Chapter 2.9

1 (a) $F = G\frac{Mm}{R^2} = 6.67\times10^{-11}\times\frac{5.98\times10^{24}\times7.35\times10^{22}}{(3.84\times10^{8})^2} = 1.99\times10^{20}$ N.

(b) $F = G\frac{Mm}{R^2} = 6.67\times10^{-11}\times\frac{1.99\times10^{30}\times1.90\times10^{27}}{(7.78\times10^{11})^2} = 4.17\times10^{23}$ N.

(c) $F = G\frac{Mm}{R^2} = 6.67\times10^{-11}\times\frac{1.67\times10^{-27}\times9.11\times10^{-31}}{(1.0\times10^{-10})^2} = 1.0\times10^{-47}$ N.

2 (a) Zero since it is being pulled equally from all directions. (b) Zero, by Newton's third law. (c) $F = G\frac{m^2}{4R^2}$, (d) $F = G\frac{m^2}{4R^2} + G\frac{Mm}{4R^2} = G\frac{m(m+M)}{4R^2}$.

3 $$\frac{g_A}{g_B} = \frac{\frac{GM}{(9R)^2}}{\frac{GM}{R^2}} = \frac{1}{81}.$$

4 $$\frac{g_A}{g_B} = \frac{\frac{G2M}{(2R)^2}}{\frac{GM}{R^2}} = \frac{1}{2}.$$

5 Since star A is 27 times as massive and the density is the same the volume of A must be 27 times as large. Its radius must therefore be 3 times as large. Hence $\frac{g_A}{g_B} = \frac{\frac{G27M}{(3R)^2}}{\frac{GM}{R^2}} = 3$.

6 $$\frac{g_{new}}{g_{old}} = \frac{\frac{GM/2}{(R/2)^2}}{\frac{GM}{R^2}} = 2.$$

7 Let this point be a distance x from the center of the Earth and let d be the center to center distance between the earth and the moon. Then

$$\frac{G81M}{x^2} = \frac{GM}{(d-x)^2}$$
$$81(d-x)^2 = x^2$$
$$9(d-x) = x$$
$$x = \frac{9d}{10}$$

8 (a) At point P the gravitational field strength is obviously zero. (b) The gravitational field strength at Q from each of the masses is

$g = \frac{GM}{R^2} = 6.67 \times 10^{-11} \times \frac{3.0 \times 10^{22}}{(\sqrt{2} \times 10^9)^2} = 1.0 \times 10^6 \text{ N kg}^{-1}$. The net field, taking components, is directed from Q tp P and has magnitude $2g\cos 45^\circ = 2 \times 1 \times 10^6 \cos 45^\circ = 1.4 \times 10^6 \text{ N kg}^{-1}$.

9 The left body has the larger mass since the equilibrium point is closer to the body on the right. If the mass is displaced to the left the attractive force to the left will be larger both because the left mass is larger and because the distance is closer. Hence the mass will move to the left and will not return to the equilibrium position.