3. (a) The forces are balanced when they sum to zero: \( \vec{F}_1 + \vec{F}_2 + \vec{F}_3 = 0 \). This means
\[
\vec{F}_3 = -\vec{F}_1 - \vec{F}_2 = -(10 \text{N})\hat{i} + (4 \text{N})\hat{j} - (17 \text{N})\hat{i} - (2 \text{N})\hat{j} = (-27 \text{N})\hat{i} + (2 \text{N})\hat{j}.
\]
(b) If \( \theta \) is the angle the vector makes with the \( x \) axis then
\[
\tan \theta = \frac{F_{3y}}{F_{3x}} = \frac{2 \text{N}}{-27 \text{N}} = -0.741.
\]
The angle is either \(-4.2^\circ\) or \(176^\circ\). The second solution yields a negative \( x \) component and a positive \( y \) component and is therefore the correct solution.
Three forces act on the sphere: the tension force $\vec{T}$ of the rope (acting along the rope), the force of the wall $\vec{N}$ (acting horizontally away from the wall), and the force of gravity $m\vec{g}$ (acting downward). Since the sphere is in equilibrium they sum to zero. Let $\theta$ be the angle between the rope and the vertical. Then, the vertical component of Newton’s second law is $T \cos \theta - mg = 0$. The horizontal component is $N - T \sin \theta = 0$.

(a) We solve the first equation for the tension: $T = mg / \cos \theta$. We substitute $\cos \theta = L / \sqrt{L^2 + r^2}$ to obtain $T = mg \sqrt{L^2 + r^2} / L$.

(b) We solve the second equation for the normal force: $N = T \sin \theta$. Using $\sin \theta = r / \sqrt{L^2 + r^2}$, we obtain

$$N = \frac{Tr}{\sqrt{L^2 + r^2}} = \frac{mg \sqrt{L^2 + r^2}}{L} \frac{r}{\sqrt{L^2 + r^2}} = \frac{mgr}{L}.$$
16. (a) Analyzing vertical forces where string 1 and string 2 meet, we find

\[ T_1 = \frac{40 \text{ N}}{\cos 35^\circ} = 49 \text{ N} . \]

(b) Looking at the horizontal forces at that point leads to

\[ T_2 = T_1 \sin 35^\circ = (49 \text{ N}) \sin 35^\circ = 28 \text{ N} . \]

(c) We denote the components of \( T_3 \) as \( T_x \) (rightward) and \( T_y \) (upward). Analyzing horizontal forces where string 2 and string 3 meet, we find \( T_x = T_2 = 28 \text{ N} \). From the vertical forces there, we conclude \( T_y = 50 \text{ N} \). Therefore,

\[ T_3 = \sqrt{T_x^2 + T_y^2} = 57 \text{ N} . \]

(d) The angle of string 3 (measured from vertical) is

\[ \theta = \tan^{-1} \left( \frac{T_x}{T_y} \right) = \tan^{-1} \left( \frac{28}{50} \right) = 29^\circ . \]
28. (a) Computing torques about the hinge, we find the tension in the wire:

\[ TL \sin \theta - Wx = 0 \implies T = \frac{Wx}{L \sin \theta}. \]

(b) The horizontal component of the tension is \( T \cos \theta \), so equilibrium of horizontal forces requires that the horizontal component of the hinge force is

\[ F_x = \left( \frac{Wx}{L \sin \theta} \right) \cos \theta = \frac{Wx}{L \tan \theta}. \]

(c) The vertical component of the tension is \( T \sin \theta \), so equilibrium of vertical forces requires that the vertical component of the hinge force is

\[ F_y = W - \left( \frac{Wx}{L \sin \theta} \right) \sin \theta = W \left( 1 - \frac{x}{L} \right). \]
37. (a) The shear stress is given by \( F/A \), where \( F \) is the magnitude of the force applied parallel to one face of the aluminum rod and \( A \) is the cross-sectional area of the rod. In this case \( F \) is the weight of the object hung on the end: \( F = mg \), where \( m \) is the mass of the object. If \( r \) is the radius of the rod then \( A = \pi r^2 \). Thus, the shear stress is

\[
\frac{F}{A} = \frac{mg}{\pi r^2} = \frac{(1200 \text{ kg})(9.8 \text{ m/s}^2)}{\pi (0.024 \text{ m})^2} = 6.5 \times 10^6 \text{ N/m}^2.
\]

(b) The shear modulus \( G \) is given by

\[
G = \frac{F/A}{\Delta x/L}
\]

where \( L \) is the protrusion of the rod and \( \Delta x \) is its vertical deflection at its end. Thus,

\[
\Delta x = \frac{(F/A)L}{G} = \frac{(6.5 \times 10^6 \text{ N/m}^2)(0.053 \text{ m})}{3.0 \times 10^{10} \text{ N/m}^2} = 1.1 \times 10^{-5} \text{ m}.
\]