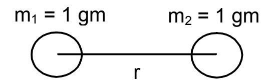
SOLUTIONS TO CONCEPTS
CHAPTER – 4



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

   $F = 6.67 \times 10^{-17} \text{ N} \Rightarrow F = \dfrac{Gm_1m_2}{r^2}$

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

   $\Rightarrow r^2 = \dfrac{6.67 \times 10^{-11} \times 10^{-6}}{6.64 \times 10^{-17}} = \dfrac{10^{-17}}{10^{-17}} = 1$

   $\Rightarrow \quad r = \sqrt{1} = 1$ 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× 10= 500 N = 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

   $= \dfrac{1}{4\pi\varepsilon_o} \dfrac{q_1 q_2}{r^2} = 9 \times 10^9 \dfrac{1}{r^2}$

   The force of attraction is equal to the weight

   $Mg = \dfrac{9 \times 10^9}{r^2}$

   $\Rightarrow r^2 = \dfrac{9 \times 10^9}{m \times 10} = \dfrac{9 \times 10^8}{m}$ [Taking g=10 m/s^2]

   $\Rightarrow r = \sqrt{\dfrac{9 \times 10^8}{m}} = \dfrac{3 \times 10^4}{\sqrt{m}}$ mt

   For example, Assuming m= 64 kg,

   $r = \dfrac{3 \times 10^4}{\sqrt{64}} = \dfrac{3}{8} 10^4 = 3750 \text{ m}$

4. mass = 50 kg

   r = 20 cm = 0.2 m

   $F_G = G\dfrac{m_1m_2}{r^2} = \dfrac{6.67 \times 10^{-11} \times 2500}{0.04}$

   Coulomb's force $\quad F_C = \dfrac{1}{4\pi\varepsilon_o}\dfrac{q_1q_2}{r^2} = 9 \times 10^9 \dfrac{q^2}{0.04}$

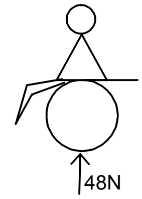
   Since, $F_G = F_c = \dfrac{6.7 \times 10^{-11} \times 2500}{0.04} = \dfrac{9 \times 10^9 \times q^2}{0.04}$

   $\Rightarrow q^2 = \dfrac{6.7 \times 10^{-11} \times 2500}{0.04} = \dfrac{6.7 \times 10^{-9}}{9 \times 10^9} \times 25$

   $= 18.07 \times 10^{-18}$

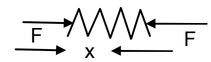
   $q = \sqrt{18.07 \times 10^{-18}} = 4.3 \times 10^{-9}$ C.

5. The limb exerts a normal force 48 N and frictional force of 20 N. Resultant magnitude of the force,



$$R = \sqrt{(48)^2 + (20)^2}$$
$$= \sqrt{2304 + 400}$$
$$= \sqrt{2704}$$
$$= 52 \text{ N}$$

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



Compression x = 20 cm = 0.2 m

$\therefore$ Total force exerted by the man = f = kx

$\Rightarrow$ kx = 150

$\Rightarrow k = \dfrac{150}{0.2} = \dfrac{1500}{2}$ = 750 N/m

7. Suppose the height is h.

At earth station F = GMm/R^2

M = mass of earth

m = mass of satellite

R = Radius of earth

$$F = \frac{GMm}{(R+h)^2} = \frac{GMm}{2R^2}$$

$\Rightarrow 2R^2 = (R + h)^2 \Rightarrow R^2 - h^2 - 2Rh = 0$

$\Rightarrow h^2 + 2Rh - R^2 = 0$

$$H = \frac{\left(-2R \pm \sqrt{4R^2 + 4R^2}\right)}{2} = \frac{-2R \pm 2\sqrt{2R}}{2}$$
$$= -R \pm \sqrt{2R} = R\left(\sqrt{2} - 1\right)$$
$$= 6400 \times (0.414)$$
$$= 2649.6 = 2650 \text{ km}$$

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

F_1 = 20 N. $\quad$ r_1 = 20 cm

F_2 = ? $\quad$ r_2 = 25 cm

Since, $F = \dfrac{1}{4\pi\varepsilon_o}\dfrac{q_1q_2}{r^2}$, $\quad F \propto \dfrac{1}{r^2}$

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

9. The force between the earth and the moon, $F = G\dfrac{m_m m_c}{r^2}$

$$F = \frac{6.67 \times 10^{-11} \times 7.36 \times 10^{22} \times 6 \times 10^{24}}{\left(3.8 \times 10^8\right)^2} = \frac{6.67 \times 7.36 \times 10^{35}}{(3.8)^2 \times 10^{16}}$$
$$= 20.3 \times 10^{19} = 2.03 \times 10^{20} \text{ N} = 2 \times 10^{20} \text{ N}$$

10. Charge on proton = 1.6×10^{-19}

$$\therefore F_{electrical} = \frac{1}{4\pi\varepsilon_o} \times \frac{q_1q_2}{r^2} = \frac{9 \times 10^9 \times (1.6)^2 \times 10^{-38}}{r^2}$$

mass of proton = 1.732×10^{-27} kg

$$F_{gravity} = G\frac{m_1m_2}{r^2} = \frac{6.67\times10^{-11}\times(1.732)\times10^{-54}}{r^2}$$

$$\frac{F_e}{F_g} = \frac{\dfrac{9\times10^9\times(1.6)^2\times10^{-38}}{r^2}}{\dfrac{6.67\times10^{-11}\times(1.732)\times10^{-54}}{r^2}} = \frac{9\times(1.6)^2\times10^{-29}}{6.67\ (1.732)^2\ 10^{-65}} = 1.24 \times 10^{36}$$

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

    a) Coulomb's force = F = $9 \times 10^9 \times \frac{q_1q_2}{r^2} = \frac{9\times10^9\times(1.0\times10^{-19})^2}{(5.3\times10^{-11})^2} = 8.2 \times 10^{-8}$ N.

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

    Coulomb's force F = $\frac{1}{4\pi\varepsilon_o}\times\frac{q_1q_2}{(4r)^2} = \frac{9\times10^9\times(1.6\times10^{-19})^2}{16\times(5.3)^2\times10^{-22}} = \frac{9\times(1.6)^2}{16\times(5.3)^2}\times10^{-7}$

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

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

    We know that, $g' = GM / (R+h)^2$

    At h = 36000 km. $g' = GM / (36000+6400)^2$

    $\therefore \frac{g`}{g} = \frac{6400\times6400}{42400\times42400} = \frac{256}{106\times106} = 0.0227$

    $\Rightarrow g' = 0.0227 \times 9.8 = 0.223$

    [taking g = 9.8 m/s^2 at the surface of the earth]

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

    Mg` = 0.233 × 120 = 26.79 = 27 N

* * * *