Chapter 13

13.1 What must the separation be between a 5.2kg particle and a 2.4 kg particle for their gravitation attraction have a magnitude of $2.3\times10^{-12}N$?

Newton's Law of Universal Gravitation states

$$F = G\frac{M\,m}{r^2}$$
$$r = \sqrt{G\frac{M\,m}{F}} = \sqrt{6.67\times10^{-11}\cdot\frac{5.2kg\cdot 2.4kg}{2.3\times10^{-12}}}$$
$$= 19.02m$$

13.3. A mass M is split into two parts, m and M-m whar are then separated by a a certain distance. What ratio m/M maximizes the magnitude of the gravitational force between the parts?

This is an optimization problem. Let's find the m that maximizes F by taking the derivative of F with respect to m and setting it equal to 0.

$$F = G\frac{(M-m)m}{r^2}$$
$$F = G\frac{Mm - m^2}{r^2}$$
$$\frac{dF}{dm} = 0 = G\frac{M-2m}{r^2}$$
$$2m = M$$
$$\frac{m}{M} = \frac{1}{2}$$

13.17 At what altitude above Earth's surface would the gravitation acceleration be 4.9 m/s^2

We begin by writing the gravitational force on a mass at a distance r from the earth's center. We then calculate the distance d above the surface.

$$ma = G\frac{M_E m}{r^2}$$

$$a = G\frac{M_E}{r^2}$$

$$r = \sqrt{G\frac{M_E}{a}} = \sqrt{6.67\times10^{-11}\frac{5.98\times10^{24}}{4.9}} = 9.02\times10^6 m$$

$$d = r - r_E = 9.02\times10^6 m - 6.37\times10^6 m$$

$$= 2.65\times10^6 m$$