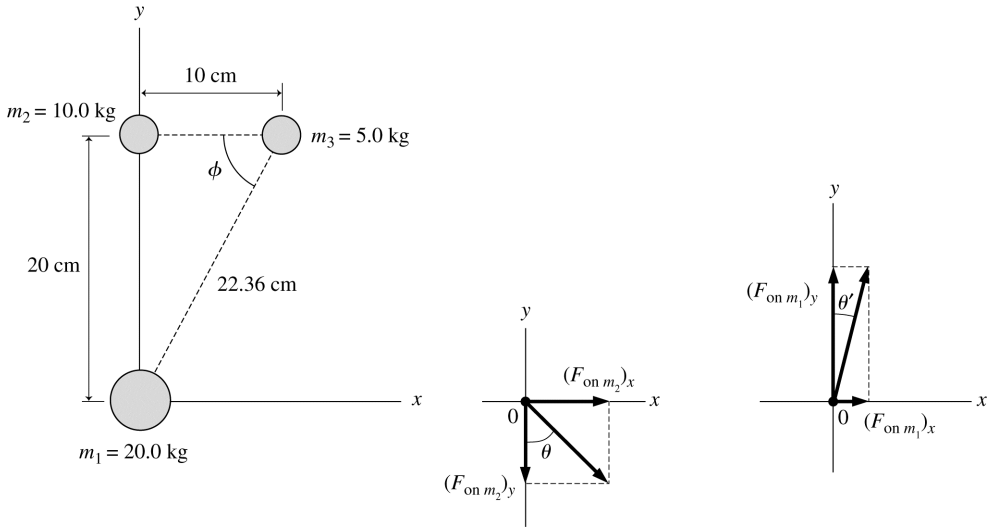
12.35. Visualize: We placed the origin of the coordinate system on the 20.0 kg mass (m_1) so that the 10.0 kg mass (m_2) is on the y-axis and the 5.0 kg mass (m_3) has the coordinates (10 cm, 20 cm).



Solve: **(a)** The forces on the 10.0 kg mass (m_2):

$$\vec{F}_{m_1 \text{ on } m_2} = -\frac{Gm_1m_2}{r_{12}^2}\hat{j} = -\frac{G(20.0 \text{ kg})(10.0 \text{ kg})}{(0.20 \text{ m})^2}\hat{j} = -3.33\times10^{-7}\,\hat{j} \text{ N}$$

$$F_{m_3 \text{ on } m_2} = \frac{Gm_2m_3}{r_{23}^2}\hat{i} = \frac{G(10.0 \text{ kg})(5.0 \text{ kg})}{(0.10 \text{ m})^2}\hat{i} = 3.33\times10^{-7}\,\hat{i} \text{ N}$$

$$\Rightarrow \vec{F}_{\text{on } m_2} = (3.33\times10^{-7})\hat{i} \text{ N} - (3.33\times10^{-7})\hat{j} \text{ N}$$

$$F_{\text{on } m_2} = \sqrt{(3.33\times10^{-7})^2 + (-3.33\times10^{-7})^2} = 4.72\times10^{-7} \text{ N} \quad \text{and} \quad \theta = \tan^{-1}\left(\frac{3.33\times10^{-7}}{3.33\times10^{-7}}\right) = 45°$$

Thus $\vec{F}_{\text{on } m_2} = \left(4.72\times10^{-7} \text{ N}, 45° \text{ ccw from the } -y\text{-axis}\right)$.

(b) The forces on the 20.0 kg mass (m_1) are

$$\vec{F}_{m_3 \text{ on } m_1} = +(1.33\times10^{-7})\cdot\cos\phi\hat{i} \text{ N} + (1.33\times10^{-7})\sin\phi\hat{j} \text{ N}$$

$$= (1.33\times10^{-7})\left(\frac{10 \text{ cm}}{22.36 \text{ cm}}\right)\hat{i} \text{ N} + (1.33\times10^{-7})\left(\frac{20 \text{ cm}}{22.36 \text{ cm}}\right)\hat{j} \text{ N}$$

$$= (0.60\times10^{-7})\hat{i} \text{ N} + (1.19\times10^{-7})\hat{j} \text{ N}$$

$$\vec{F}_{m_2 \text{ on } m_1} = 3.33\times10^{-7}\,\hat{j} \text{ N}$$

$$\Rightarrow \vec{F}_{\text{on } m_1} = \vec{F}_{m_2 \text{ on } m_1} + \vec{F}_{m_3 \text{ on } m_1} = (0.60\times10^{-7})\hat{i} \text{ N} + (4.52\times10^{-7})\hat{j} \text{ N}$$

$$F_{\text{on } m_1} = \sqrt{(894\ G)^2 + (6789\ G)^2} = 4.56\times10^{-7} \text{ N} \quad \text{and} \quad \theta' = \tan^{-1}\left(\frac{0.60\times10^{-7}}{4.52\times10^{-7}}\right) = 7.6°$$

where the angle is clockwise of the positive y-axis.

Thus $\vec{F}_{\text{on } m_1} = \left(4.56\times10^{-7} \text{ N}, 7.6° \text{ cw from the } y\text{-axis}\right)$.