The Forces

Exercise Solutions

Solution 1:
Mass of the particle, m = 1 g or 1/1000 kg

Let the r be the distance between the particles, then the gravitational force between the particles,
F = 6.67 x 10^{-17} N

Now, gravitational force existing between the particles:

$$F = G \times \frac{m_1 m_2}{r^2}$$

$$6.67 \times 10^{-17} = 6.67 \times 10^{-11} \times \left(\frac{\frac{1}{1000} \times \frac{1}{1000}}{r^2}\right)$$

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

=> r = 1m

Separation between the particles is 1 m.

Solution 2:
Let m be the mass of the man standing on earth, the earth's gravitational force will act on man mg.

Where m = mass of the man and g = acceleration due to gravity on the surface of earth =10 m/s^2

Let mass of the man=50 kg.
F = W = mg = 50x10 = 500N = force acting on the man.
Man is also attracting the earth with a force of 500 N.

Solution 3:

Coulomb's force of attraction between two charges is given by –

$$F = k\ \frac{q_1 \times q_2}{r^2}$$

Where, q_1 and q_2 are the charges, r= distance between the charges and k = proportionality constant

Here $q_1 = q_2 = 1C$ and $k = 9 \times 10^9$

=> $F = k/r^2$ ...(1)

Force of attraction is equal to the weight (Given)
$F = mg$ ...(2)

Equation (1) and (2), we have

$mg = k/r^2$ ...(3)

Let us assume that, mass = m = 64 kg

(3)=> $r = (3x10^4)/\sqrt{64}$

r = 3750 m

Solution 4:
Given, mass = 50 kg, r = 20 cm or 0.2 m

Coulomb's force of repulsion between two charges:

$$F_c = k\,\frac{q_1 \times q_2}{r^2}$$

Where, q_1 and q_2 are the charges, r= distance between the charges and k = proportionality constant

Here $q_1 = q_2 = 1C$ and $k = 9 \times 10^9$

Again, gravitational force,

$$F_G = G \times \frac{m_1 \times m_2}{r^2}$$

Where, G = universal gravitation constant

m_1 = mass of first object and m_2 = mass of second object and r = distance between the objects

$m_1 = m_2 = 50Kg$

Now,

$F_G = F_C$

=>

$$G \times \frac{m_1 \times m_2}{r^2} = k\ \frac{q \times q}{r^2}$$

By putting the values, we have

$$6.67\ \times\ 10^{-11} \times \frac{50 \times 50}{0.2^2} = 9 \times 10^9\ \frac{q \times q}{0.2^2}$$

$$\Rightarrow q = \ 4.3 \times 10^{-9}\ C$$

Solution 5:

Given: Normal force = 48N and Frictional force = 20N

The resultant magnitude of the force, say R,

$R^2 = (48)^2 + (20)^2$

or R = 52 N

Solution 6:

Body builder exerts a force = 150N

Compressed length = 20cm or 0.2m

Force applied on a string: F = kx

Where, K = spring constant and x = displacement

150 = k x 0.2

=> k = 750 N/m

Solution 7:

Given, radius of Earth = 6400 Km

Let R be the radius of earth, M be the mass of earth and m be the mass of the satellite.

Also assume, at height h, the force on the satellite due to earth is reduce to half.

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

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

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

$$H = \frac{\left(-2R \pm \sqrt{4R^2 + 4R^2}\right)}{2} = \frac{-2R \pm 2\sqrt{2R}}{2}$$

$$= -R \pm \sqrt{2R} = R\left(\sqrt{2} - 1\right)$$

= 6400 x 0.414

= 2650 km

Solution 8:

Coulomb's force between two charges:

$$F_c = k\,\frac{q_1 \times q_2}{r^2}$$

Where, q_1 and q_2 are the charges, r= distance between the charges and k = proportionality constant

and $k = 9 \times 10^9$

When, r = 20 cm = 0.2m, Coulomb's force = 20 N

$$F_1 = 20 = k\,\frac{q_1 \times q_2}{0.2^2}$$

When r = 25 cm

$$F_2 = k\,\frac{q_1 \times q_2}{0.25^2}$$

Now, ratio of F_1 and F_2

$F_1/F_2 = 20/F_2 = (0.2)^2/(0.25)^2$

=> F_2 = 13 N (approx)

Solution 9:
mass of the moon = 7.36×10^{22} kg

mass of the earth = 6×10^{24} kg

distance between moon and earth =3.8×10^{5} km

The force between moon and earth:

$$F_G = G \times \frac{m_1 \times m_2}{r^2}$$

$$F_G = 6.67 \times 10^{-11} \times \frac{7.36 \times 10^{22} \times 6 \times 10^{24}}{(3.8 \times 105)^2}$$

$$= 2 \times 10^{20} N$$

Weight of the moon is 2.0×10^{20} N.

Solution 10:
Coulomb's force of repulsion between two protons

$$F_c = k \frac{q_1 \times q_2}{r^2}$$

and gravitational force

$$F_G = G \times \frac{m_1 \times m_2}{r^2}$$

$G = 6.67 \times 10^{-11}$
$m_1 = m_2 = 1.67 \times 10^{-27}$

Coulomb force of repulsion between the two protons

$$F_c = 9 \times 10^9 \times \frac{(1.6 \times 10^{-19})^2}{r^2}$$

Ratio of the magnitude of the electric force to the gravitational force acting between two protons:

$$\frac{F_c}{F_G} = \frac{9 \times 10^9 \times \frac{(1.6 \times 10^{-19})^2}{r^2}}{6.67 \times 10^{-11} \times \frac{(1.67 \times 10^{-27})^2}{r^2}}$$

$$= 1.24 \times 10^{36}$$

Solution 11:

The average separation between the proton and the electron of a Hydrogen atom in ground state, r = 5.3×10^{-11} m

(a) Coulomb's force of between electron and proton

$$F_c = k\,\frac{q_1 \times q_2}{r^2}$$

Where, q_1 and q_2 are the charges, r= distance between the charges and k = proportionality constant

and k = 9×10^9

$$F_c = 9 \times 10^9 \times \frac{(1.6 \times 10^{-19})}{(5.3\ \times\ 10^{-11})^2}$$

$$= 8.2\ \times\ 10^{-8}\ N,$$

(b) the Coulomb force when the average separation between the proton and the electron increases to four times its value in the ground state:

$$F_c = 9 \times 10^9 \times \frac{(1.6 \times 10^{-19})}{(4\ \times 5.3\ \times\ 10^{-11})^2}$$

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

Solution 12:

The radius of the earth = 6400 km.

Equipment weight = 120-kg

Also given, geostationary orbit of the earth is at a distance of about 36000 km from the earth's surface.

The value acceleration due to gravity above the surface of the Earth

$$g' = G \times \frac{m}{(R+h)^2}$$

$$g' = G \times \frac{m}{(36000+6400)^2}$$

acceleration due to gravity is 9.8 m/s^2

$$g = G \times \frac{m}{(6400)^2}$$

$$9.8 = G \times \frac{m}{(6400)^2}$$

Now, ratio:

$$\frac{g'}{g} = \frac{G \times \frac{m}{(36000+6400)^2}}{G \times \frac{m}{(6400)^2}}$$