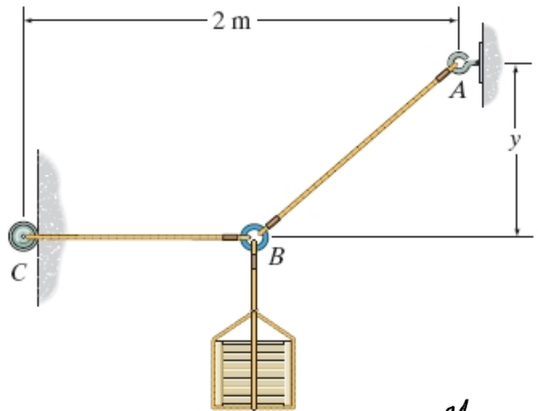
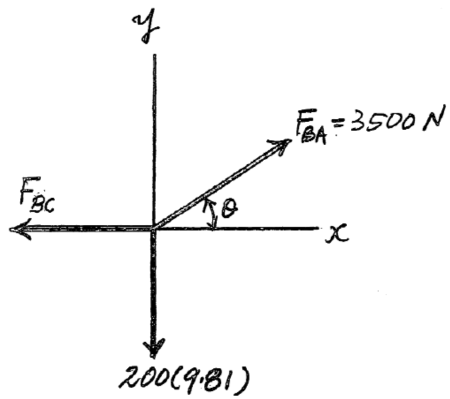
3–2. If the 1.5-m-long cord AB can withstand a maximum force of 3500 N, determine the force in cord BC and the distance y so that the 200-kg crate can be supported.

(Find solution for y minimum)





$+\uparrow \Sigma F_y = 0;$

$\xrightarrow{+} \Sigma F_x = 0;$

$3500 \sin\theta - 200(9.81) = 0 \qquad \theta = 34.10°$

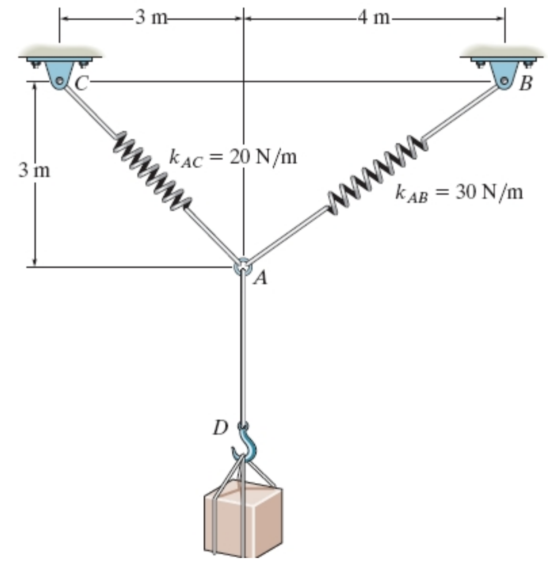
$3500 \cos 34.10° - F_{BC} = 0 \qquad F_{BC} = 2898.37\text{ N} = 2.90\text{ kN}$

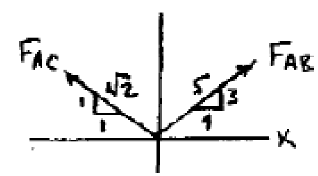
Ans.

$y = 1.5 \sin 34.10° = 0.841\text{ m} = 841\text{ mm}$ **Ans.**

Minimum y = 841 mm

3–15. The unstretched length of spring AB is 3 m. If the block is held in the equilibrium position shown, determine the mass of the block at D.





$F = kx = 30(5 - 3) = 60\text{ N}$

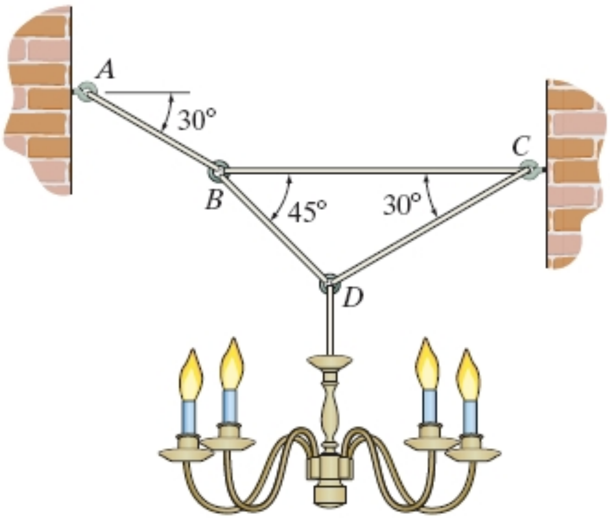
$\xrightarrow{+} \Sigma F_x = 0; \qquad T\cos 45° - 60\left(\frac{4}{5}\right) = 0$

$T = 67.88\text{ N}$

$+\uparrow \Sigma F_y = 0; \qquad -W + 67.88 \sin 45° + 60\left(\frac{3}{5}\right) = 0$

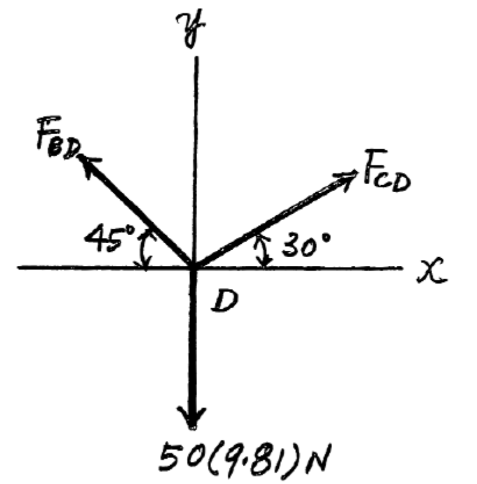
$W = 84\text{ N}$

$m = \frac{84}{9.81} = 8.56\text{ kg}$ **Ans.**



***3–20.** Determine the tension developed in each wire used to support the 50-kg chandelier.

Equations of Equilibrium: First, we will apply the equations of equilibrium along the x and y axes to the free-body diagram of joint D shown in Fig. (a).



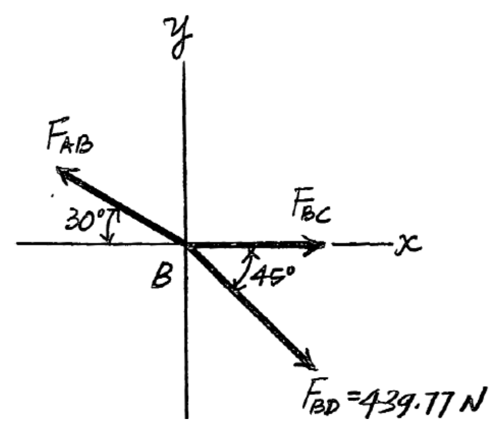
$$\overset{+}{\rightarrow}\Sigma F_x = 0; \qquad F_{CD}\cos 30° - F_{BD}\cos 45° = 0 \qquad (1)$$

$$+\uparrow \Sigma F_y = 0; \qquad F_{CD}\sin 30° + F_{BD}\sin 45° - 50(9.81) = 0 \qquad (2)$$

Solving Eqs. (1) and (2), yields

$$F_{CD} = 359\text{ N} \qquad F_{BD} = 439.77\text{ N} = 440\text{ N} \qquad \textbf{Ans.}$$

Using the result $F_{BD} = 439.77$ N and applying the equations of equilibrium along the x and y axes to the free-body diagram of joint B shown in Fig. (b),



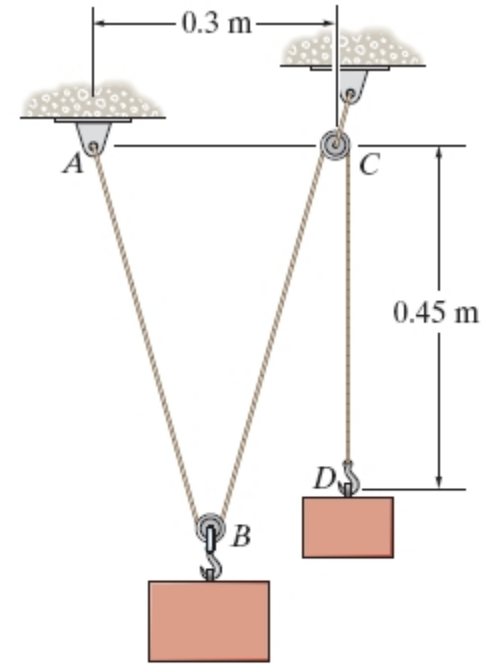
$$+\uparrow \Sigma F_y = 0; \qquad F_{AB}\sin 30° - 439.77\sin 45° = 0$$

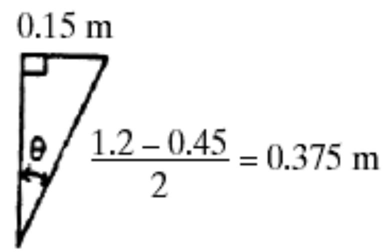
$$F_{AB} = 621.93\text{N} = 622\text{ N} \qquad \textbf{Ans.}$$

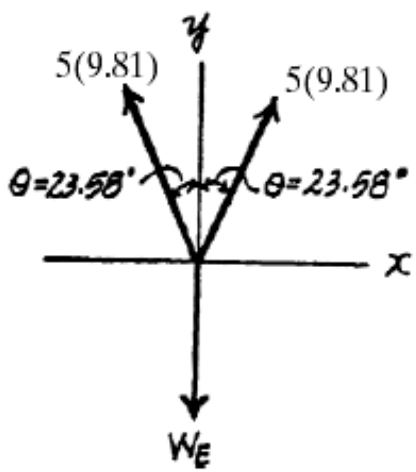
$$\overset{+}{\rightarrow}\Sigma F_x = 0; \qquad F_{BC} + 439.77\cos 45° - 621.93\cos 30° = 0$$

$$F_{BC} = 228\text{ N} \qquad \textbf{Ans.}$$

•**3–39.** A “scale” is constructed with a 1.2-m-long cord and the 5-kg block D. The cord is fixed to a pin at A and passes over two *small* pulleys at B and C. Determine the weight of the suspended block at B if the system is in equilibrium.







Free Body Diagram : The tension force in the cord is the same throughout the cord, that is 5(9.81). From the geometry.

$$\theta = \sin^{-1}\left(\frac{0.15}{0.375}\right) = 23.58^\circ.$$

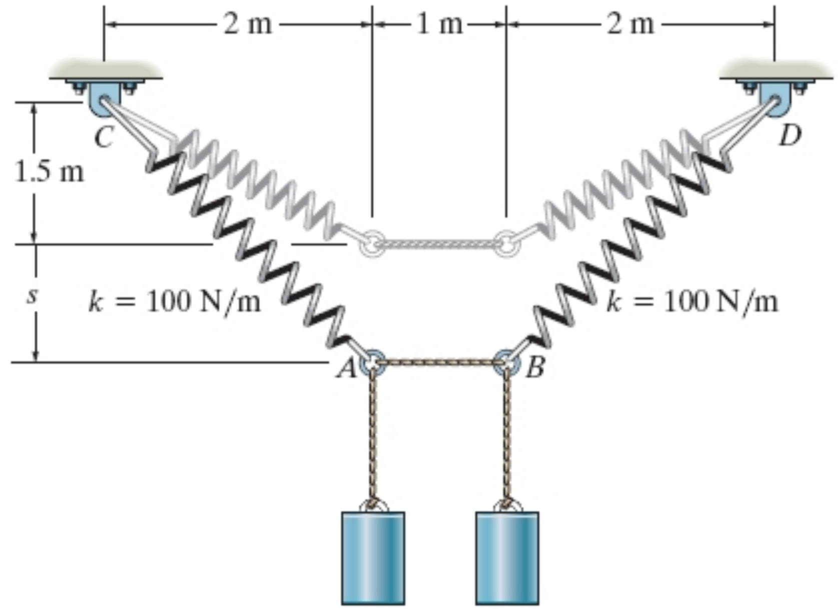
Equations of Equilibrium :

$$\overset{+}{\rightarrow}\Sigma F_x = 0; \quad 5(9.81)\sin 23.58^\circ - 5(9.81)\sin 23.58^\circ = 0 \quad (\textit{Satisfied!})$$

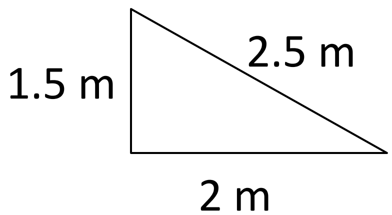
$$+\uparrow\Sigma F_y = 0; \quad 2(5)(9.81)\cos 23.58^\circ - W_g = 0$$

$$W_g = 89.9 \text{ N}$$ **Ans**

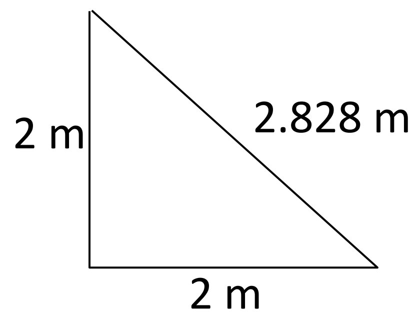
3–42. Determine the mass of each of the two cylinders if they cause a sag of $s = 0.5$ m when suspended from the rings at A and B. Note that $s = 0$ when the cylinders are removed.

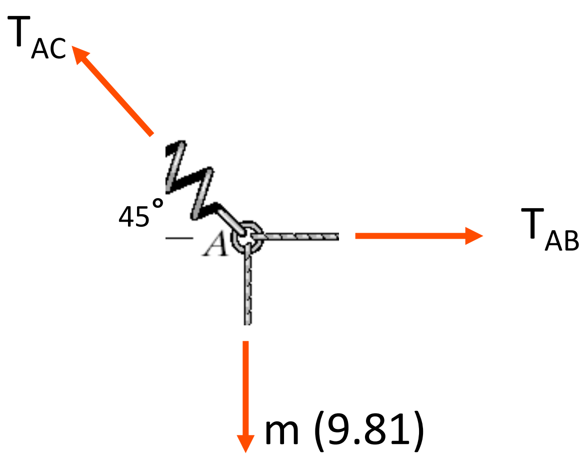


Undeformed



Deformed



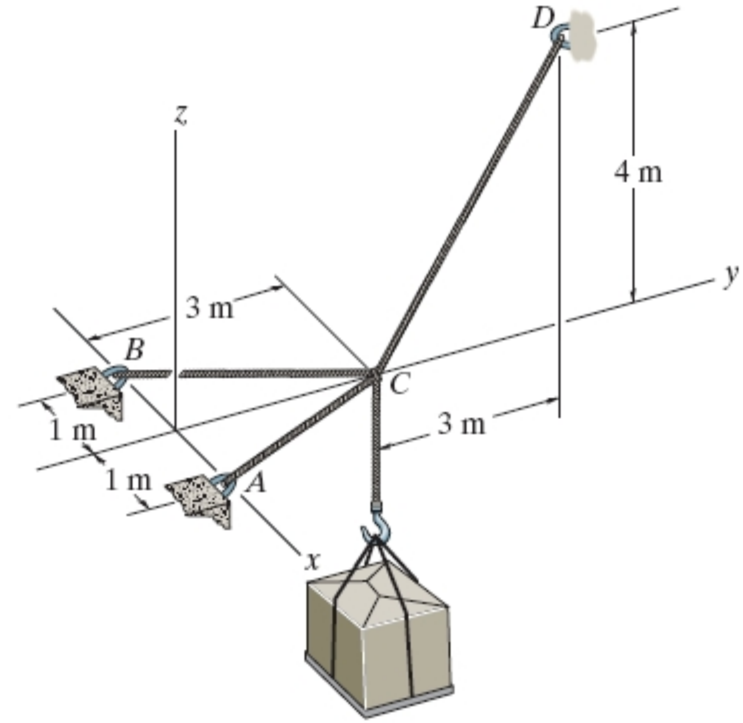


$T_{AC} = kx = 100 \text{ N/m } (2.828 - 2.5)\text{m} = 32.84 \text{ N}$

$\sum F_y = 0; \quad 32.84 \cos 45^\circ - m(9.81) = 0$

$m = 2.37 \text{ kg}$ <u>Ans</u>

3–78. Determine the force in each cable needed to support the 2.5-kN load.



Equations of Equilibrium :

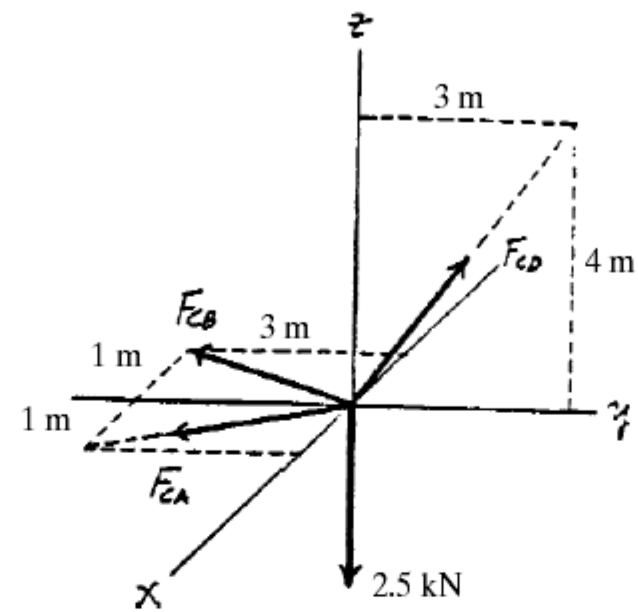
$$\Sigma F_z = 0; \quad F_{CD}\left(\frac{4}{5}\right) - 2.5 = 0 \qquad F_{CD} = 3.125 \text{ kN} \qquad \textbf{Ans}$$

Using the results $F_{CD} = 3.125$ kN and then summing forces along x and y axes we have

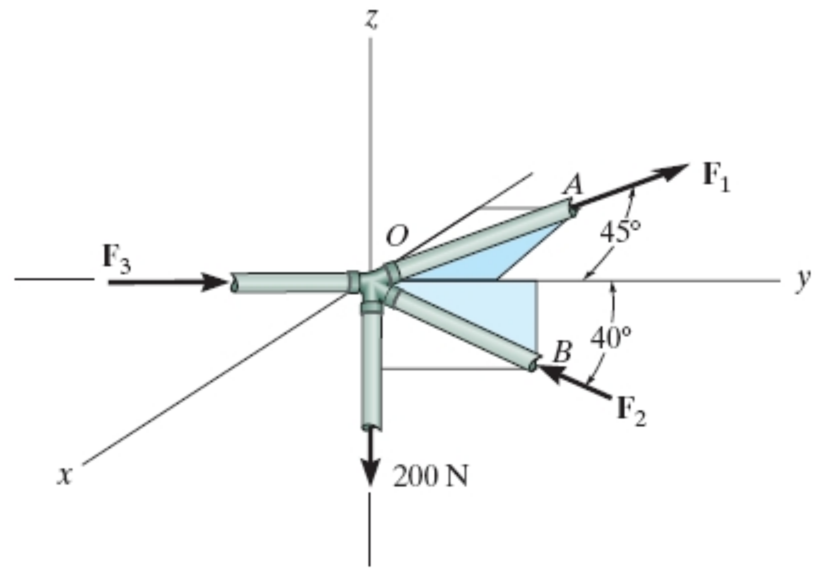
$$\Sigma F_x = 0; \quad F_{CA}\left(\frac{1}{\sqrt{10}}\right) - F_{CB}\left(\frac{1}{\sqrt{10}}\right) = 0 \qquad F_{CA} = F_{CB} = F$$

$$\Sigma F_y = 0; \quad 2F\left(\frac{3}{\sqrt{10}}\right) - 3.125\left(\frac{3}{5}\right) = 0$$

$$F_{CA} = F_{CB} = F = 0.988 \text{ kN} \qquad \textbf{Ans}$$



3–79. The joint of a space frame is subjected to four member forces. Member OA lies in the x–y plane and member OB lies in the y–z plane. Determine the forces acting in each of the members required for equilibrium of the joint.



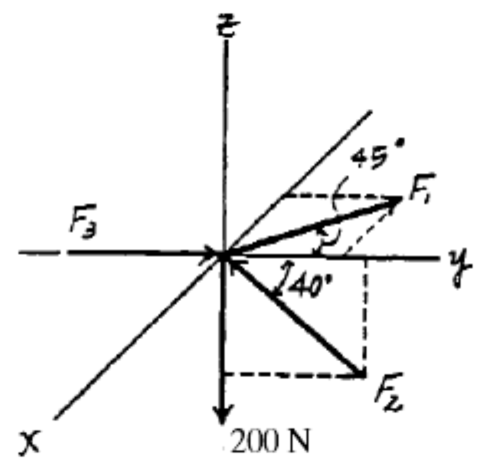
Equations of Equilibrium :

$\Sigma F_x = 0;\quad F_1 \sin 45° = 0 \qquad F_1 = 0\ \text{N}$ **Ans**

$\Sigma F_z = 0;\quad F_2 \sin 40° - 200 = 0 \qquad F_2 = 311.14\ \text{N} = 311\ \text{N}$ **Ans**

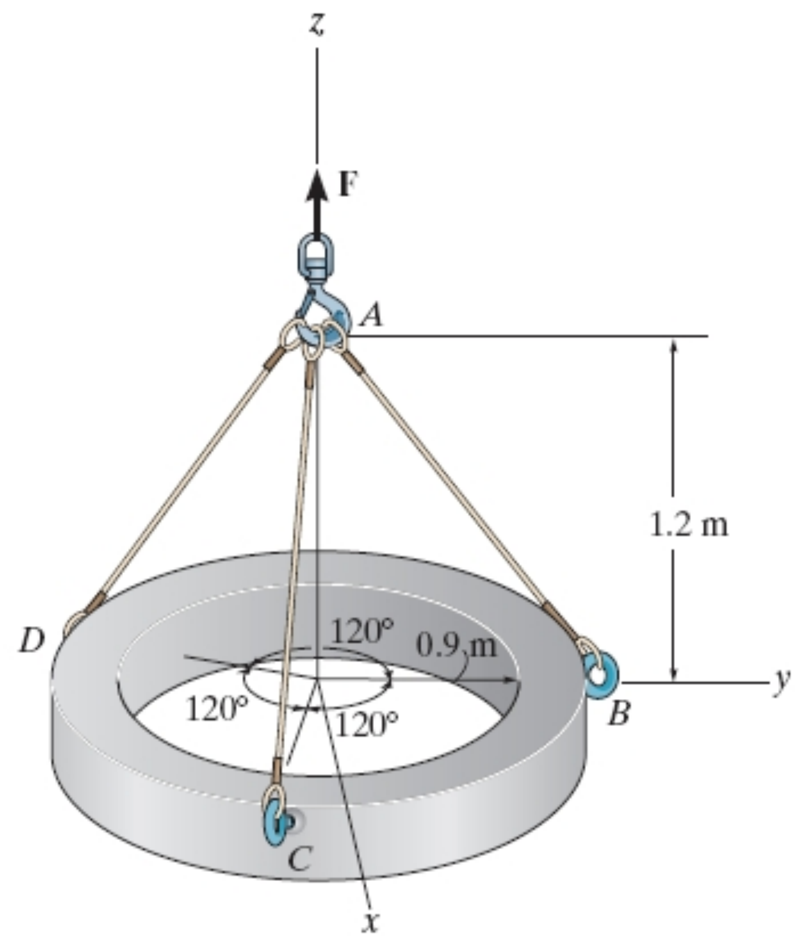
Using the results $F_1 = 0$ and $F_2 = 311.14$ N and then summing forces along the y axis, we have

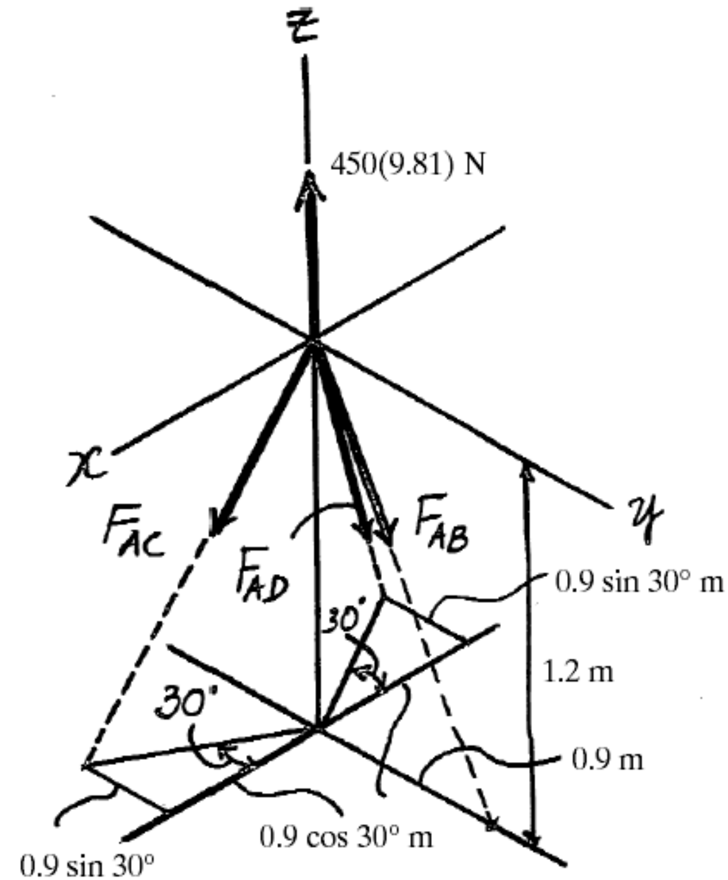
$\Sigma F_y = 0;\quad F_3 - 311.14 \cos 40° = 0 \qquad F_3 = 238\ \text{N}$ **Ans**

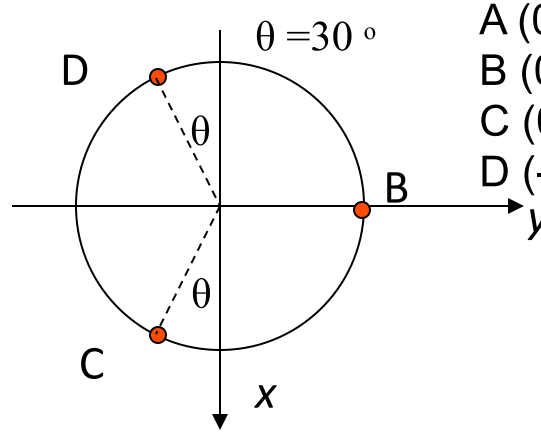


3–67. Three cables are used to support a 450-kg ring. Determine the tension in each cable for equilibrium.

(Radius to point B, C and D = 0.9 m)







A (0, 0, 1.2)
B (0, 0.9, 0)
C (0.9cos θ , - 0.9sin θ , 0)
D (-0.9cos θ , -0.9sin θ, 0)

Cartesian Vector Notation :

$$\mathbf{F}_{AB} = F_{AB}\left(\frac{0.9\mathbf{j} - 1.2\mathbf{k}}{\sqrt{0.9^2 + (-1.2)^2}}\right) = 0.6F_{AB}\mathbf{j} - 0.8F_{AB}\mathbf{k}$$

$$\mathbf{F}_{AC} = F_{AC}\left(\frac{0.9\cos 30°\mathbf{i} - 0.9\sin 30°\mathbf{j} - 1.2\mathbf{k}}{\sqrt{(0.9\cos 30°)^2 + (-0.9\sin 30°)^2 + (-1.2)^2}}\right)$$

$$= 0.5196F_{AC}\mathbf{i} - 0.3F_{AC}\mathbf{j} - 0.8F_{AC}\mathbf{k}$$

$$\mathbf{F}_{AD} = F_{AD}\left(\frac{-0.9\cos 30°\mathbf{i} - 0.9\sin 30°\mathbf{j} - 1.2\mathbf{k}}{\sqrt{(-0.9\cos 30°)^2 + (-0.9\sin 30°)^2 + (-1.2)^2}}\right)$$

$$= -0.5196F_{AD}\mathbf{i} - 0.3F_{AD}\mathbf{j} - 0.8F_{AD}\mathbf{k}$$

$$\mathbf{F} = \{450(9.81)\}\ \mathbf{k}\ \text{N}$$

Equations of Equilibrium :

$$\Sigma\mathbf{F} = \mathbf{0}; \qquad \mathbf{F}_{AB} + \mathbf{F}_{AC} + \mathbf{F}_{AD} + \mathbf{F} = \mathbf{0}$$

$$(0.5196F_{AC} - 0.5196F_{AD})\mathbf{i} + (0.6F_{AB} - 0.3F_{AC} - 0.3F_{AD})\mathbf{j}$$
$$+ (-0.8F_{AB} - 0.8F_{AC} - 0.8F_{AD} + 450(9.81))\mathbf{k} = 0$$

Equating the **i**, **j** and **k** components, we have

$$0.5196F_{AC} - 0.5196F_{AD} = 0 \qquad [1]$$
$$0.6F_{AB} - 0.3F_{AC} - 0.3F_{AD} = 0 \qquad [2]$$
$$-0.8F_{AB} - 0.8F_{AC} - 0.8F_{AD} + 450(9.81) = 0 \qquad [3]$$

Solving Eqs. [1], [2] and [3] yields

$$F_{AB} = F_{AC} = F_{AD} = 1839.4\ \text{N} \qquad \textbf{Ans}$$

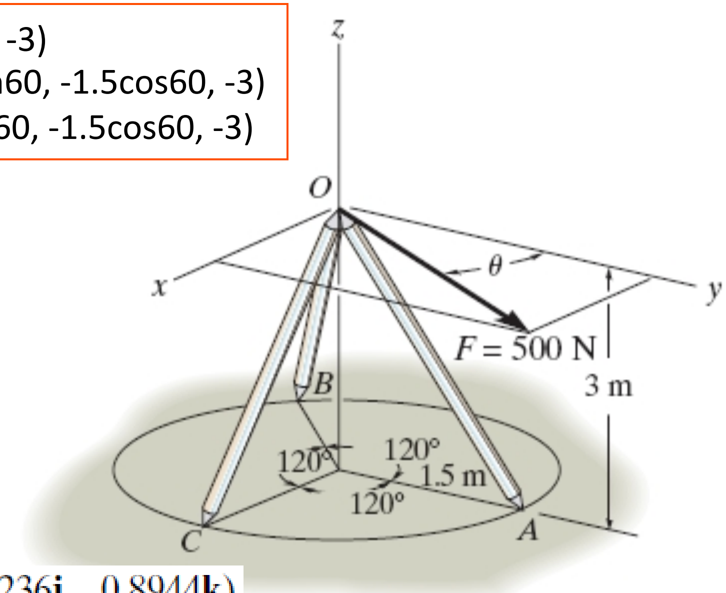
Or

Due to symmetry, all cable are subjected to the same tensile force; $F_{AB}=F_{AC}=F_{AD}=F$, then summation of force along z-axis yields;

$$\Sigma F_z = 0; \qquad 450(9.81) - 3F\left(\frac{4}{5}\right) = 0 \qquad F = 1839.4\ \text{N}$$

•3–69. Determine the angle θ such that an equal force is developed in legs OB and OC. What is the force in each leg if the force is directed along the axis of each leg? The force **F** lies in the $x-y$ plane. The supports at A, B, C can exert forces in either direction along the attached legs.

A (0, 1.5, -3)
B (-1.5sin60, -1.5cos60, -3)
C (1.5sin60, -1.5cos60, -3)



Assume that F_{OA} is compression and F_{OB} and F_{OC} are tension

$$\mathbf{F}_{OA} = F_{OA}\left(-\frac{1.5}{3.3541}\mathbf{j} + \frac{3}{3.3541}\mathbf{k}\right) = F_{OA}\,(-0.4472\mathbf{j} + 0.89443\mathbf{k})$$

$$\mathbf{F}_{OB} = F_{OB}\left(-\frac{1.5\sin 60^\circ}{3.3541}\mathbf{i} - \frac{1.5\cos 60^\circ}{3.3541}\mathbf{j} - \frac{3}{3.3541}\mathbf{k}\right) = F_{OB}\,(-0.3873\mathbf{i} - 0.2236\mathbf{j} - 0.8944\mathbf{k})$$

$$\mathbf{F}_{OC} = F_{OC}\left(\frac{1.5\sin 60^\circ}{3.3541}\mathbf{i} - \frac{1.5\cos 60^\circ}{3.3541}\mathbf{j} - \frac{3}{3.3541}\mathbf{k}\right) = F_{OC}\,(0.3873\mathbf{i} + 0.2236\mathbf{j} - 0.8944\mathbf{k})$$

$$\mathbf{F} = 500\,(\sin\theta\,\mathbf{i} + \cos\theta\,\mathbf{j})$$

$\Sigma F_x = \mathbf{0};\quad -0.3873\,F_{OB} + 0.3873\,F_{OC} + 500\sin\theta = 0$

If $F_{OC} = F_{OB}$, then $100\sin\theta = 0;\quad \theta = 0^\circ$ **Ans**

$\Sigma F_y = 0;\quad -0.4472\,F_{OA} - 0.2236\,F_{OB} - 0.2236\,F_{OC} + 500 = 0$

$\Sigma F_z = 0;\quad 0.8944\,F_{OA} - 0.8944\,F_{OB} - 0.8944\,F_{OC} = 0$

$F_{OA} = 745.4$ N **Ans**

$F_{OB} = F_{OC} = 372.7$ N **Ans**