What is the average gravitational force acting between two objects standing 10 m way ? Assume each of the objects has 78 kg mass.

$$F = G\, M_1\, M_2 \,/\, R^2$$

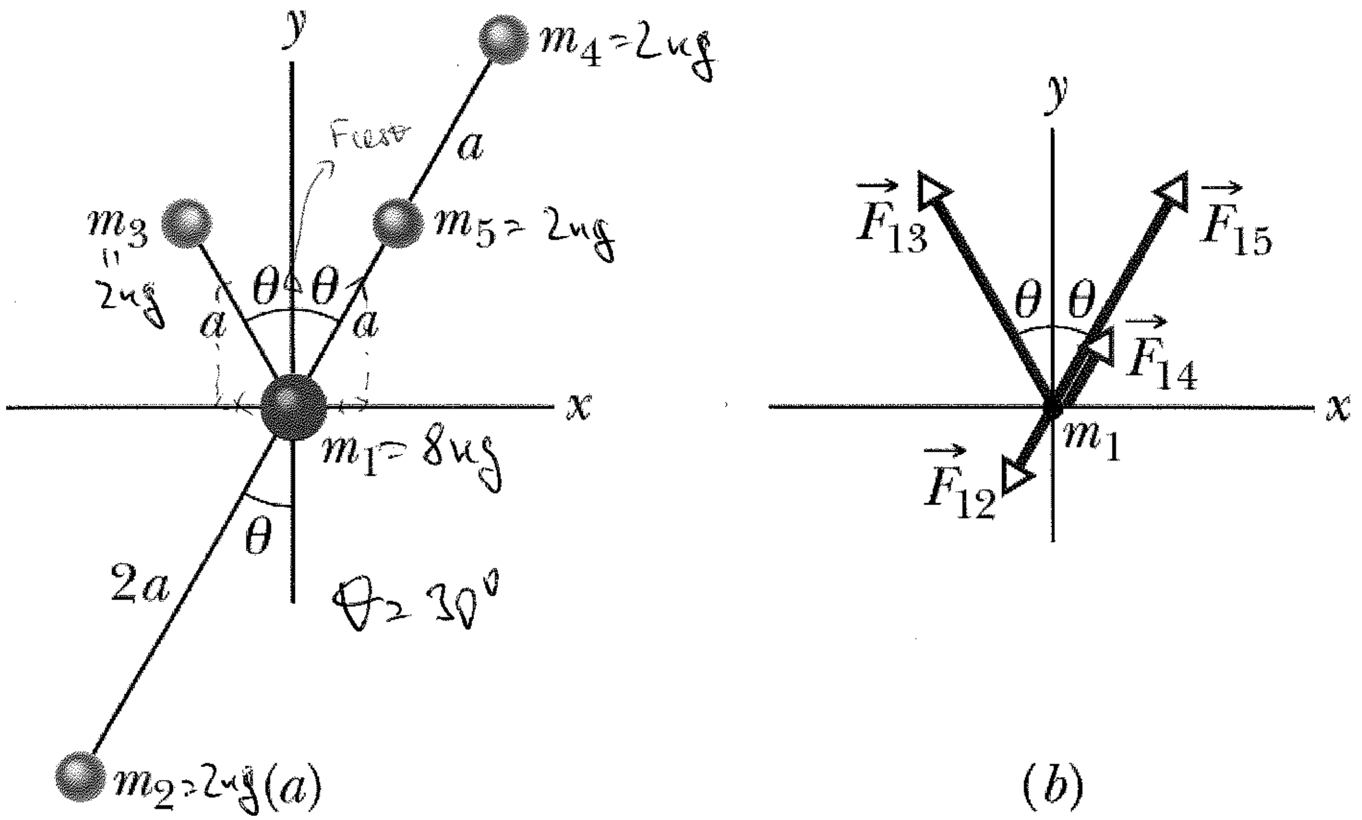
$$G = 6.67 * 10^{-11}\ N.m^2/kg^2$$

$$M_1 = M_2 = 78\ kg$$

$$R = 10\ m$$

$$F = (6.67 * 10^{-11}\ N.m^2/kg^2 * 78 * 78)/(10\ m * 10\ m)$$

$$F = 4.06 * 10^{-9}\ N$$



$$F_{12} = F_{14} = \frac{G m_1 m_2}{(2a)^2} \quad , \quad \vec{F}_{12} = -\vec{F}_{14}$$

$$|F_{13}| = |F_{15}| = \frac{G m_1 m_3}{a^2}$$

$$\vec{F}_{net} = 2 F_{13} \cos\theta = 4.6 \times 10^{-6}\ N$$

6E. A spaceship is on a straight-line path between Earth and its moon. At what distance from Earth is the net gravitational force on the spaceship zero?

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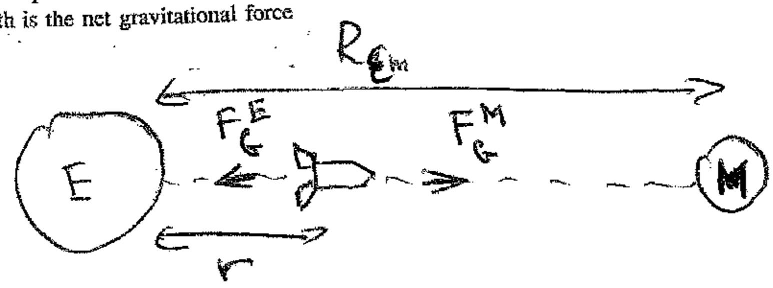

6. Let the distance from Earth to the spaceship be r. $R_{em} = 3.82 \times 10^8$ m is the distance from Earth to the moon. Thus,

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

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

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

$$\frac{M_m}{(R_{Em} - r)^2} = \frac{M_E}{r^2}$$

$$\frac{M_m}{M_E} = \frac{(R_{em} - r)^2}{r^2}$$

$$\sqrt{\frac{M_m}{M_E}} = \frac{R_{em} - r}{r} = \frac{R_{em}}{r} - 1$$

$$\sqrt{\frac{M_m}{M_E}} + 1 = \frac{R_{em}}{r}$$

$$r = \frac{R_{em}}{\sqrt{\frac{M_m}{M_E}} + 1}$$

$M_E = 5.98 \times 10^{24}$ kg

$M_M = 7.36 \times 10^{22}$ kg

$r = 5.29\times10^{-11}$ m, $m_e = 9.11\times10^{-31}$ kg; $m_p = 1.67\times10^{-27}$ kg

33. ORGANIZE AND PLAN Newton's law of gravitation works for protons and electrons as well as for heavenly bodies. The mass of the proton is [Eq. 1] $m_p = 1.67\times10^{-27}$ kg, and of the electron is [Eq. 2] $m_{e^-} = 9.11\times10^{-31}$ kg

Known: $r = 5.29\times10^{-11}$ m.

SOLVE Using Newton's law of gravitation, the force between the electron and proton is [Eq. 3]

$$F = \frac{Gm_p m_{e^-}}{r^2}$$

$$F = \frac{(6.67\times10^{-11}\ \text{N}\cdot\text{kg}^2/\text{m}^2)(1.67\times10^{-27}\ \text{kg})(9.11\times10^{-31}\ \text{kg})}{(5.29\times10^{-11}\ \text{m})^2} = 3.63\times10^{-47}\ \text{N}$$

REFLECT The electromagnetic force is some 10^{36} times stronger than the force due to gravity. This means the electromagnetic force between two protons a light-year apart would be approximately the same as the gravitational force between protons and centimeter apart.