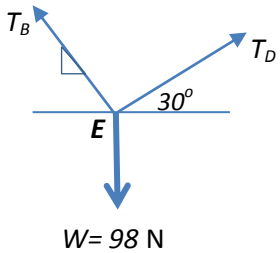
$$R = \sqrt{(\sum F_x)^2 + (\sum F_y)^2} = 456.5\ \text{N}$$

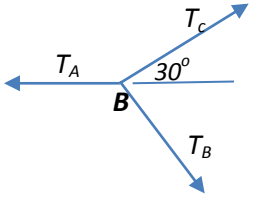
$$\theta = tan^{-1}\left(\frac{\sum F_y}{\sum F_x}\right) = tan^{-1}\left(\frac{-90}{447.5}\right) = -11.4^0$$




**Question 3**: (*10 points*)

The 10-kg bucket is supported at $E$ by a system of five cords as shown. Determine the force in each cord for equilibrium.




Equilibrium of point E:

$$\sum F_x = 0;\ T_D\cos 30 = \frac{3}{5}T_B \rightarrow T_D = 0.693T_B$$

$$\sum F_y = 0;\ T_D\sin 30 + \frac{4}{5}T_B = 98 \rightarrow 1.147\,T_B = 98$$

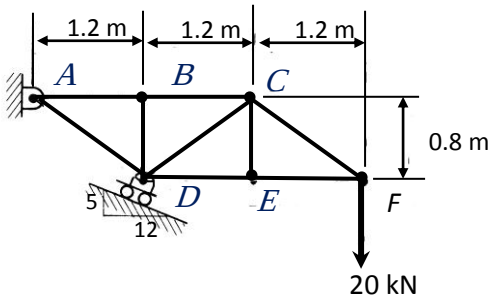
$$\therefore\ T_B = 85.5\ \text{N} \quad \text{and} \quad \therefore\ T_D = 59.2\ \text{N} \quad \textbf{\textit{Ans}}$$

Equilibrium of point B:

$$\sum F_x = 0;\ T_C\cos 30 + \frac{3}{5}T_B = T_A$$

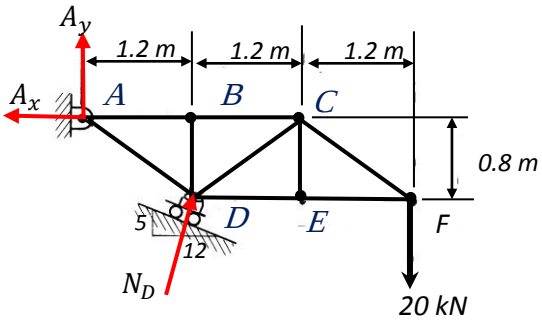
$$\sum F_y = 0;\ T_C\sin 30 = \frac{4}{5}T_B \rightarrow T_C = 136.8\ N\ \textbf{\textit{Ans}}$$

$$\therefore \quad T_A = 169.8\ \text{N} \quad \textbf{\textit{Ans.}}$$




**Question 4**: (*8 points*)

The frame shown in figure is supported by a pin at $A$ and roller at $D$. The frame is subjected to 20 kN load at $F$. Determine the reactions at $A$ and $B$.




$$\sum M_A = 0; \quad N_D cos\theta(1.2) + N_D sin\theta(0.8) = 20(3.6)$$

$$(1.108 + 0.308)N_D = 72 \quad \rightarrow N_D = 50.8\ kN$$

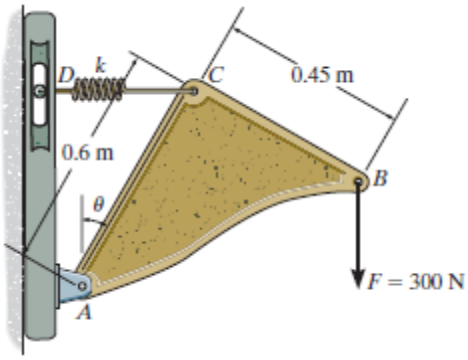
$$\sum F_x = 0; \quad A_x = N_D sin\theta = 50.8(\tfrac{5}{13}) = 19.53\ kN$$

$$\sum F_y = 0; \quad A_y + N_D cos\theta = 20$$

$$A_y = 20 - 50.8\left(\tfrac{12}{13}\right) = -26.89\ kN$$

**Question 5**: (*8 points*)

Spring *CD* remains in the horizontal position at all times due to the roller at *D*. If $\theta = 30^{\circ}$, Determine the force developed in the spring at C and the vertical and horizontal components of the reaction at hinge *A*.

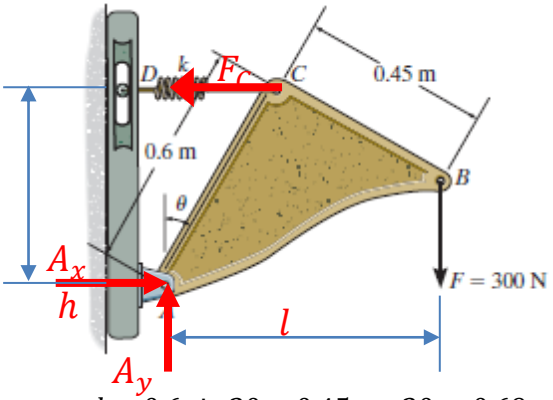



$$\sum M_A = 0; \quad F_C \times h = F \times l$$

$$\therefore F_C = 300(0.69)/0.52 \quad \rightarrow F_C = 398.4N$$

$$\sum F_x = 0; \quad A_x = F_C = 398.4\ N$$

$$\sum F_y = 0; \quad A_y = F = 300\ N$$

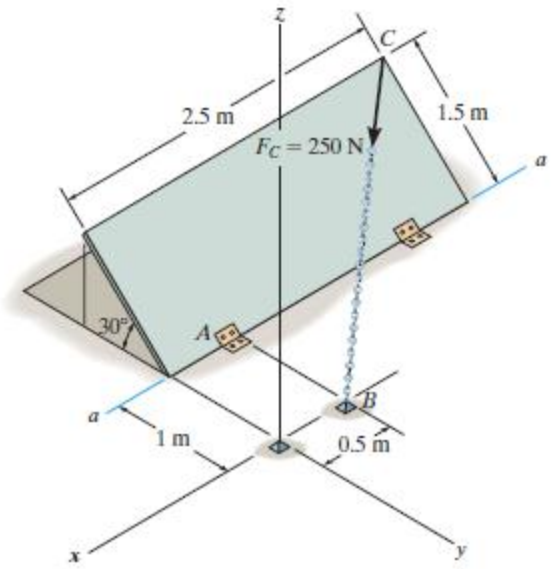



$l = 0.6 \sin 30 + 0.45 \cos 30 = 0.69$

$h = 0.6 \cos 30 = 0.52$

**Question 6**: (*7 points*)

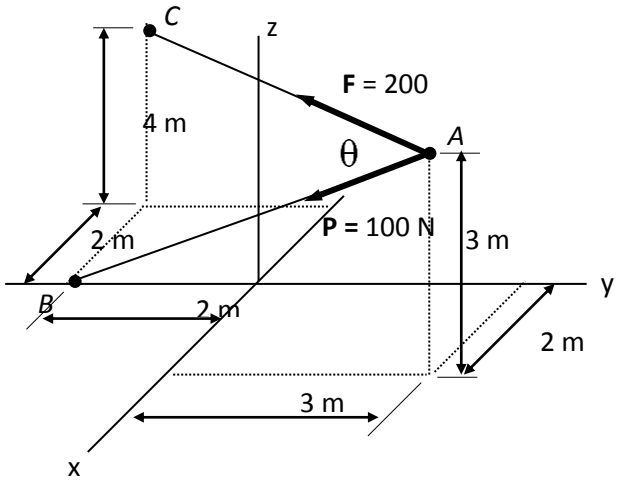
The force $F_c$ shown in Figure is expressed in Cartesian form as: $F_c = (160\,i + 183\,j - 60\,k)N$. Determine the moment of this force about point *A.*




$$M_A = r_{AB} \times F = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 0 & 1 & 0 \\ 160 & 183 & -60 \end{vmatrix} = -60\,\mathbf{i} - 160\,\mathbf{k}$$

**Question 7**: (*7 points*)

Determine the angle $\theta$ between the tails of the two forces shown.




*C:* (-2, -2, 4) ; B: (0, -2, 0); *A:* (2, 3, 3)

$$\mathbf{r}_{AB} = -2\,\mathbf{i} - 5\mathbf{j} - 3\mathbf{k}$$

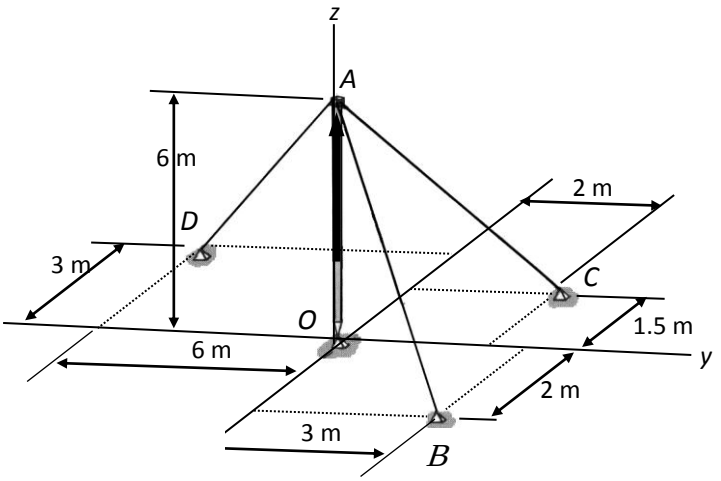
$$\mathbf{r}_{AC} = -4\,\mathbf{i} - 5\mathbf{j} - \mathbf{k}$$

$$\cos\theta = \frac{\mathbf{r}_{AB}.\mathbf{r}_{Ac}}{(r_{AB})(r_{AB})} = \frac{8+25+3}{(6.164)(6.481)} = 0.901$$

$$\theta = cos^{-1}(0.901) = 25.69^o$$

**Question 8**: (*8 points*)

The mast *OA* is supported by three cables. If cable *AB* is subjected to a tension of 500 N, and cable *AC* is subjected to a tension of 300 N and cable *AD* is subjected to a tension of 200 N determine the resultant of the three forces.




*C:* (-1.5, 2, 0); *B*: (2, 3, 0); *D*:(-3, -6, 0); *A*:(0, 0, 6)

$\mathbf{r}_{AB} = 2\,\mathbf{i} + 3\mathbf{j} - 6\mathbf{k}$; $r_{AB} = \mathbf{7}$

$\mathbf{r}_{AC} = -1.5\,\mathbf{i} + 2\mathbf{j} - 6\mathbf{k}$; $r_{AC} = \mathbf{6.5}$

$\mathbf{r}_{AD} = -3\,\mathbf{i} - 6\mathbf{j} - 6\mathbf{k}$; $r_{AD} = \mathbf{9}$

$\mathbf{F}_{AB} = \frac{500}{7}(2\,\mathbf{i} + 3\mathbf{j} - 6\mathbf{k}) = 142.86\,\mathbf{i} + 214.29\mathbf{j} - 428.57\mathbf{k}$

$\mathbf{F}_{AC} = \frac{300}{6.5}(-1.5\,\mathbf{i} + 2\mathbf{j} - 6\mathbf{k}) = -69.23\,\mathbf{i} + 92.31\mathbf{j} - 276.92\mathbf{k}$

$\mathbf{F}_{AD} = \frac{200}{9}(-3\,\mathbf{i} - 6\mathbf{j} - 6\mathbf{k}) = -66.67\,\mathbf{i} - 133.33\mathbf{j} - 133.33\mathbf{k}$

$\therefore\ \mathbf{R} = 6.96\,\mathbf{i} + 173.27\mathbf{j} - 838.82\mathbf{k}$

انتهت الأسئلة.. والأجوبة مع التمنيات بالتوفيق.

أ.د. بشري عبد المؤمن