PRISM WORLD

Std.: 10 (English) **Science - I**

Chapter: 1

Q.1 Textbook activity question **2**

1 Will your weight remain constant as you go above the surface of the earth?

Ans i. Weight of a body depends on acceleration due to gravity. W = m × g.
ii. As we go above the surface of the earth height increases and hence acceleration decreases.
iii. As acceleration due to gravity decreases consequently weight decreases.

2 Will the direction of the gravitational force change as we go inside the earth?

Ans The direction of earth's gravitational force is towards the center of earth so it will not change.

Q.2 Match the pair **2**

1

I	II	III
i. Acceleration due to gravity	m/s^2	Zero at the centre
ii. Gravitational constant	Kg	Measure of inertia
	Nm^2/Kg^2	Same in entire universe
	N	Depends on height

Ans

I	II	III
i. Acceleration due to gravity	m/s^2	Depends on height
ii. Gravitational constant	Nm^2/Kg^2	Same in entire universe

2

I	II	III
i. Mass	m/s^2	Zero at the centre
ii. Weight	Kg	Measure of inertia
	Nm^2/Kg^2	Same in the entire universe
	N	Depends on height

Ans

I	II	III
i. Mass	Kg	Measure of inertia
ii. Weight	N	Zero at the centre

Q.3 Give scientific reasons **4**

1 If the value of ‘g’ suddenly becomes twice its value, it will become two times more difficult to pull a heavy object along the floor.

Ans i. Weight of an object depends on the value of ‘g’ as it is the force acting on the mass of that object by gravitation pull.
ii. Weight is directly proportional to value of ‘g’, and this increase as ‘g’ increase.
iii. As the value of ‘g’ is doubled, the weight of the object increases by factor 2, making the object heavy.
iv. Therefore, as weight is doubled, it becomes two times harder to pull the heavy object across the floor.

2 Value of ‘g’ at the centre of the earth is zero.

Ans i. As we go down towards the centre of the earth, the distance decreases and value of ‘g’ is expected to increase as it is inversely proportional to the distance.

ii. However, with increase in depth, the mass of the earth which contributes towards the gravitation also significantly decreases.

iii. Due to this, the value of ‘g’ decreased as the depth increase towards the centre.

iv. At centre of the earth, the mass contributing to gravitation becomes zero and therefore, value of ‘g’ becomes zero.

Q.4 Solve Numerical problems. **22**

1 Calculate the escape velocity on the surface of the moon given the mass and radius of the moon to be 7.34×10^{22} kg and 1.74×10^{6} m respectively.

Ans Given:

$G = 6.67 \times 10^{-11}$ N m^2/kg^2, mass of the moon = M = 7.34×10^{22} kg and radius of the moon = R = 1.74×10^{6} m.

Escape velocit y = $v_{esc} = \sqrt{\frac{2\ GM}{R}} \sqrt{\frac{2 \times 6.67 \times 10^{-11} \times 7.34 \times 10^{22}}{1.74 \times 10^{6}}}$

= 2.37 km/s

Escape velocity on the moon 2.37 km/s.

2 A tennis ball is thrown up and reaches a height of 4.05 m before coming down. What was its initial velocity? How much total time will it take to come down? Assume g = 10 m/s^2.

Ans For the upward motion of the ball, the final velocity of the ball = v = 0

Distance travelled by the ball = 4.05 m

acceleration a = - g = -10 m/s^2

Using Newton’s third equation of motion

$v^2 = u^2 + 2\ a\ s$

$0 = u^2 + 2\ (-10) \times 4.05$

$\therefore\ u^2 = 81$

u = 9 m/s The initial velocity of the ball is 9 m/s

Now let us consider the downward motion of the ball. Suppose the ball takes t seconds to come down. Now the initial velocity of the ball is zero, u = 0. Distance travelled by the ball on reaching the ground = 4.05 m. As the velocity and acceleration are in the same direction,

a = g = 10 m/s

According to Newton’s second equation of motion

$s = u\ t + \frac{1}{2} a\ t^2$

$4.05 = 0 + \frac{1}{2}\ 10\ t^2$

$t^2 = \frac{4.05}{5} = 0.81$, t = 0.9 s

The ball will take 0.9 s to reach the ground. It will take the same time to go up. Thus, the total time taken = 2 × 0.9 = 1.8 s

3 The masses of earth and moon are 6×10^{24} kg and 7.4×10^{22} kg respectively. The distance between them is 3.84×10^{5} km. Calculate gravitational force of attraction between the two? (G = 6.7×10^{-11} $NM^2\ kg^{-2}$).

Ans Given : Mass of earth = $M_E = 6 \times 10^{24}$kg

Mass of moon = $M_N = 7.4 \times 10^{22}$kg

Distance between them = d = 3.84×10^{5} km

= 3.84×10^{8} m

To find: Gravitational force, F = ?

Working: $F = \frac{G \times m_E \times m_N}{d^2}$

$\therefore$ $= \frac{6.7 \times 10^{-11} \times 6 \times 10^{24} \times 7.4 \times 10^{22}}{\left(3.84 \times 10^{8}\right)^2}$

$= \frac{297.48 \times 10^{35}}{14.75 \times 10^{16}} \times 2.016 \times 10^{20}$

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

Ans.: The gravitational force of attraction between Earth and the Moon

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

4 Let the period of revolution of a plant at a distance R from a star be T prove that if it was at distance 2R, its period of revolution will be $\sqrt{8}$ T.

Ans In first case : distance d_1 = R

time taken = t_1 = T

On increasing the distance to 2R,

Distance = D_2 = 2R

Time taken = t_2

Using Kepler's third law in both cases,

$$\frac{t_1^2}{d_1^3} = \text{constant} \quad \text{... (1)}$$

and $$\frac{t_2^2}{d_2^3} = \text{constant} \quad \text{... (2)}$$

Therefore:

$$\frac{t_1^2}{d_1^3} = \frac{t_2^2}{d_2^3}$$

Substituting values given:

$$\frac{T^2}{R^3} = \frac{t_2^2}{(2R)^3}$$

$$\frac{T^2}{R^3} = \frac{t^2}{8R^3}$$

$$t_2^2 = 8T^2$$

Taking square root on both sides.

$$t_2 = \sqrt{8}T$$

Hence proved.

5 Calculate the gravitational force due to the earth on Mahendra in the earlier example.

Ans Mass of the earth = m_1 = 6 × 1024 kg

Radius of the earth = R = 6.4×10^6 m

Mahendra's mass = m_2 = 75 kg

G = 6.67×10^{-11} Nm^2 /kg^2

Using the force law, the gravitational force on Mahendra due to earth is given by

This force is 1.83×10^9 times larger than the gravitational force between Mahendra and Virat.

$$F = \frac{G\, m_1 m_2}{R^2}$$

$$F = \frac{6.67 \times 10^{-11} \times 75 \times 6 \times 10^{24}}{(6.4 \times 10^6)^2} N = 733 \text{ N}$$

6 If a person weighs 750 N on earth, how much would be his weight on the Moon given that moon's mass is $\frac{1}{81}$ of that of the earth and its radius is $\frac{1}{3.7}$ of that of the earth ?

Ans **Given :**

Weight on earth = 750 N,

Ratio of mass of the earth (M_E) to mass of the moon (M_M) = $\frac{M_E}{M_M}$ = 81

Ratio of radius of earth (R_E) to radius of moon (R_M) = $\frac{R_E}{R_M}$ = 3.7

Let the mass of the person be m kg

Weight on the earth = m g = 750 = $\frac{m\, G\, M_E}{R_E^2}$

$\therefore$ m = $\frac{750\, R_E^2}{(G\, M_E)}$ ..... (i)

Weight on Moon = $\frac{m\, G\, M_M}{R_M^2}$ using (i)

$$= \frac{750\, R_E^2}{(G\, M_E)} \times \frac{G\, M_M}{R_M^2} = 750\, \frac{R_E^2}{R_M^2} \times \frac{M_M}{M_E} = 750 \times (3.7)^2 \times \frac{1}{81} = 126.8 \text{ N}$$

The weight on the moon is nearly 1/6th of the weight on the earth. We can write the weight on moon as mg_m (g_m is the accelaration due to gravity on the moon). Thus g_m is 1/6th of the g on the earth.

7 Show that in SI units, the unit of G is Newton m^2 kg^{-2}. The value of G was first experimentally measured by Henry Cavendish. In SI units its value is 6.673×10^{-11} N m^2 kg^{-2}.

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

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

G (SI unit) = $\frac{N.\,m^2}{kg.\ kg} = \frac{Nm^2}{kg^2}$

8 In the above example, assuming that the bench on which Mahendra is sitting is frictionless, starting with zero velocity, what will be Mahendra's velocity of motion towards Virat after 1 s ? Will this velocity change with time and how?

Ans **Given:** Force on Mahendra = F = 4.002 × 10^{-7} N,

Mahendra's mass = m = 75 kg

According to Newton's second law, the acceleration produced by the force on Mahendra = m = 75 kg.

$a = \frac{F}{m} = \frac{4.002 \times 10^{-7}}{75}$ = 5.34 × 10^{-9} m/s^2.

Using Newton's first equation, we can calculate Mahendra's velocity after 1s, Newton's first equation of motion is

v = u + at;

As Mahendra is sitting on the bench, his initial velocity is zero (u = 0)

Assuming the bench to be frictionless,

v = 0 + 5.34 × 10^{-9} × 1 m/s

= 5.34 × 10^{-9} m/s

Mahendra's velocity after 1 s will be 5.34 × 10^{-9} m/s .

9 An object takes 5 s to reach the ground from a height of 5m on a planet. What is value of g on the planet?

Ans Given :time taken = t – 5s

Height = s = 5m

As it is free fall ; initial velocity – u = 0

Using second kinematical equation

$S = ut + \frac{1}{2}\,a\,t^2$

S = 5m ; t = 5s; a = g and u = o

$\therefore \quad 5 = \frac{1}{2} \times g \times (5)^2$

$\therefore \quad g = \frac{5 \times 2}{25} = \frac{2}{5}$

$\therefore \quad g = 0.4\ m/s^2$

$\boxed{\text{Value of g on the planet} = 0.4 m/s^2}$

10 The radius of planet A is half the radius of planet B. If mass of A is M_A, what must be mass of B so that value of g on B is half that of its value on A?

Ans R_A = radius of A $\quad$ g on A = g_A

R_B = radius of B $\quad$ g on B = g_B

Given : $\frac{R_A}{R_B} = \frac{1}{2}$ $\quad \therefore \quad R_B = 2R_A$

$\frac{g_B}{g_A} = \frac{1}{2}$ $\quad \therefore \quad g_A = 2g_B$

Now; $g = \frac{GM}{R^2}$ $\quad \therefore \quad g_A = \frac{GM_A}{R_A{}^2}$ and $g_B = \frac{GM_B}{R_B{}^2}$

$g_A = 2g_B$

$\therefore \quad \frac{GM_A}{R_A{}^2} = \frac{2\,GM_B}{R_B{}^2}$

$\therefore \quad \frac{M_A}{R_A{}^2} = \frac{2M_B}{R_B{}^2}$

$\therefore \quad \frac{M_A}{R_A{}^2} = \frac{2M_B}{(2R_A)^2}$ $\quad (\because R_B = 2R_A)$

$\therefore \quad \frac{M_A}{R_A{}^2} = \frac{2M_B}{4\,RA^2}$

$\therefore \quad \boxed{M_B = 2M_A}$

$\therefore$ The mass of the planet B should be double of the mass of the planet A, so that the value of g on B is half that of its value on A.

11 Suppose you are standing on a tall ladder. If your distance from the centre of the earth is 2R, what will be your weight?

Ans Weight, W = $\frac{Gmm}{r^2} = \frac{Gmm}{(2R)^2} = \frac{GMm}{4R^2}$

$= \frac{1}{4}\left(\frac{GMm}{R^2}\right)$

$= \frac{\text{weight on the surface of the earth}}{4}$

Q.5 **Laws/define/principles** **4**

1 Define escape velocity.

Ans The minimum velocity with which a body should be projected from the surface of a planet or moon, so that it escapes from the gravitational influence of the planet or moon is called as escape velocity.

2 Define the following:
1. Acceleration due to gravity
2. Free fall

Ans i. The acceleration produced in a body under the influence of the force of gravity alone is called acceleration due to gravity.
ii. The motion of any object under the influence of the force of gravity alone is called as free fall.

Q.6 **Answer the following.** **22**

1 What are Newton's laws of motion?

Ans Three fundamental laws of Newton's. The first states that a body continues in a state of rest or uniform motion in a straight line unless it is acted on by an external force. The second states that the rate of change of momentum of a moving body is proportional to the force acting to produce the change. The third states that if one body exerts a force on another, there is an equal and opposite force (or reaction) exerted by the second body on the first.

2 According to Newton's law of gravitation, every object attracts every other object.

Ans (i) The apple attract the earth with the same force with which the earth attracts the apple.
(ii) According to newtons's third law , these two forces are equal and opposite in direction.
(iii) For same magnitude of force, the acceleration produced in a body is inversely proportional to its mass.
(iv) As the mass of the earth is very large compared to that of the apple, the acceleration of the earth is too small compared to the acceleration of the apple that it cannot be noticed.
Hence , the apple falls towards the earth while the earth does not move towards the apple.

3 Starting from rest, what will be Mahendra's velocity after one second if he is falling down due to the gravitational force of the earth?

Ans **Given:**
u = 0, F = 733 N, Mahendra's mass = m = 75 kg
time t = 1 s
Mahendra's acceleration
a = $\frac{F}{m} = \frac{733}{75}$ m/s^2
According to Newton's first equation of motion,
v = u + at
Mahendra's velocity after 1 second
v = 0 + 9.77 × 1 m/s
v = 9.77 m/s
This is 1.83 × 10^9 times Mahendra's velocity in example 2, on page 6.

4 What is free fall? When is it possible?

Ans 1. The falling of a body from a height towards the earth under the gravitational force of earth alone is called free fall.
2. Free fall occurs when an object is subject to gravity alone, with no other forces acting on it. This happens when an object is dropped in a vacuum or when air resistance is negligible compared to the force of gravity. In such conditions, the object accelerates towards the Earth at a constant rate, determined by the acceleration due to gravity (approximately 9.8 m/s2 on Earth's surface).

5 According to Newton's law of gravitation, earth's gravitational force is higher on an object of larger mass. Why doesn't that object fall down with higher velocity as compared to an object with lower mass?

Ans i. The acceleration due to gravity g on an object only depends on mas (M) and radius (R) of the earth $g = \frac{GM}{R^2}$.

ii. It does not depend on mass (m) of the object.

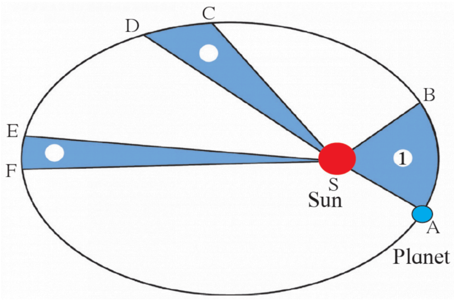
iii. The acceleration produced at a given point is the same for all objects.

iv. Hence object of larger mass does not fall down with higher velocity as compared to an object with lower mass.

6 Define: Acceleration due to gravity. Or Wht are acceleration due to gravity?

Ans According to Newton's second law of motion, a force acting on a body results in its acceleration. Thus, the gravitational force due to the earth on a body results in its acceleration. This is called acceleration due to gravity and is denoted by 'g'.

7 If the area ESF is equal to area ASB, what will you infer about EF?



Ans EF and AB are distances covered by planet in the same time. Explanation: According to Kepler's second law, if area of ESF = area of ASB, then the planet covers distances EF and AB in the same time.

8 Define: centripetal force? Or What is centripetal force?

Ans A force acting on any object moving along a circle and directed towards the centre of the circle is called as centripetal force.

9 What do you know about the gravitational force?

Ans The gravitational force is a force that attracts any two objects with mass.
We call the gravitational force attractive because it always tries to pull masses together, it never pushes them apart. In fact, every object, including you, is pulling on every other object in the entire universe!

10 What types of forces are you familiar with?

Ans A force is referred as a push or pull of an object that is caused due to its interaction with another object.
There are many types of forces that act on humans in everyday life. A few of them are - Frictional force, gravitational force, Magnetic force, contact forces like push and pull, electromagnetic force, spring force, resistance force, weak and strong interaction forces, etc.

11 What are the effects of a force acting on an object?

Ans **Effects of Force -**
A force acting on an object causes the object to change its shape or size, to start moving, to stop moving, to accelerate or decelerate. When there's the interaction between two objects they exert a force on each other, these exerted forces are equal in size but opposite in direction.

Q.7 **Solve Numerical problems** **15**

1 A stone thrown vertically upwards with initial velocity 'u' reaches a height 'h' before coming down. Show that time taken to go up is same as time taken to come down.

Ans Let t_1 be the time taken to go upwards white t_2 be the time take to come downwards.
Using second kinematical equation

$$s = u + \frac{1}{2} at^2$$

While going upwards: s = h, t = t, and a = − g

$$\therefore \quad h = ut_1 + \frac{1}{2} (-g)\, t_1^2$$

$h = ut_1 - \frac{1}{2}(-g)t_1^2$ ... (1)

While coming downwards: s = h, u = o, t = t_2 , a = g

$\therefore$ $h = (o)\, t_2 + \frac{1}{2} g\, t_1^2$

$\therefore$ $h = \frac{1}{2} g\, t_1^2$ ... (2)

From equations (1) and (2)

$ut_1 - \frac{1}{2} g\, t_1^2 = \frac{1}{2} g\, t_2^2$

$\left(u - \frac{1}{2} gt_1\right) t1 = \frac{1}{2} g\, t_2^2$ ... (3)

Now; on applying first kinematical equation when stone going upwards we get

v = u + a t

Since v = o and a = $-$g ; o = u + (g) t_1

$u = gt_1$ ... (4)

Substituting u = gt, in equation ... (3)

$\left(gt_1 - \frac{1}{2} g\, t_1\right) t_1 = \frac{1}{2} gt_2^2$

$\therefore$ $\frac{1}{2} g\, t_2^2 = \frac{1}{2} g\, t_2^2$

$\therefore$ $t_1^2 = t_2^2$

$\therefore$ $\boxed{t_1 = t_2}$

Hence proved.

2 The mass of the earth is 6 $\times$ 10^{24} kg. The distance between the earth and Sun is 1.5 $\times$ 10^{11}m. If gravitational force between them is 3.5 $\times$ 10^{22}N, what is the mass of the sun? (G = 6.7 $\times$ 10^{-11} NM^2 kg^{-2})

Ans Given : Mass of earth = Me = 6 $\times$ 10^{24}kg

Distance between = d = 1.5 $\times$ 10^{11} m

Gravitational Force = F = 3.5 $\times$ 10^{22} N

G = 6.7 $\times$ 10^{-11} Nm^2 Kg^{-2}

Mass of sun = M_s

We know; Gravitation force is given by

$F = G \frac{MeMs}{d^2}$

$\therefore$ $M_s = \frac{F.d^2}{G.m_e}$

$\therefore$ $M_s = \frac{3.5 \times 10^{22} \times 1.5 \times 1.5 \times 10^{22}}{6.7 \times 10^{-11} \times 6 \times 10^{24}}$

$\therefore$ $M_s = \frac{3.5 \times 1.5 \times 1.5 \times 10^{(22+22+11-24)}}{6.7 \times 6}$

$\therefore$ $M_s = \frac{7.87 \times 10^{(31)}}{40.2}$

$\therefore$ $M_s = 0.1958 \times 10^{31}$

$\therefore$ M_s = $\mathbf{1.96 \times 10^{30}}$ **kg**

$\therefore$ Mass of the sun = $\mathbf{1.96 \times 10^{30}}$ **kg**

3 A ball falls off a table and reaches ground in 1 s. assuming g = 10m/s^2, calculate its speed on reaching the ground and the height of the table.

Ans Given : Time taken = t = 1s

= g = 10 m/s^2

It's a free fall motion

$\therefore$ height = s = $\frac{1}{2} gt^2$

$s = \frac{1}{2} \times 10 \times (t)^2$

s = 5 m

using third kinematical equation

$v^2 = u^2 + 2as$

u = 0 and a = g in free fall

$\therefore$ $v^2 = 2gs$

$\therefore$ $v^2 = 2 \times 10 \times 5$

$\therefore$ $v^2 = 100$

$\therefore$ $v = \sqrt{100}$

$\therefore$ **v = 10 m/s**

$\therefore$ Height of table = 5m

Speed of reaching to the ground = 10m/s

4 An object thrown vertically upwards reaches height of 500m. What was its initial velocity? How long will it take to come back to the earth? Assume g = 10m/s

Ans Given : Height = s = 500 m

$g = 10\ m/s^2$

since, object is thrown upwards against gravity.

acceleration = $-g = -10\ m/s^2$ and final velocity = v = O m/s

using third kinematical equation

$v^2 = u^2 + 2as$

$a = -g$; $v = 0$

$\therefore$ $u^2 = 2gs$

$\therefore$ $u^2 = 2\times10\times500$

$\therefore$ $u^2 = 10^4$

$\therefore$ $u = \sqrt{10^4}$

$\therefore$ $u = 10^2 = 100$ m/s.

Time taken to reach 500m

$v = u + at$

$v = 0$ and $a = -g$

$\therefore$ $u = gt$

$\therefore$ $100 = 10 \times t$

$\therefore$ t = 10s

Same time is required for the object to reach the ground so total time taken will be

$T = 2\times t = 2\times10 =$ **20s**

$\therefore$ Initial velocity (upwards) 100 m/s

Total time taken by object = **20s**

5 An iron ball of mass 3 kg is released from a height of 125 m and falls freely to the ground. Assuming that the value of g is 10 m/s^2, calculate

(i) time taken by the ball to reach the ground

(ii) velocity of the ball on reaching the ground

(iii) the height of the ball at half the time it takes to reach the ground.

Ans Given:

m = 3 kg, distance travelled by the ball s = 125 m, initial velocity of the ball = u = o and acceleration a = g = 10 m/s^2.

(i) Newton's second equation of motion gives

$s = u\,t + \frac{1}{2}\,a\,t^2$

$\therefore\ 125 = 0\,t + \frac{1}{2} \times 10 \times t^2 = 5\,t^2$

$t^2 = \frac{125}{5} = 25,\ t = 5\ s$

The ball takes 5 seconds to reach the ground.

(ii) According to Newton's first equation of motion final velocity = $v = u + a\,t$

$= 0 + 10 \times 5$

$= 50$ m/s

The velocity of the ball on reaching the ground is 50 m/s

(iii) Half time = $t = \frac{5}{2} = 2.5$ s

Ball's height at this time = s

According to Newton's second equation

$s = u\,t + \frac{1}{2}\,a\,t^2$

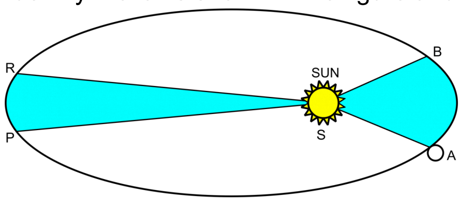
$s = 0 + \frac{1}{2} 10 \times (2.5)^2 = 31.25$ m.

Thus the height of the ball at half time

= 125-31.25 = 93.75 m

Q.8 **Write laws, theories and explain.** 3

1 Identify the laws shown in the figure and state three respective laws.



Ans Figure explains Kepler's laws. They are stated as follows :

i. Kepler's First Law:

The orbit of planet is an ellipse, with the sun at one of the foci.

ii. Kepler's Second Law:

The line joining the planet and the sun sweeps equal areas in equal intervals of time.

According to this law, Area ASB and PSR are equal, covered by planet in equal time intervals.

iii.Kepler's Third Law:

The square of the period of revolution around the sun is directly proportional to the cube of the mean distance of a planet from the sun If 'R' is the mean distance and T is the period of revolution then,

$T^2 \propto R^3$ i.e. $\frac{T^2}{R^3}$ = constant

Newton formulated the Gravitational Force equation in which the force is inversely proportional to the distance between the object. This inverse square dependence in his law helped by Kepler's third law.

Q.9 **Answer the following based on the paragraphs** 3

1 If the value of g suddenly becomes twice its value, it will becomes two times more difficult to pull a heavy object along the floor. Why ?

Ans (i) The weight of an object is defined as the force with which the earth attracts the object. It is given as, W = F = mg.

(ii) The weight of an object depends on the mass of the object and the value of acceleration due to gravity.

(iii) If the value of g doubles, the force with which the earth attracts the object also becomes twice.

(iv) Thus, the object becomes twice as heavier, making it harder to be pulled along the floor.

Q.10 **Answer the following** 3

1 What is the difference between mass and weight of an object. Will the mass and weight of the object on earth be same as their values on Mars ? Why ?

Ans

	Mass	**Weight**
i.	Mass is the amount matter present in an object.	Weight is the force on an object due to gravitational pull.

ii.	Mass of any object is universally constant and does not change.	Wight changes with the change in Gravitational acceleration.
iii.	Mass is measured by a beam balance.	Weight is measured by a spring balance.
iv.	It's a scalar quantity.	It's a vector quantity.

i. On Mars, the mass will remain same but weight will vary from that on the earth.

ii. This is because the gravitational accelerating of Mars is only 3.711 m/s^2 and hence will be different resulting in change of weight. The 'g' on earth is 9.8m/s^2. Hence the weight on Mars will be lesser or almost 1/3rd.

Q.11 Answer the following in detail 20

1 Explain why the value of g is zero at the centre of the earth.

Ans At the centre of Earth, force due to any portion of the Earth at the centre will be cancelled due to the portion opposite to it. Thus, the gravitational force at the centre on any body will be 0. Since, from Newton's law, we know F = mg. Since, mass m of an object can never be 0. Therefore, when F = 0, then g has to be 0. Thus, the value of g is zero at the centre of the Earth.

2 The mass and weight of an object on earth are 5 kg and 49 N respectively. What will be their values on the moon ? Assume that the acceleration due to gravity on the moon is 1/6 th of that on the earth.

Ans The mass remains same, hence it is 5 kg. Weight = 49 N on earth.

$g_M = \frac{g_E}{6}$, W (on the moon) = ?

The mass of the object on the moon = the mass of the object on the earth = 5 kg

W = mg

$$\therefore \frac{W_M}{W_E} = \frac{mg_m}{mg_E} = \frac{g_m}{g_E} = \frac{1}{6}$$

$$\therefore W_M = \frac{W_E}{6} = \frac{49N}{6} = 8.17N$$

3 Write the three laws given by Kepler. How did they help Newton to arrive at the inverse square law of gravity?

Ans
(1) **Kepler's first law:** The orbit of a planet is an ellipse with the Sun at one of the foci.
(2) **Kepler's second law:** The line joining the planet and the Sun sweeps equal areas in equal intervals of time.
(3) **Kepler's third law:** The square of the period of revolution of a planet around the Sun is directly proportional to the cube of the mean distance of the planet from the Sun.

Inverse square law of gravity with the help of Kepler's third law:

(1) Consider that a planet with mass m, moving with a speed v, revolves around the Sun in a circular orbit of radius r.
(2) The centripetal force acting on the planet towards the Sun can be written as F = $\frac{mv^2}{r}$.
(3) The distance travelled by the planet in one revolution = perimeter of the orbit = 2π, where r = distance of the planet from the Sun. Time taken = Period of revolution = T

v = $\frac{\text{distance travelled}}{\text{time taken}} = \frac{2\pi r}{T}$

F = $\frac{mv^2}{r}$ = m $\frac{\left(\frac{2\pi r}{T}\right)^2}{r} = \frac{4m\pi r}{T^2}$

Multiplying and dividing by r^2, we get,

F = $\frac{4m\pi r}{T^2} \times \frac{r^2}{r^2}$

= $\frac{4m\pi}{T^2} \times \frac{r^3}{r^3}$

= $\frac{4m\pi}{r^2} \times \frac{r^3}{T^2}$

According to Kepler's law, $\frac{T^2}{r^3}$ = K,

$\therefore \frac{r^3}{T^2} = \frac{1}{K}$

$F = \frac{4m\pi}{r^2 K}$, But = $\frac{4m\pi}{K}$ = Constant

$\therefore$ $F \propto \frac{1}{r^2}$

(4) Thus, Newton concluded that the centripetal force, which is the force acting on the planet and is responsible for its circular motion, must be inversely proportional to the square of the distance between the planet and the Sun.

(5) Newton identified this force as the force of gravity and hence postulated the inverse square law of gravity.

4 The masses of the earth and moon are 6×10^{24} kg and 7.4×10^{22} kg, respectively. The distance between them is 3.84×10^5 km. Calculate the gravitational force of attraction between the two.(Use $G = 6.7 \times 10^{-11}$ $Nm^2\ Kg^{-2}$)

Ans : $M_e = 6 \times 10^{24}$ kg

$M_m = 7.4 \times 10^{22}$ kg

$d = 3.84 \times 10^5$ km $= 3.84 \times 10^8$ m

$G = 6.7 \times 10^{-11}\ Nm^2/kg^2$

F = ?

$$F = \frac{GM_eM_m}{d^2}$$

$$= \frac{6.7 \times 10^{-11} \times 6 \times 10^{24} \times 7.4 \times 10^{22}}{(3.84 \times 10^8)^2}$$

$$= \frac{6.7 \times 6 \times 7.4 \times 10^{35}}{3.84 \times 3.84 \times 10^{16}}$$

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