1. \( m = 1 \text{ gm} = 1/1000 \text{ kg} \)

\[ F = 6.67 \times 10^{-17} \text{ N} \Rightarrow F = \frac{Gm_1m_2}{r^2} \]

\[ \therefore 6.67 \times 20^{-17} = \frac{6.67 \times 10^{-11} \times (1/1000) \times (1/1000)}{r^2} \]

\[ \Rightarrow r^2 = \frac{6.67 \times 10^{-11} \times 10^{-6}}{6.64 \times 10^{-17}} = 10^{-17} \]

\[ \Rightarrow r = \sqrt{1} = 1 \text{ metre}. \]

So, the separation between the particles is 1 m.

2. A man is standing on the surface of earth

The force acting on the man = \( mg \) ………(i)

Assuming that, \( m \) = mass of the man = 50 kg

And \( g \) = acceleration due to gravity on the surface of earth = 10 m/s\(^2\)

\( W = mg = 50 \times 10 = 500 \text{ N} = \text{force acting on the man} \)

So, the man is also attracting the earth with a force of 500 N

3. The force of attraction between the two charges

\[ F = \frac{1}{4\pi\varepsilon_o} \frac{q_1q_2}{r^2} = 9 \times 10^9 \frac{1}{r^2} \]

The force of attraction is equal to the weight

\[ Mg = \frac{9 \times 10^9}{r^2} \]

\[ \Rightarrow r^2 = \frac{9 \times 10^9}{m \times 10} = \frac{9 \times 10^8}{m} \]

\[ \Rightarrow r = \sqrt{\frac{9 \times 10^8}{m}} \frac{3 \times 10^4}{\sqrt{m}} \text{ mt} \]

For example, Assuming \( m=64 \text{ kg} \),

\[ r = \frac{3 \times 10^4}{\sqrt{64}} = \frac{3 \times 10^4}{8} = 3750 \text{ m} \]

4. mass = 50 kg

\( r = 20 \text{ cm} = 0.2 \text{ m} \)

\[ F_G = G\frac{m_1m_2}{r^2} = \frac{6.67 \times 10^{-11} \times 2500}{0.04} \]

Coulomb’s force

\[ F_C = \frac{1}{4\pi\varepsilon_o} \frac{q_1q_2}{r^2} = 9 \times 10^9 \frac{q^2}{0.04} \]

Since, \( F_G = F_C \)

\[ \Rightarrow q^2 = \frac{6.7 \times 10^{-11} \times 2500}{0.04} = \frac{6.7 \times 10^{-9} \times 25}{9 \times 10^6 \times 25} \]

\[ = 18.07 \times 10^{-18} \]

\[ q = \sqrt{18.07 \times 10^{-18}} = 4.3 \times 10^{-9} \text{ C}. \]

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4.1
5. The limb exerts a normal force 48 N and frictional force of 20 N. Resultant magnitude of the force,
\[ R = \sqrt{(48)^2 + (20)^2} \]
\[ = \sqrt{2304 + 400} \]
\[ = \sqrt{2704} \]
\[ = 52 N \]

6. The body builder exerts a force = 150 N.

Compression \( x = 20 \text{ cm} = 0.2 \text{ m} \)

\[ \therefore \text{Total force exerted by the man} = f = kx \]
\[ \Rightarrow kx = 150 \]
\[ \Rightarrow k = \frac{150}{0.2} = 750 \text{ N/m} \]

7. Suppose the height is \( h \).

At earth station \( F = \frac{GMm}{R^2} \)

\( M = \) mass of earth
\( m = \) mass of satellite
\( R = \) Radius of earth

\[ F = \frac{GMm}{(R + h)^2} = \frac{GMm}{2R^2} \]
\[ \Rightarrow 2R^2 = (R + h)^2 \Rightarrow R^2 - h^2 - 2Rh = 0 \]
\[ \Rightarrow h^2 + 2Rh = R^2 \]
\[ H = \frac{-2R \pm \sqrt{4R^2 + 4R^2}}{2} = \frac{-2R \pm 2R}{2} \]
\[ = -R \pm \sqrt{R^2} = R(\sqrt{2} - 1) \]
\[ = 6400 \times (0.414) \]
\[ = 2649.6 = 2650 \text{ km} \]

8. Two charged particle placed at a separation 2m. exert a force of 20m.

\( F_1 = 20 \text{ N.} \quad r_1 = 20 \text{ cm} \)

\( F_2 = ? \quad r_2 = 25 \text{ cm} \)

Since, \( F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \), \( F \propto \frac{1}{r^2} \)

\[ \frac{F_1}{F_2} = \frac{r_2^2}{r_1^2} \Rightarrow F_2 = F_1 \times \left( \frac{r_1}{r_2} \right)^2 = 20 \times \left( \frac{20}{25} \right)^2 = 20 \times \frac{16}{25} = \frac{64}{5} = 12.8 \text{ N = 13 N.} \]

9. The force between the earth and the moon, \( F = \frac{G m_m m_e}{r^2} \)

\[ F = 6.67 \times 10^{-11} \times 7.36 \times 10^{22} \times 6 \times 10^{24} \]
\[ = \frac{6.67 \times 7.36 \times 10^{35}}{(3.8 \times 10^8)^2} \]
\[ = 20.3 \times 10^{19} \text{ N} = 2 \times 10^{20} \text{ N} \]

10. Charge on proton = \( 1.6 \times 10^{-19} \)

\[ \therefore F_{\text{electrical}} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} = \frac{9 \times 10^9 \times (1.6)^2 \times 10^{-38}}{r^2} \]

mass of proton = \( 1.732 \times 10^{-27} \text{ kg} \)
\[ F_{\text{gravity}} = G \frac{m_1 m_2}{r^2} = \frac{6.67 \times 10^{-11} \times (1.732) \times 10^{-54}}{r^2} \]

\[ F_e = \frac{9 \times 10^9 \times (1.6)^2 \times 10^{-38}}{r^2} \]

\[ F_g = \frac{6.67 \times 10^{-11} \times (1.732) \times 10^{-54}}{r^2} = \frac{9 \times (1.6)^2 \times 10^{-29}}{6.67 (1.732)^2 \times 10^{-65}} = 1.24 \times 10^{36} \]

11. The average separation between proton and electron of Hydrogen atom is \( r = 5.3 \times 10^{-11} \) m.

a) Coulomb’s force \( F = 9 \times 10^9 \times \frac{q_1 q_2}{r^2} = \frac{9 \times 10^9 \times (1.0 \times 10^{-19})^2}{(5.3 \times 10^{-11})^2} = 8.2 \times 10^{-8} \) N.

b) When the average distance between proton and electron becomes 4 times that of its ground state

Coulomb’s force \( F = \frac{1}{4 \pi \varepsilon_0} \times \frac{q_1 q_2}{(4r)^2} = \frac{9 \times 10^9 \times (1.6 \times 10^{-19})^2}{16 \times (5.3)^2 \times 10^{-22}} = \frac{9 \times (1.6)^2}{16 \times (5.3)^2} \times 10^{-7} \)

\[ = 0.0512 \times 10^{-7} = 5.1 \times 10^{-9} \) N.

12. The geostationary orbit of earth is at a distance of about 36000km.

We know that, \( g' = \frac{GM}{(R+h)^2} \)

At \( h = 36000 \) km. \( g' = \frac{GM}{(36000+6400)^2} \)

\[ \therefore \frac{g'}{g} = \frac{6400 \times 6400}{42400 \times 42400} = \frac{256}{106 \times 106} = 0.0227 \]

\[ \Rightarrow g' = 0.0227 \times 9.8 = 0.223 \]

[ taking \( g = 9.8 \text{ m/s}^2 \) at the surface of the earth]

A 120 kg equipment placed in a geostationary satellite will have weight

\[ Mg' = 0.233 \times 120 = 26.79 = 27 \) N

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