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ENGS141 Engineering Statics - Homework 1

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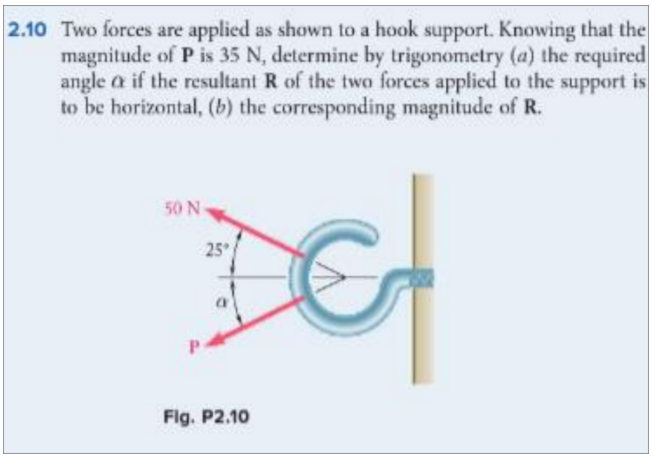
Problem 10 (8 points).

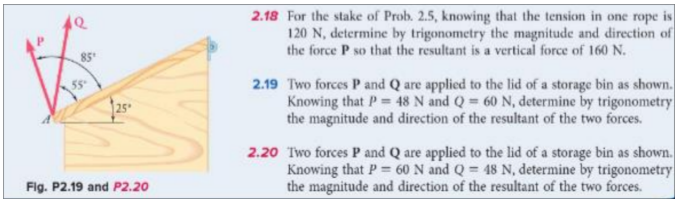


Denote the vertical axis y, and the horizontal axis x. Since no vertical component:

$$P_y = 35 \sin \alpha = 50 \sin 25^\circ \implies \alpha \approx 37.1^\circ$$

$$\|\mathbf{R}\| = R_x = 35 \cos \alpha + 50 \cos 25^\circ \approx 73.2N$$

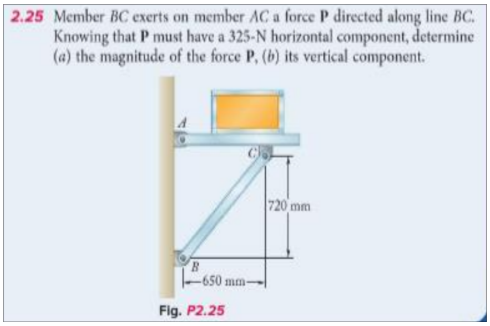
Problem 20 (8 points).



Denote the vertical axis y, and the horizontal axis x, the resultant force $\mathbf{R}$.

$$\mathbf{R} = \begin{bmatrix} P_x + Q_x \\ P_y + Q_y \end{bmatrix} = \begin{bmatrix} 60 \cos 110^\circ + 48 \cos 80^\circ \\ 60 \sin 110^\circ + 48 \sin 80^\circ \end{bmatrix} \approx \begin{bmatrix} -12.2 \\ 103.7 \end{bmatrix} N$$

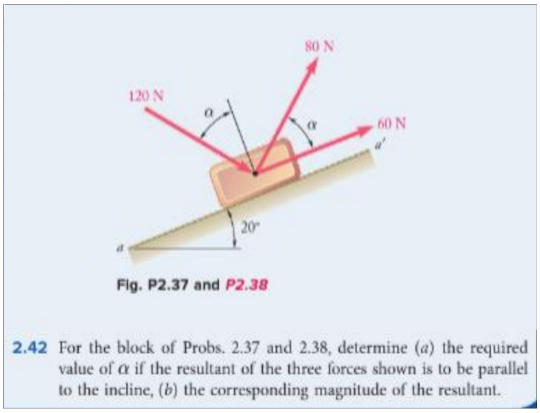
Problem 25 (8 points).



Denote the vertical axis y, and the horizontal axis x.

$$BC = \sqrt{720^2 + 650^2} = 970mm \implies \|\mathbf{P}\| = 325 \cdot \frac{970}{650} = 485N, P_y = 325 \cdot \frac{720}{650} = 360N$$

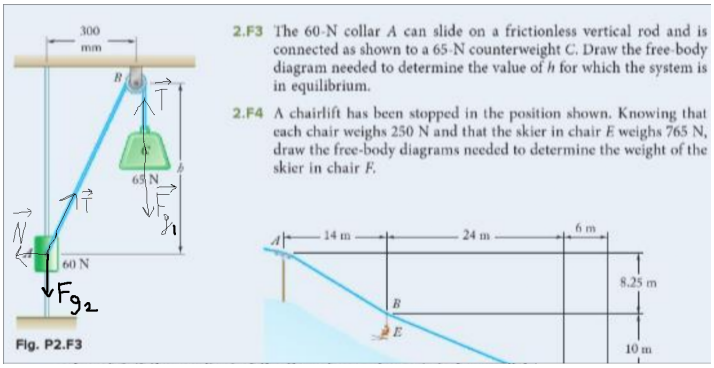
Problem 42 (8 points).

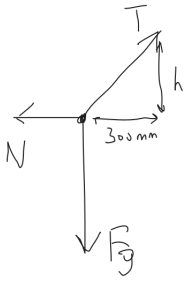


Denote the axis of incline x, and axis perpendicular to it y, and the resultant force $\mathbf{R}$. From the problem we have:

$$R_y = 0 \implies 80\sin\alpha - 120\cos\alpha = 0 \implies \alpha \approx 56.3^\circ \implies \|\mathbf{R}\| = R_x = 60 + 80\cos\alpha + 120\sin\alpha \approx 204.2N$$

Problem 2F3 (8 points).





Denote the vertical axis y, and the horizontal axis x.

$$F_{g1} = T, F_{g2} = T \cdot \frac{h}{\sqrt{300^2 + h^2}} \implies 65^2 h^2 = 60^2(300^2 + h^2) \implies h = 720mm$$

Problem 50 (8 points).

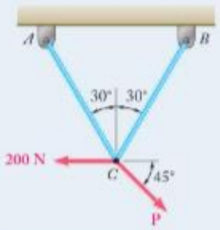


Fig. P2.49 and P2.50

2.50 Two cables are tied together at *C* and are loaded as shown. Determine the range of values of **P** for which both cables remain taut.

Denote the vertical axis y, and the horizontal axis x. To keep the cables taut, the resultant force should be directed downwards, between the lines AC and AB. To find the range, we need to find the two end points.

$$\mathbf{R} = \begin{bmatrix} P\cos 45° - 200 \\ -P\sin 45° \end{bmatrix} \implies \tan -30° = -\frac{1}{\sqrt{3}} \leq \frac{P\cos 45° - 200}{P\sin 45°} \leq \tan 30° = \frac{1}{\sqrt{3}}$$

$$-\frac{P}{\sqrt{6}} = \frac{P}{\sqrt{2}} - 200 \implies P_0 \approx 179.3N, \frac{P}{\sqrt{6}} = \frac{P}{\sqrt{2}} - 200 \implies P_0 \approx 669.2N$$

$$\therefore P \in [179.3, 669.2]N$$

Problem 70 (8 points).

2.69 A load **Q** is applied to pulley *C*, which can roll on the cable *ACB*. The pulley is held in the position shown by a second cable *CAD*, which passes over the pulley *A* and supports a load **P**. Knowing that $P = 750$ N, determine (*a*) the tension in cable *ACB*, (*b*) the magnitude of load **Q**.

2.70 An 1800-N load **Q** is applied to pulley *C*, which can roll on the cable *ACB*. The pulley is held in the position shown by a second cable *CAD*, which passes over the pulley *A* and supports a load **P**. Determine (*a*) the tension in cable *ACB*, (*b*) the magnitude of load **P**.

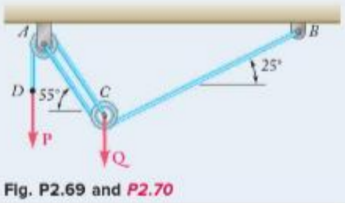


Fig. P2.69 and P2.70

Denote the vertical axis y, and the horizontal axis x. Newton's second law was used for each component:

$$\begin{cases} T_{ACB}(\sin 55^\circ + \sin 25^\circ) + T_{DAC}\sin 55^\circ = 1800 \\ T_{ACB}(\cos 25^\circ - \cos 55^\circ) - T_{DAC}\cos 55^\circ = 0 \end{cases} \implies \begin{bmatrix} \sin 55^\circ + \sin 25^\circ & \sin 55^\circ \\ \cos 25^\circ - \cos 55^\circ & \cos 55^\circ \end{bmatrix} \begin{bmatrix} T_{ACB} \\ T_{DAC} \end{bmatrix} = \begin{bmatrix} 1800 \\ 0 \end{bmatrix}$$

$$\therefore T_{ACB} = 1050N \text{ and } P = T_{DAC} = 608N$$

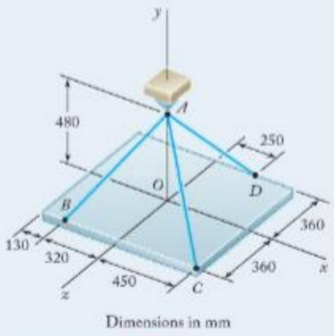
Problem 80 (8 points).

2.80 Determine the magnitude and direction of the force $\mathbf{F} = (320\ \text{N})\mathbf{i} + (400\ \text{N})\mathbf{j} - (250\ \text{N})\mathbf{k}$.

$$\|\mathbf{F}\| = \sqrt{320^2 + 400^2 + 250^2} = 570N$$

$$\alpha_x = \arccos\left(\frac{320}{570}\right) \approx 55.8^\circ, \alpha_y = \arccos\left(\frac{400}{570}\right) \approx 45.4^\circ, \alpha_z = \arccos\left(\frac{-250}{570}\right) \approx 116.0^\circ$$

Problem 90 (8 points).



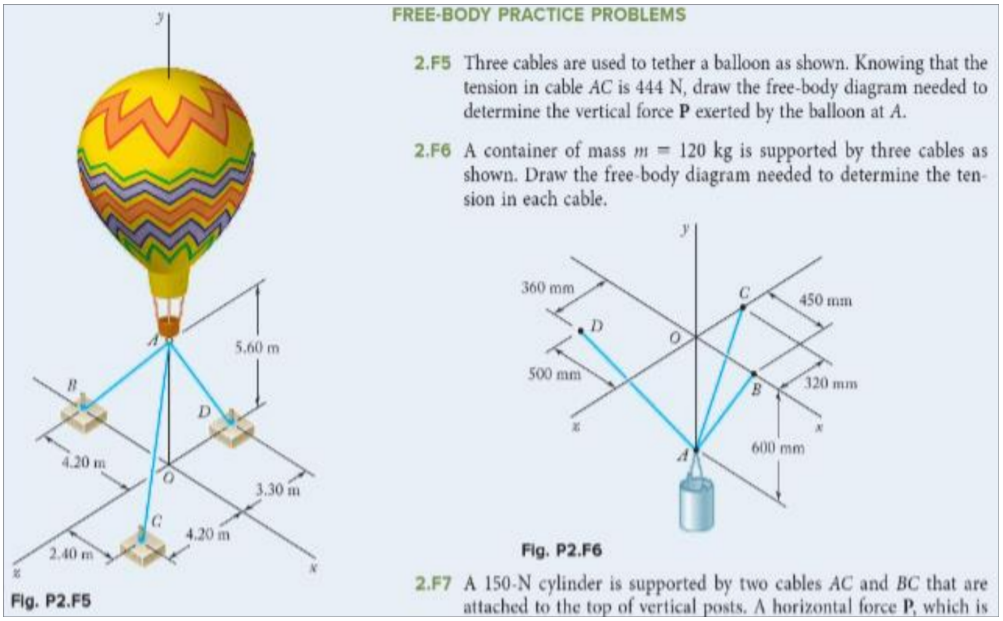
Dimensions in mm

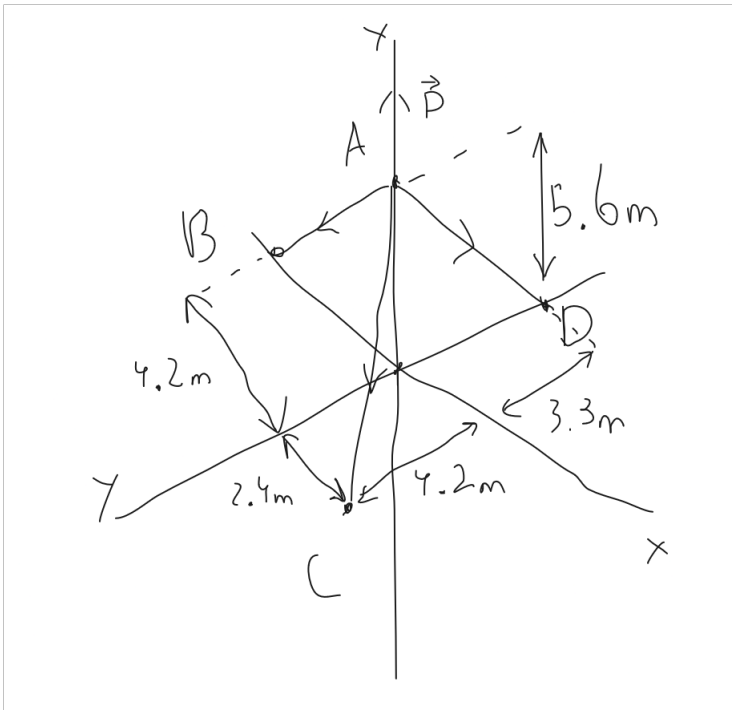
Fig. P2.89 and P2.90

2.90 A rectangular plate is supported by three cables as shown. Knowing that the tension in cable AD is 429 N, determine the components of the force exerted on the plate at D.

$$AD = \sqrt{250^2 + 480^2 + 360^2} = 650 \implies F = \begin{bmatrix} -429 \cdot \frac{250}{650} \\ 429 \cdot \frac{480}{650} \\ 429 \cdot \frac{360}{650} \end{bmatrix} = \begin{bmatrix} -165N \\ 316.8N \\ 237.6N \end{bmatrix}$$

Problem 2F5 (13 points).





$$\mathbf{T}_{AC} = T_{AC}\begin{bmatrix} \frac{4.2}{\sqrt{4.2^2+2.4^2+5,6^2}} \\ \frac{2.4}{\sqrt{4.2^2+2.4^2+5,6^2}} \\ -\frac{5.6}{\sqrt{4.2^2+2.4^2+5,6^2}} \end{bmatrix} = \begin{bmatrix} 252 \\ 144 \\ 336 \end{bmatrix} N \implies T_{AB_y} = 336N, T_{AD_y} = -570N \implies P = 1050N$$

Problem 123 (15 points).

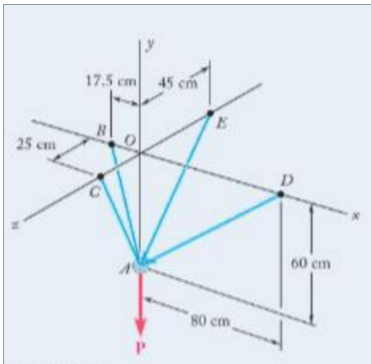


Fig. P2.123

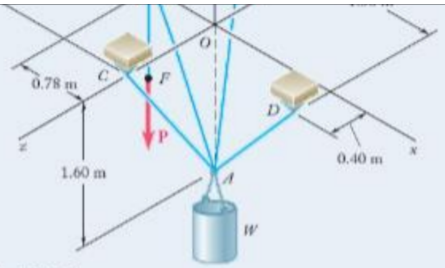


Fig. P2.121

2.122 Knowing that the tension in cable *AC* of the system described in Prob. 2.121 is 150 N, determine (*a*) the magnitude of the force **P**, (*b*) the weight *W* of the container.

2.123 Cable *BAC* passes through a frictionless ring *A* and is attached to fixed supports at *B* and *C*, while cables *AD* and *AE* are both tied to the ring and are attached, respectively, to supports at *D* and *E*. Knowing that a 200-N vertical load **P** is applied to ring *A*, determine the tension in each of the three cables.

$$\mathbf{T}_{AB} = T_{BAC} \begin{bmatrix} -\frac{17.5}{\sqrt{17.5^2+60^2}} \\ \frac{60}{\sqrt{17.5^2+60^2}} \\ 0 \end{bmatrix} = T_{BAC} \begin{bmatrix} -0.28 \\ 0.96 \\ 0 \end{bmatrix}$$

$$\mathbf{T}_{AC} = T_{BAC} \begin{bmatrix} 0 \\ \frac{60}{\sqrt{25^2+60^2}} \\ frac25\sqrt{25^2+60^2} \end{bmatrix} = T_{BAC} \begin{bmatrix} 0 \\ 12/13 \\ 5/13 \end{bmatrix}$$

$$\mathbf{T}_{AD} = T_{AD} \begin{bmatrix} \frac{80}{\sqrt{80^2+60^2}} \\ \frac{60}{\sqrt{80^2+60^2}} \\ 0 \end{bmatrix} = T_{AD} \begin{bmatrix} 0.8 \\ 0.6 \\ 0 \end{bmatrix}$$

$$\mathbf{T}_{AE} = T_{AE} \begin{bmatrix} 0 \\ \frac{60}{\sqrt{45^2+60^2}} \\ -\frac{45}{\sqrt{45^2+60^2}} \end{bmatrix} = T_{AE} \begin{bmatrix} 0 \\ 0.8 \\ -0.6 \end{bmatrix}$$

$$\begin{cases} -0.28T_{BAC} + 0.8T_{AD} = 0 \\ (0.96 - 12/13)T_{BAC} - 0.6T_{AD} + 0.8T_{AE} = 200 \\ 5/13T_{BAC} - 0.6T_{AE} = 0 \end{cases} \implies \begin{cases} T_{BAC} \approx 76.7N \\ T_{AD} \approx 26.9N \\ T_{AE} \approx 49.2N \end{cases}$$