6. Let the distance from Earth to the spaceship be r. $R_{em} = 3.82 \times 10^8$ m is the distance from Earth to the moon. Thus,

$$F_m = \frac{GM_m m}{(R_{em} - r)^2} = F_E = \frac{GM_e m}{r^2} \, ,$$

where m is the mass of the spaceship. Solving for r, we obtain

$$\begin{aligned} r &= \frac{R_{em}}{\sqrt{M_m/M_e} + 1} \\ &= \frac{3.82 \times 10^8 \text{ m}}{\sqrt{(7.36 \times 10^{22} \text{ kg})/(5.98 \times 10^{24} \text{ kg})} + 1} = 3.44 \times 10^8 \text{ m} \, . \end{aligned}$$

8. Using $F = GmM/r^2$, we find that the topmost mass pulls upward on the one at the origin with 1.9×10^{-8} N, and the rightmost mass pulls rightward on the one at the origin with 1.0×10^{-8} N. Thus, the (x, y) components of the net force, which can be converted to polar components (here we use magnitude-angle notation), are

$$\vec{F}_{\text{net}} = \left(1.0 \times 10^{-8}, 1.9 \times 10^{-8}\right) \implies \left(2.1 \times 10^{-8} \angle\, 61^\circ\right) .$$

The magnitude of the force is 2.1×10^{-8} N.

16. (a) The gravitational acceleration at the surface of the Moon is $g_{\text{moon}} = 1.67$ m/s^2 (see Appendix C). The ratio of weights (for a given mass) is the ratio of g-values, so $W_{\text{moon}} = (100\,\text{N})(1.67/9.8) = 17\,\text{N}$.

(b) For the force on that object caused by Earth's gravity to equal 17 N, then the free-fall acceleration at its location must be $a_g = 1.67$ m/s^2. Thus,

$$a_g = \frac{GM_E}{r^2} \implies r = \sqrt{\frac{GM_E}{a_g}} = 1.5 \times 10^7\,\text{m}$$

so the object would need to be a distance of $r/R_E = 2.4$ "radii" from Earth's center.

22. (a) What contributes to the GmM/r^2 force on m is the (spherically distributed) mass M contained within r (where r is measured from the center of M). At point A we see that $M_1 + M_2$ is at a smaller radius than $r = a$ and thus contributes to the force:

$$|F_{\text{on}\,m}| = \frac{G\,(M_1 + M_2)\,m}{a^2} \quad .$$

(b) In the case $r = b$, only M_1 is contained within that radius, so the force on m becomes GM_1m/b^2.

(c) If the particle is at C, then no other mass is at smaller radius and the gravitational force on it is zero.

29. (a) The density of a uniform sphere is given by $\rho = 3M/4\pi R^3$, where M is its mass and R is its radius. The ratio of the density of Mars to the density of Earth is

$$\frac{\rho_M}{\rho_E} = \frac{M_M}{M_E}\,\frac{R_E^3}{R_M^3} = 0.11\left(\frac{0.65\times 10^4\,\text{km}}{3.45\times 10^3\,\text{km}}\right)^3 = 0.74\ .$$

(b) The value of a_g at the surface of a planet is given by $a_g = GM/R^2$, so the value for Mars is

$$a_{gM} = \frac{M_M}{M_E}\,\frac{R_E^2}{R_M^2}\,a_{gE} = 0.11\left(\frac{0.65\times 10^4\,\text{km}}{3.45\times 10^3\,\text{km}}\right)^2 (9.8\,\text{m/s}^2) = 3.8\ \text{m/s}^2\ .$$

(c) If v is the escape speed, then, for a particle of mass m

$$\tfrac{1}{2}mv^2 = G\frac{mM}{R}$$

and

$$v = \sqrt{\frac{2GM}{R}}\ .$$

For Mars

$$v = \sqrt{\frac{2(6.67\times 10^{-11}\,\text{m}^3/\text{s}^2\cdot\text{kg})(0.11)(5.98\times 10^{24}\,\text{kg})}{3.45\times 10^6\,\text{m}}} = 5.0\times 10^3\ \text{m/s}\ .$$

42. With $T = 27.3(86400) = 2.36 \times 10^6$ s, Kepler's law of periods becomes

$$T^2 = \left(\frac{4\pi^2}{GM_E}\right) r^3 \quad \Longrightarrow \quad M_E = \frac{4\pi^2 \left(3.82 \times 10^8\right)^3}{(6.67 \times 10^{-11}) \left(2.36 \times 10^6\right)^2}$$

which yields $M_E = 5.93 \times 10^{24}$ kg for the mass of Earth.