Chapter 13 Solutions

P13.1 For two 70-kg persons, modeled as spheres,

$$F_g = \frac{Gm_1m_2}{r^2} = \frac{\left(6.67\times10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2\right)(70\ \text{kg})(70\ \text{kg})}{(2\ \text{m})^2}\boxed{\sim 10^{-7}\ \text{N}}$$

P13.3 (a) At the midpoint between the two objects, the forces exerted by the 200-kg and 500-kg objects are oppositely directed,

and from $F_g = \frac{Gm_1m_2}{r^2}$

we have $\sum F = \frac{G(50.0\ \text{kg})(500\ \text{kg} - 200\ \text{kg})}{(0.200\ \text{m})^2} = \boxed{2.50\times10^{-5}\ \text{N}}$ toward the 500-kg object.

(b) At a point between the two objects at a distance d from the 500-kg objects, the net force on the 50.0-kg object will be zero when

$$\frac{G(50.0\ \text{kg})(200\ \text{kg})}{(0.400\ \text{m} - d)^2} = \frac{G(50.0\ \text{kg})(500\ \text{kg})}{d^2}$$

To solve, cross-multiply to clear of fractions and take the square root of both sides. The result is $d = \boxed{0.245\ \text{m from the 500-kg object toward the smaller object}}$.

P13.5 The force exerted on the 4.00-kg mass by the 2.00-kg mass is directed upward and given by

$$\vec{F}_{24} = G\frac{m_4m_2}{r_{24}^2}\hat{\mathbf{j}} = \left(6.67\times10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2\right)\frac{(4.00\ \text{kg})(2.00\ \text{kg})}{(3.00\ \text{m})^2}\mathbf{j}$$

$$= 5.93\times10^{-11}\,\hat{\mathbf{j}}\ \text{N}$$

The force exerted on the 4.00-kg mass by the 6.00-kg mass is directed to the left

$$\vec{F}_{64} = G\frac{m_4m_6}{r_{64}^2}\left(-\hat{\mathbf{i}}\right) = \left(-6.67\times10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2\right)\frac{(4.00\ \text{kg})(6.00\ \text{kg})}{(4.00\ \text{m})^2}\mathbf{i}$$

$$= -10.0\times10^{-11}\,\hat{\mathbf{i}}\ \text{N}$$

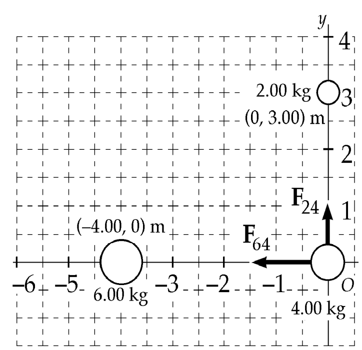

FIG. P13.5

Therefore, the resultant force on the 4.00-kg mass is $\vec{F}_4 = \vec{F}_{24} + \vec{F}_{64} = \boxed{\left(-10.0\hat{\mathbf{i}} + 5.93\mathbf{j}\right)\times10^{-11}\ \text{N}}$.

P13.7 $$F = \frac{GMm}{r^2} = \left(6.67\times10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2\right)\frac{(1.50\ \text{kg})\left(15.0\times10^{-3}\ \text{kg}\right)}{\left(4.50\times10^{-2}\ \text{m}\right)^2} = \boxed{7.41\times10^{-10}\ \text{N}}$$

P13.9 $a = \frac{MG}{(4R_E)^2} = \frac{9.80\ \text{m/s}^2}{16.0} = \boxed{0.613\ \text{m/s}^2}$ toward the Earth.

P13.11 $$g = \frac{GM}{R^2} = \frac{G\rho\left(4\pi R^3/3\right)}{R^2} = \frac{4}{3}\pi G\rho R$$

If $$\frac{g_M}{g_E} = \frac{1}{6} = \frac{4\pi G\rho_M R_M/3}{4\pi G\rho_E R_E/3}$$

then $$\frac{\rho_M}{\rho_E} = \left(\frac{g_M}{g_E}\right)\left(\frac{R_E}{R_M}\right) = \left(\frac{1}{6}\right)(4) = \boxed{\frac{2}{3}}$$