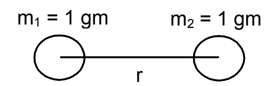
SOLUTIONS TO CONCEPTS
CHAPTER – 4

1. m = 1 gm = 1/1000 kg



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

$\therefore 6.67 \times 20^{-17} = \frac{6.67\times10^{-11}\times(1/1000)\times(1/1000)}{r^2}$

$\Rightarrow r^2 = \frac{6.67\times10^{-11}\times10^{-6}}{6.64\times10^{-17}} = \frac{10^{-17}}{10^{-17}} = 1$

$\Rightarrow\ r = \sqrt{1}$ = 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

$= \frac{1}{4\pi\varepsilon_o}\ \frac{q_1 q_2}{r^2} = 9\times10^9\ \frac{1}{r^2}$

The force of attraction is equal to the weight

$Mg = \frac{9\times10^9}{r^2}$

$\Rightarrow r^2 = \frac{9\times10^9}{m\times10} = \frac{9\times10^8}{m}$ [Taking g=10 m/s^2]

$\Rightarrow r = \sqrt{\frac{9\times10^8}{m}} = \frac{3\times10^4}{\sqrt{m}}$ mt

For example, Assuming m= 64 kg,

$r = \frac{3\times10^4}{\sqrt{64}} = \frac{3}{8}10^4$ = 3750 m

4. mass = 50 kg

r = 20 cm = 0.2 m

$F_G = G\frac{m_1m_2}{r^2} = \frac{6.67\times10^{-11}\times2500}{0.04}$

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

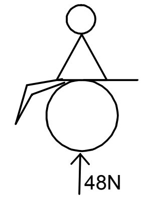
Since, $F_G = F_c = \frac{6.7\times10^{-11}\times2500}{0.04} = \frac{9\times10^9\times q^2}{0.04}$

$\Rightarrow q^2 = \frac{6.7\times10^{-11}\times2500}{0.04} = \frac{6.7\times10^{-9}}{9\times10^9}\times25$

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

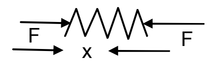
$q = \sqrt{18.07\times10^{-18}} = 4.3 \times 10^{-9}$ C.

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

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

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

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

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

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

$$= 20.3 \times 10^{19} = 2.03 \times 10^{20} \text{ N} = 2 \times 10^{20} \text{ N}$$

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

$$F_{gravity} = G\frac{m_1m_2}{r^2} = \frac{6.67 \times 10^{-11} \times (1.732) \times 10^{-54}}{r^2}$$

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

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

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

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