

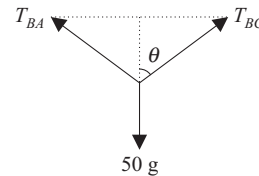
Chapter 5

5.1:

$$T_{BA} = T_{BC} = T \quad \left[\tan \theta = \frac{10}{3} \Rightarrow \theta = 73.3^\circ \right]$$

$$2T \cos \theta = 50 \text{ g.}$$

$$T = \frac{50 \times 9.81}{2 \times \cos \theta} = \frac{50 \times 9.81}{2 \times \cos 73.3} = 853.5 \text{ N}$$



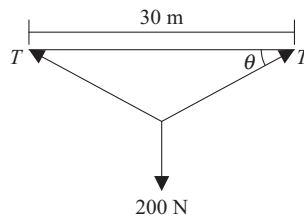
5.2:

$$2T \sin \theta = W$$

$$\sin \theta = \frac{W}{2T} = \frac{W}{2.3W} = 1/6$$

$$\Rightarrow \theta = 9.59^\circ = 9.6^\circ$$

$$y = 1.5 \tan \theta = 2.54 \text{ m}$$

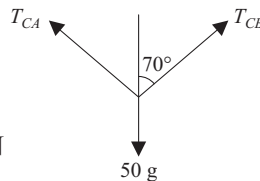


5.3:

$$T_{CA} = T_{CB} = T$$

$$2T \cos 70 = 50 \text{ g}$$

$$\Rightarrow T = \frac{50 \times 9.81}{2 \times \cos 70} = 717.1 \text{ N}$$

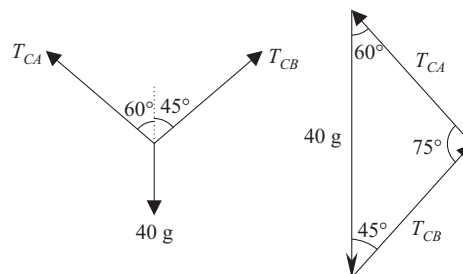


5.4:

$$\frac{40 \text{ g}}{\sin 75^\circ} = \frac{T_{CA}}{\sin 45^\circ} = \frac{T_{CB}}{\sin 60^\circ}$$

$$\Rightarrow T_{CA} = 287.3 \text{ N}$$

$$T_{CB} = 351.8 \text{ N}$$



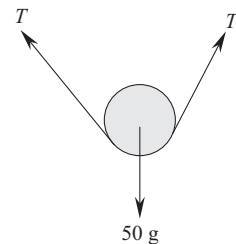
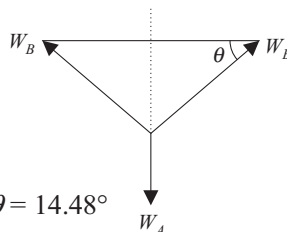
5.5:

$$2W_B \sin \theta = W_A$$

$$\sin \theta = \frac{W_A}{2W_B}$$

$$\text{When } W_A = W_B, \sin \theta = 1/2 \Rightarrow \theta = 30^\circ$$

$$W_A = W, W_B = 2W, \sin \theta = 1/4 \Rightarrow \theta = 14.48^\circ$$



5.6:

$$2T \cos 30^\circ = 50 \text{ g}$$

$$T = 283.2 \text{ N}$$

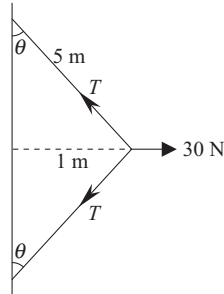
5.7:

$$\sin \theta = 1/5$$

$$2T \sin \theta = 30$$

$$2T \cdot \frac{1}{5} = 30$$

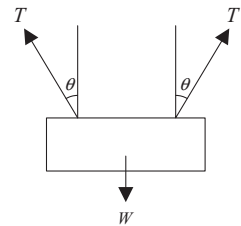
$$\Rightarrow T = 75 \text{ N}$$



5.8:

$$2T \cos \theta = W$$

$$\cos \theta = W/2T = \frac{1}{2} \Rightarrow \theta = 60^\circ$$



5.9:

$$1 = T_{BA} \cos \theta$$

$$T_{BC} = T_{CD} \sin \theta$$

$$\tan \theta = \frac{0.3}{0.4} \Rightarrow \theta = 36.87^\circ$$

$$2 = T_{CD} \cos \theta$$

$$\Rightarrow T_{BA} = 1.25 \text{ kN}$$

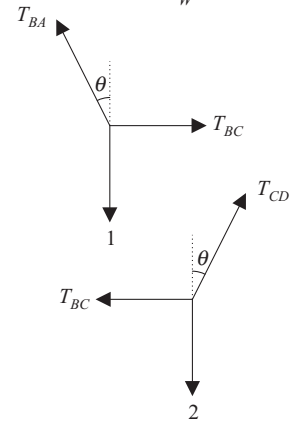
$$\frac{T_{BC}}{2} = \tan \theta = \frac{x}{0.4} \Rightarrow x = 0.15 \text{ m}$$

$$T_{BC} = T_{BA} \sin \theta$$

$$\text{Also, } \theta = 20.56^\circ$$

$$\Rightarrow T_{BC} = 0.75 \text{ kN}$$

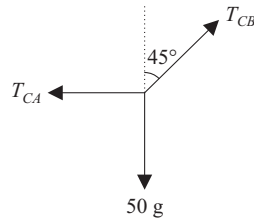
$$\therefore T_{CD} = 2.14 \text{ kN}$$



5.10:

$$T_{CB} \cos 45^\circ = 50g \Rightarrow T_{CB} = 693.7 \text{ N}$$

$$T_{CB} \sin 45^\circ = T_{CA} \Rightarrow T_{CA} = 490.5 \text{ N}$$



5.11:

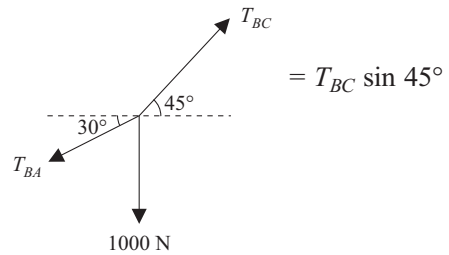
$$T_{BC} \cos 45^\circ = T_{BA} \cos 30^\circ$$

$$1000 + T_{BA} \sin 30^\circ$$

$$\Rightarrow T_{BA} = \frac{1000}{\cos 30^\circ - \sin 30^\circ} = 2732.05 \text{ N}$$

$$T_{BC} = 3346.06 \text{ N}$$

$$T_{BD} = 1000 \text{ N}$$



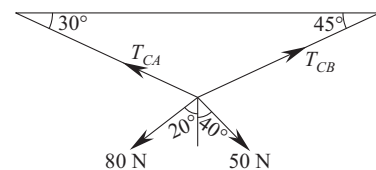
5.12:

$$T_{CA} \sin 30^\circ + T_{CB} \sin 45^\circ = 80 \cos 20^\circ + 50 \cos 40^\circ$$

$$0.5 T_{CA} + 0.707 T_{CB} = 113.48 \text{ N}$$

$$T_{CA} \cos 30^\circ + 80 \sin 20^\circ = T_{CB} \cos 45^\circ + 50 \sin 40^\circ$$

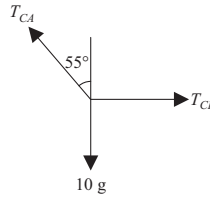
$$0.866 T_{CA} - 0.707 T_{CB} = 4.78 \text{ N}$$



$$\begin{aligned} 1.366 T_{CA} &= 118.26 \\ \Rightarrow T_{CA} &= 86.57 \text{ N} \\ T_{CB} &= 99.3 \text{ N} \end{aligned}$$

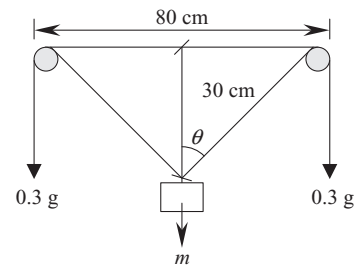
5.13:

$$\begin{aligned} T_{CA} \sin 55^\circ &= T_{CB} \\ T_{CA} \cos 55^\circ &= 10 \text{ g} \\ \Rightarrow T_{CB} &= 10 \text{ g} \tan 55^\circ = 140.1 \text{ N} \\ T_{CA} &= 171.03 \text{ N} \end{aligned}$$



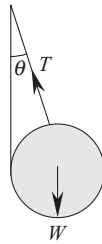
5.14:

$$\begin{aligned} mg &= (2) 300 \text{ g} \cos \theta \\ &= (2) 300 \frac{3}{5} \\ &= 360 \text{ g} \end{aligned} \quad \left[\begin{array}{l} \tan \theta = \frac{4}{3} \\ \therefore \cos \theta = \frac{3}{5} \end{array} \right]$$



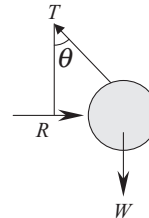
5.15:

$$\begin{aligned} W &= T \cos \theta \\ W &= 2W \cos \theta \\ \Rightarrow \theta &= 60^\circ \end{aligned}$$



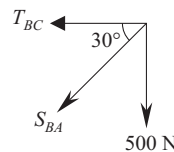
5.16:

$$\begin{aligned} W &= T \cos \theta \Rightarrow \theta = \frac{W}{\frac{3}{2}W} = 48.19^\circ \\ R &= T \sin \theta = \frac{3}{2}W \sin 48.19^\circ = 1.12 \text{ W} \end{aligned}$$



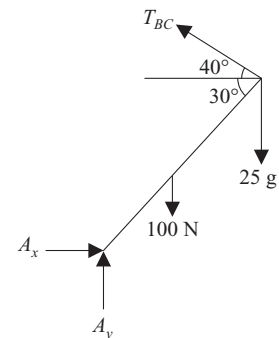
5.17:

$$\begin{aligned} T_{BC} + S_{BA} \cos 30^\circ &= 0 \Rightarrow T_{BC} = + 866.03 \text{ N} \\ S_{BA} \sin 30^\circ + 500 &= 0 \Rightarrow S_{BA} = - 1000 \text{ N} \end{aligned}$$



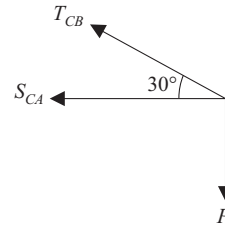
5.18:

$$\begin{aligned} T \sin 70^\circ \times 6 &= 25 \text{ g} \times 6 \cos 30^\circ + 100 \times 3 \cos 30^\circ \\ \Rightarrow T &= 272.1 \text{ N} \\ A_x &= T \cos 40^\circ = 208.4 \text{ N} \\ A_y &= 100 + (25 \text{ g}) - T \sin 40^\circ = 170.35 \text{ N} \end{aligned}$$



5.19:

$$\begin{aligned}
 T_{CB} \sin 30^\circ &= P & S_{CA} + T_{CB} \cos 30^\circ &= 0 \\
 \Rightarrow T_{CB} &= 2P & \Rightarrow S_{CA} &= -T_{CB} \cos 30^\circ \\
 & & &= -2P \frac{\sqrt{3}}{2} = -\sqrt{3} P
 \end{aligned}$$



5.20:

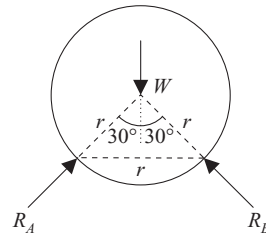
$$\begin{aligned}
 \Sigma F_x = 0 &\Rightarrow 3000 - 2000 - Q \cos 30^\circ - P \cos 45^\circ = 0 \\
 P \cos 45^\circ + Q \cos 30^\circ &= 1000 \\
 \Sigma F_y = 0 &\Rightarrow Q \sin 30^\circ = P \sin 45^\circ \\
 P &= 517.64 \text{ N} \\
 Q &= 732.05 \text{ N}
 \end{aligned}$$

5.21:

$$\begin{aligned}
 W &= R_A \cos 30^\circ + R_B \cos 30^\circ \\
 &= 2R \cos 30^\circ
 \end{aligned}$$

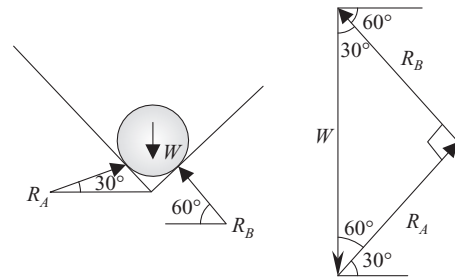
$$= 2R \frac{\sqrt{3}}{2}$$

$$\Rightarrow R = \frac{W}{\sqrt{3}}$$



5.22:

$$\begin{aligned}
 \frac{W}{\sin 90^\circ} &= \frac{R_A}{\sin 30^\circ} = \frac{R_B}{\sin 60^\circ} \\
 \Rightarrow R_A &= \frac{\sin 30^\circ}{\sin 90^\circ} W = W/2 \\
 R_B &= \frac{\sin 60^\circ}{\sin 90^\circ} W = \sqrt{3} W/2
 \end{aligned}$$



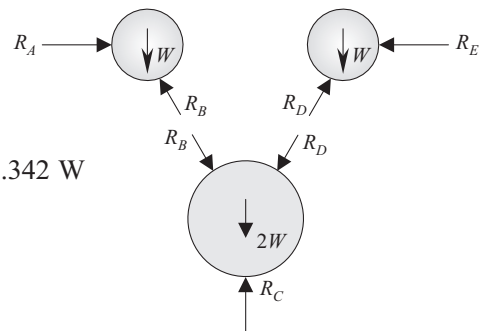
5.23:

$$\cos \theta = \frac{\sqrt{5}r}{3r}$$

$$\sin \theta = \frac{2r}{3r}$$

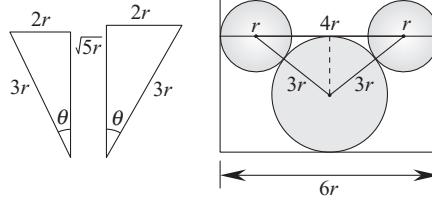
$$R_B \cos \theta = W \Rightarrow R_B = 1.342 W \quad \therefore R_D = R_B = 1.342 W$$

$$R_B \sin \theta = R_A \Rightarrow R_A = R_E = 0.895 W$$



$$R_C = 2W + R_B \cos \theta + R_D \cos \theta$$

$$= 4W$$



5.24:

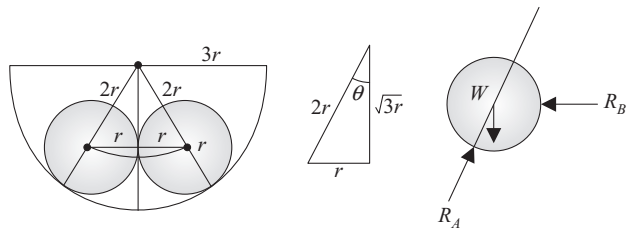
$$R_A \cos \theta = W$$

$$R_A = W / \cos \theta$$

$$= \frac{W}{\sqrt{3}/2} = \frac{2}{\sqrt{3}} W$$

$$R_B = R_A \sin \theta$$

$$= R_A \frac{r}{2r} = \frac{W}{\sqrt{3}}$$



5.25:

$$W_2 = R_D \cos 30^\circ + R_C \sin 30^\circ$$

$$R_C \cos 30^\circ = R_D \sin 30^\circ$$

$$\Rightarrow R_D = 129.9 \text{ N}$$

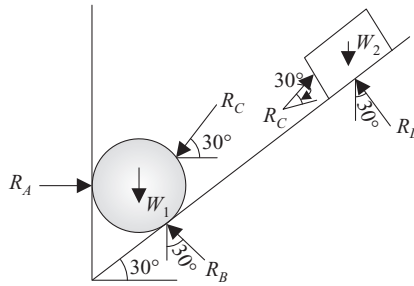
$$R_C = 75 \text{ N}$$

$$R_A = R_B \sin 30^\circ + R_C \cos 30^\circ$$

$$R_B \cos 30^\circ = W_1 + R_C \sin 30^\circ$$

$$\Rightarrow R_B = 101.04 \text{ N}$$

$$R_A = 115.5 \text{ N}$$

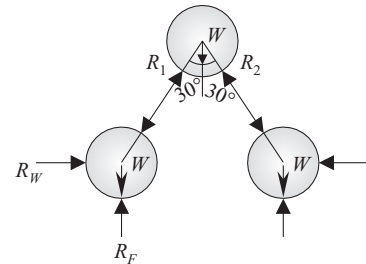
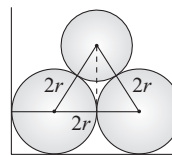


5.26:

$$W = 2R \cos 30^\circ = 2R \frac{\sqrt{3}}{2}$$

$$\Rightarrow R = \frac{W}{\sqrt{3}}$$

$$R_w = R \sin 30^\circ = \frac{W}{2\sqrt{3}}$$



5.27:

$$R_C \sin \theta = W \Rightarrow R_C = 1.512 W$$

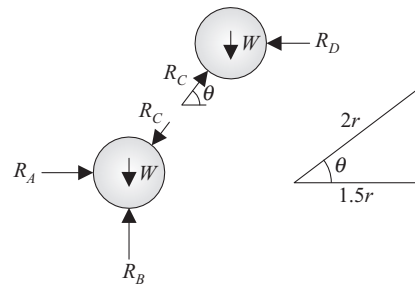
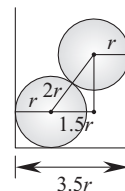
$$R_C \cos \theta = R_D \quad R_D = 1.134 W$$

$$R_A = R_C \cos \theta = R_D = 1.134 W$$

$$R_B = W + R_C \sin \theta = 2W$$

$$\cos \theta = \frac{1.5r}{2r} = \frac{3}{4}$$

$$\Rightarrow \theta = 41.41^\circ$$



5.28:

$$R_C \sin \theta = 2W \Rightarrow R_C = 2.68 W$$

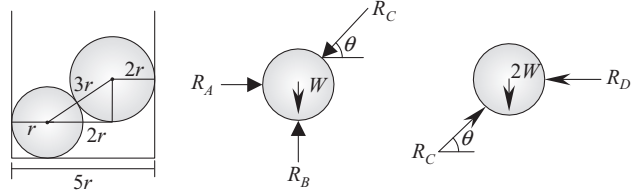
$$R_C \cos \theta = R_D \Rightarrow R_D = 1.79 W$$

$$\cos \theta = \frac{2}{3}$$

$$\Rightarrow \theta = 48.19^\circ$$

$$R_A = R_C \cos \theta = R_D = 1.79 W$$

$$R_B = W + R_C \sin \theta = 3W$$



5.29:

$$\theta = \cos^{-1} \left[\frac{1.5}{2} \right] = 41.41^\circ$$

$$R_C \sin \theta = W \Rightarrow R_C = 1.512 W$$

$$R_C \cos \theta = R_D \Rightarrow R_D = 1.134 W$$

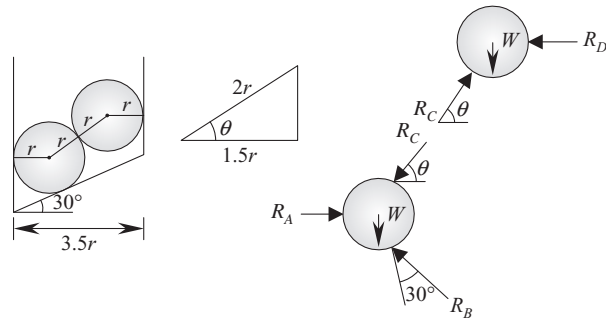
$$R_A = R_C \cos \theta + R_B \sin 30^\circ$$

$$\Rightarrow R_B \cos 30^\circ = W + R_C \sin \theta$$

$$R_B = 2.31 W$$

$$R_A = 1.134 W + 2.31 W \sin 30^\circ$$

$$= 2.29 W$$



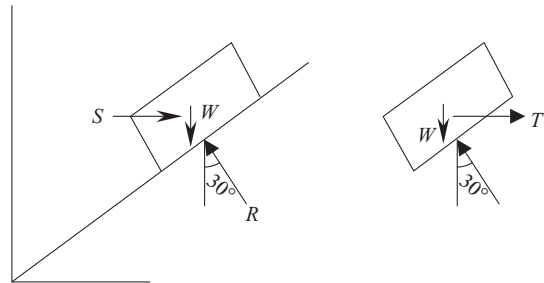
5.30:

$$W = R \cos 30^\circ \Rightarrow R = \frac{W}{\cos 30^\circ}$$

$$S = R \sin 30^\circ = W \tan 30^\circ$$

(i) member is in compression

(ii) member is in tension



5.31:

$$\tan \theta = 3/4$$

$$\theta = 36.87^\circ$$

$$T \sin (66.87^\circ) \times 6 = 28.5 \times 6 \times 9.81 \times 3 \cos 30^\circ$$

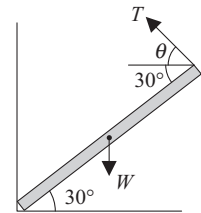
$$T = 790 \text{ N}$$

$$A_x = T \cos 36.87 = 632 \text{ N}$$

$$A_y + T \sin 36.87 = W$$

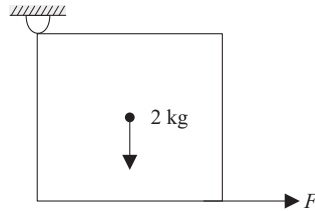
$$\Rightarrow A_y = W - 790 \sin 36.87$$

$$= 1203.5 \text{ N}$$



5.32:

$$F \cdot a = 2g \cdot \frac{a}{2} = 9.81 \text{ N}$$

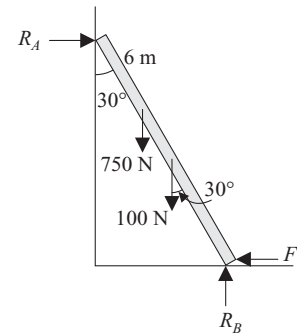


5.33:

$$R_A 6 \cos 30^\circ = 100 \times 3 \sin 30^\circ + 750 \times 4 \sin 30^\circ$$

$$\Rightarrow R_A = 317.54 \text{ N}$$

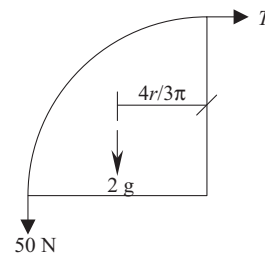
$$\therefore F = R_A = 317.5 \text{ N}$$



5.34:

$$50 \cdot x r + 2g \frac{4r}{3\pi} = T \cdot r$$

$$\Rightarrow T = 58.33 \text{ N}$$

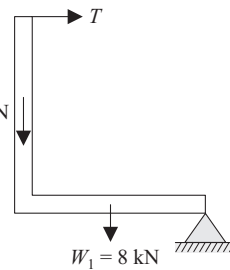


5.35:

$$W_1 \times 2 + W_2 \times 4 = T \times 3$$

$$T = \frac{16 + 24}{3} = 13.33 \text{ kN}$$

$$W_2 = 6 \text{ kN}$$



5.36:

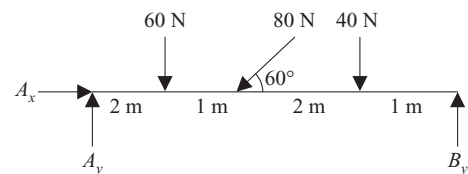
$$A_x = 80 \cos 60^\circ = 40 \text{ N}$$

$$A_y + B_y = 60 + 40 + 80 \sin 60^\circ = 169.3 \text{ N}$$

$$B_y \times 6 = 60 \times 2 + 80 \sin 60^\circ \times 3 + 40 \times 5$$

$$\Rightarrow B_y = 88 \text{ N}$$

$$A_y = 81.3 \text{ N}$$



5.37:

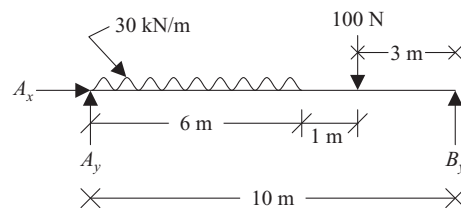
$$A_x = 0$$

$$A_y + B_y = 30 \times 6 + 100 = 280 \text{ N}$$

$$B_y \times 10 = 100 \times 7 + 180 \times 3$$

$$\Rightarrow B_y = 124 \text{ N}$$

$$A_y = 156 \text{ N}$$



5.38:

$$A_x = \frac{R_B}{\sqrt{2}}$$

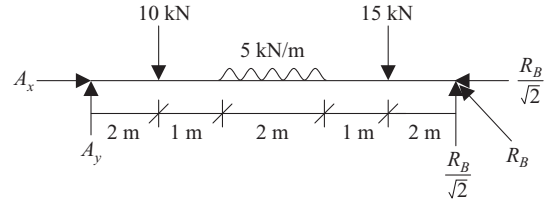
$$A_y + \frac{R_B}{\sqrt{2}} = 10 + (5 \times 2) + 15 = 35 \text{ kN}$$

$$\frac{R_B}{\sqrt{2}} \cdot 8 = (10 \times 2) + (10 \times 4) + (15 \times 6)$$

$$\Rightarrow R_B = 26.52 \text{ kN}$$

$$\therefore A_x = 18.75 \text{ kN}$$

$$A_y = 16.25 \text{ kN}$$



5.39:

$$A_x = 0 \quad A_y + B_y = \frac{1}{2} \times (2 \times 4) + \frac{1}{2} \times (4^2 \times 4) + 10 = 22 \text{ kN}$$

$$B_y \times 8 = \frac{1}{2} (2 \times 4) \times \left(\frac{4}{3}\right) + \frac{1}{2} (4 \times 4) \left[4 + \frac{2}{3} \cdot 4\right] + 10 \times 6$$

$$\Rightarrow B_y = 14.8 \text{ kN}$$

$$A_y = 7.2 \text{ kN}$$

5.40:

$$C_x = T \cos \theta = T \cdot \frac{4}{5} = 4000 \times \frac{4}{5} = 3200 \text{ N}$$

$$C_y = 4000 - T \sin \theta = 4000 \left[1 - \frac{3}{5}\right] = 1600 \text{ N}$$

$$A_x + T \cos \theta = C_x$$

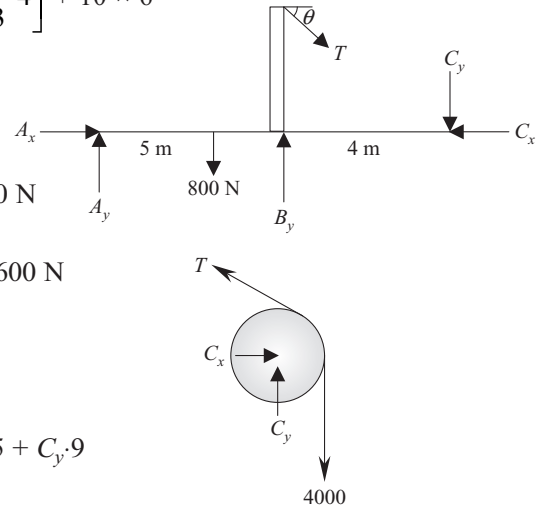
$$A_x = C_x - T \cos \theta = 0$$

$$A_y + B_y = T \sin \theta + C_y + 800 = 4800$$

$$B_y \cdot 5 = T \cos \theta \cdot 3 + T \cos \theta \cdot 5 + 800 \times 4.5 + C_y \cdot 9$$

$$\Rightarrow B_y = 7920 \text{ N}$$

$$\therefore A_y = -3120 \text{ N}$$



5.41:

$$W = -50 \text{ g } \vec{j}$$

$$\vec{DA} = \vec{OA} - \vec{OD} = -4\vec{i} + 3\vec{j} - \vec{k}$$

$$\vec{DB} = \vec{OB} - \vec{OD} = 3\vec{i} + 3\vec{j} - \vec{k}$$

$$\vec{DC} = \vec{OC} - \vec{OD} = -\vec{k}$$

$$\vec{T}_{DA} = T_{DA} \left[\frac{-4\vec{i} + 3\vec{j} - \vec{k}}{\sqrt{26}} \right]$$

$$\vec{T}_{DB} = T_{DB} \left[\frac{3\vec{i} + 3\vec{j} - \vec{k}}{\sqrt{19}} \right]$$

$$\begin{aligned}
 \vec{R}_{DC} &= R_{DC} [-\vec{k}] \\
 \vec{R} = \vec{O} &= \vec{T}_{DA} + \vec{T}_{DB} + \vec{R}_{DC} \Rightarrow \\
 \frac{-4}{\sqrt{26}} T_{DA} + \frac{3}{\sqrt{19}} T_{DB} &= 0 \quad \Rightarrow \quad -0.784 T_{DA} + 0.688 T_{DB} = 0 \\
 \frac{3}{\sqrt{26}} T_{DA} + \frac{3}{\sqrt{19}} T_{DB} - 50 \text{ g} &= 0 \quad 0.588 T_{DA} + 0.688 T_{DB} - 490.5 = 0 \\
 \frac{-T_{DA}}{\sqrt{26}} - \frac{T_{DB}}{\sqrt{19}} - R_{DC} &= 0 \quad -0.196 T_{DA} - 0.229 T_{DB} - R_{DC} = 0 \\
 T_{DB} &= 407.4 \text{ N} \\
 T_{DA} &= 357.5 \text{ N} \\
 R_{DC} &= -163.4 \text{ N}
 \end{aligned}$$

∴

5.42:

$$A (0, 0, 0) \quad \vec{BD} = \vec{OD} - \vec{OB} = -4\vec{i} - 2\vec{j} + 3\vec{k}$$

$$B (4, 0, 0)$$

$$C (4.5, 0, 0) \quad \vec{BE} = \vec{OE} - \vec{OB} = -4\vec{i} + 3\vec{j} + 4\vec{k}$$

$$D (0, -2, 3)$$

$$E (0, 3, 4)$$

$$\vec{T}_{BD} = T_{BD} \left[\frac{-4\vec{i} - 2\vec{j} + 3\vec{k}}{\sqrt{29}} \right]$$

$$\vec{T}_{BE} = T_{BE} \left[\frac{-4\vec{i} + 3\vec{j} + 4\vec{k}}{\sqrt{41}} \right]$$

$$\vec{W} = -20\vec{k}$$

$$\vec{A} = A_x\vec{i} + A_y\vec{j} + A_z\vec{k}$$

$$\Sigma F_x = 0 \quad \Rightarrow \quad \frac{-4}{\sqrt{29}} T_{BD} - \frac{4}{\sqrt{41}} T_{BE} + A_x = 0$$

$$\Sigma F_y = 0 \quad \Rightarrow \quad \frac{-2}{\sqrt{29}} T_{BD} + \frac{3}{\sqrt{41}} T_{BE} + A_y = 0$$

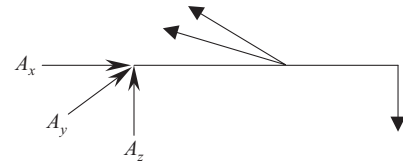
$$\Sigma F_z = 0 \quad \Rightarrow \quad \frac{3}{\sqrt{29}} T_{BD} + \frac{4}{\sqrt{41}} T_{BE} - 20 + A_z = 0$$

$$\Sigma \vec{M} = \vec{O} \quad 4\vec{i} \times T_{BD} \left[\frac{-4}{\sqrt{29}} \vec{i} - \frac{2}{\sqrt{29}} \vec{j} + \frac{3}{\sqrt{29}} \vec{k} \right]$$

$$+ 4\vec{i} \times \frac{T_{BE}}{\sqrt{41}} [-4\vec{i} + 3\vec{j} + 4\vec{k}]$$

$$+ 4.5\vec{i} \times (-20\vec{k}) = \vec{O}$$

$$\frac{-8}{\sqrt{29}} T_{BD} \vec{k} - \frac{12}{\sqrt{29}} T_{BD} \vec{j}$$



$$\frac{12}{\sqrt{41}} T_{BE} \vec{k} - \frac{16}{\sqrt{41}} T_{BE} \vec{j} \quad 135\vec{j} = \vec{O}$$

$$\frac{-8}{\sqrt{29}} T_{BD} + \frac{12}{\sqrt{41}} T_{BE} = 0$$

$$\frac{-12}{\sqrt{29}} T_{BD} + \frac{16}{\sqrt{41}} T_{BE} + 135 = 0$$

$$T_{BE} = 16.95 \text{ kN}$$

$$T_{BD} = 21.4 \text{ kN}$$

$$\begin{aligned} \therefore A_x &= 26.5 \text{ kN} \\ A_y &= 6.3 \text{ N} \\ A_z &= -2.51 \text{ kN} \end{aligned}$$

5.43:

$$\vec{W} = -100 \text{ g } \vec{k} \quad \vec{r} = 0.6\vec{i} - 0.3\vec{k} \quad A(1, 0, 0)$$

$$\vec{AC} = -\vec{i} - 0.5\vec{j} + 0.8\vec{k} \quad B(1, 2, 0, 0)$$

$$\vec{BD} = -102\vec{i} + 1.5\vec{j} + \vec{k} \quad C(0, -0.5, 0.8)$$

$$D(0, 1.5, 1)$$

$$\vec{T}_{AC} = T_{AC} \left[\frac{-\vec{i} - 0.5\vec{j} + 0.8\vec{k}}{\sqrt{1.89}} \right] \quad T_{AC} = [-0.727\vec{i} - 0.364\vec{j} + 0.582\vec{k}]$$

$$\vec{T}_{BD} = T_{BD} \left[\frac{-1.2\vec{i} - 1.5\vec{j} + \vec{k}}{\sqrt{4.69}} \right] = [-0.554\vec{i} - 0.693\vec{j} + 0.462\vec{k}] T_{BD}$$

$$\vec{O} = O_x \vec{i} + O_y \vec{j} + O_z \vec{k}$$

$$\Sigma F_x = O \Rightarrow -0.727 T_{AC} - 0.554 T_{BD} + O_y = 0$$

$$-0.364 T_{AC} + 0.693 T_{BD} + O_y = 0$$

$$0.582 T_{AC} + 0.462 T_{BD} + O_z - 981 = 0$$

$$\begin{aligned} \Sigma \vec{M} = O \Rightarrow & (0.6\vec{i} - 0.3\vec{k}) \times (-100 \text{ g } \vec{k}) \\ & + (\vec{i}) \times (0.727\vec{i} - 0.364\vec{j} + 0.582\vec{k}) T_{AC} \\ & + (1.2\vec{i}) \times (-0.554\vec{i} + 0.693\vec{j} + 0.462\vec{k}) T_{BD} = \vec{O} \end{aligned}$$

$$\begin{aligned} & + 60 \text{ g } \vec{i} \\ & - 0.582 T_{AC} \vec{j} - 0.364 \vec{k} (T_{AC}) \\ & - 0.554 T_{BD} \vec{j} + 0.832 \vec{k} T_{BD} = \vec{O} \end{aligned} \quad \left| \Rightarrow \begin{aligned} & -0.364 T_{AC} + 0.832 T_{BD} = 0 \\ & -0.582 T_{AC} - 0.554 T_{BD} + 60 \text{ g} = 0 \end{aligned} \right.$$

$$T_{BD} = 312.4 \text{ N}$$

$$T_{AC} = 714.1 \text{ N}$$

$$O_x = 692.2 \text{ N}, \quad O_y = 43.4 \text{ N} \quad O_z = 421.1 \text{ N}$$