Very Short Answer Type Questions

[1 mark]

Q. 1. What will happen to the gravitational force between two bodies if the masses of one body is doubled?

Ans. If the mass of one body is doubled, force is also doubled.

Q. 2. Why is 'G' called the universal gravitational constant?

Ans. The constant G' is universal because it is independent of the nature and sizes of bodies, the spare where they are kept and at the time at which the force is considered.

Q. 3. who formulated the universal law of gravitation?

Ans. Isaac Newton

Q. 4. How is gravitation different from gravity?

Ans. Gravitation is the force of attraction between any two bodies while gravity refers to attraction between any body and the earth.

Q. 5. What does a small value of G indicate?

Ans. A small value of G indicates that the force of gravitational attraction between two ordinary size objects is a very weak force.

Q. 6. At what place on the earth's surface is the weight of a body maximum?

Ans. At the poles.

Q. 7. At what place on the earth's surface is the weight of a body minimum?

Ans. At the equator.

Q. 8. If the mass of a body is 9.8 kg on the earth, what would be its mass on the moon?

Ans. It will remain the same on the moon, *i.e.,* 9.8 kg.

Q. 9. Do fluids possess weight?

Ans. Yes, fluids have weight.

Q. 10. Why can one jump higher on the surface of the moon than on the earth?

Ans. Because the value of acceleration due to gravity (g) on the moon's surface is nearly 1/6th to that the surface of the earth.

Q. 11. Define the standard kilogram.

Ans. The standard kilogram is the mass of a block of a platinum alloy kept at the international bureau of weights and measures near Paris in France.

Q. 12. If the earth attracts two objects with equal force, can we say that their masses must be equal?

Ans. No

Q. 13. Is weight a force?

Ans. Yes.

Q. 14. What keeps the moon in uniform circular motion around the earth?

Ans. Gravitational force between moon and the earth keeps moon in uniform circular motion around the earth.

Q. 15. When a body is dropped from a height, what is its initial velocity?

Ans. Zero.

Q. 16. When a body is thrown vertically upwards, what is its final velocity?

Ans. Zero.

Q. 17. Is the time taken by a body to rise to the highest point equal to the time taken to fall from the same height?

Ans. Yes.

Q. 18. Is the acceleration due to gravity acting on a freely falling body directly proportional to the (a) mass of the body? (b) time of fall of the body?

Ans. (a) No (b) No

Q. 19. Suppose gravity of earth suddenly becomes zero, then which direction will the moon begin to move if no other celestial body affects it?

Ans. The moon will begin to move in a straight line in the direction in which it was moving at that instant because the circular motion of moon is due to centripetal force provided by the gravitational force of the earth.

Q. 20. The earth is acted upon by gravitation of sun, even though it does not fall into the sun. Why?

Ans. The gravitational force is responsible for providing the necessary centripetal force which allows the earth to move around the sun at the defined path or orbit. So, the earth does not fall into the sun.

Q. 21. If the small and big stones are dropped from the roof of a house simultaneously, they will reach the ground at the same time. Why?

Ans. The acceleration due to gravity does not depend upon the mass of the stone or body. Both the bodies fall with the same acceleration towards the surface of the earth. Thus a big stone will fall with the same acceleration as a small stone. So, both the stones will reach the ground at the same time when dropped simultaneously.

Short Answer Type Questions – I

[2 marks]

Q.1. The earth attracts an apple. Does the apple also attract the earth? If it does, why does the earth not move towards the apple?

Ans. According to Newton's third law of motion, action and reaction are equal and opposite. It means that the force on the apple due to earth's attraction is equal to that on the earth due to apple's attraction. But we know, acceleration $\propto 1/m$.
As the mass of the earth is very large as compared to that of the apple, the acceleration experienced by the earth will be so small that it will not be noticeable.

Q. 2. Mention any four phenomena that the universal law of gravitation was able to explain.

Ans. The universal law of gravitation was able to explain successfully
1. the force that binds us to the earth.
2. the motion of the moon around the earth.
3. the motion of planets around the sun.
4. the tides due to the moon and the sun.

Q. 3. When does an object show weightlessness?

Ans. Weightlessness is a state when an object does not weigh anything. It occurs only when a body is in a state of free fall under the effect of gravity alone.

Q. 4. Why does a body reach the ground quicker at poles than at the equator when dropped from the same height?

Ans. The acceleration due to gravity is more at the poles than at the equator. The time taken for a body is less if the acceleration due to gravity is more when the initial velocities and the distance travelled are the same So, when dropped from the same height a body reaches the ground quicker at the poles than at the equator.

Q. 5. What is the source of centripetal force that a planet requires to revolve around the sun? On what factors does that force depend?

Ans. Gravitational force. This force depends on the product of the masses of the planet and sun and the distance between them.

Short Answer Type Questions – II

[3 marks]

Q. 1. Suppose that the radius of the earth becomes twice of its original radius without any change in is mass. Then what will happen to your weight?

Ans. We know that F = $\frac{GMm}{r^2}$ as weight of a body is the force with which a body is attracted towards the earth,

$\therefore \quad W = \frac{GMm}{r^2}$

If the radius of the earth becomes twice of its original radius, then

W = $\frac{GMm}{(2r^2)}$

= $\frac{GMm}{4r^2} = \frac{W}{4}$

i.e., weight will be reduced to one-fourth of the original.

Q. 2. Prove that if the earth attracts two bodies placed at same distance from the centre of the earth with the same force, then their masses are equal.

Ans. Let P and Q be the two bodies,

the mass of body P = m_1

And the mass of body Q = m_2

As per the universal law of gravitation, the force of attraction between the earth and the body P is given by,

$F_P = \frac{G \times M_e \times M_1}{R^2}$ … (1)

Where, R is the distance of the body from the centre of the earth.
Similarly, the force of attraction between the earth and the body Q is given by

$F_Q = \frac{G \times M_e \times M_2}{R^2}$ … (2)

Since, the two forces, *i.e.*, F_P and F_Q are equal, thus from (1) and (2),

$\frac{G \times M_e \times M_1}{R^2} = \frac{G \times M_e \times M_2}{R^2}$

$\Longrightarrow \quad m_1 = m_2$

Q. 3. Give three differences between acceleration due to gravity (g) and universal gravitational constant (G).

Ans. Differences between g and G

Acceleration due to gravity (g)	Universal gravitational constant (G)
1. Acceleration due to gravity is the acceleration acquired by a body due to the earth's gravitational pull on it.	1. Gravitational constant is numerically equal to the force of attraction between two masses of 1 kg that are separated by a distance of 1 m.
2. g is a vector quantity.	2. G is a scalar quantity.
3. It is different at different places on the surface of the earth. Its value also varies from one celestial body to another.	3. The 'G' is a universal constant, *i.e*., its value is the same (*i.e*. 6.7 x 10^{-11} Nm^2 kg^{-2}) everywhere in the universe.

Q. 4. On the earth, a stone is thrown from a height in a direction parallel to the earth's surface while another stone is simultaneously dropped from the same height. Which stone would reach the ground first and why?

Ans. For both the stones
Initial velocity, $u = 0$
Acceleration in downward direction = g

Now, $$h = ut + \frac{1}{2} gt^2$$

$\Longrightarrow$ $$h = 0 + \frac{1}{2} gt^2$$

$\Longrightarrow$ $$h = \frac{1}{2} gt^2$$

$\Longrightarrow$ $$t = \sqrt{\frac{2h}{g}}$$

Both stones will take the same time to reach the ground because the two stones fall from the same height.

Q. 5. Calculate the average density of the earth in terms of g, G and R.

Ans. we know that $g = \frac{GM}{R^2}$ or $M = \frac{gR^2}{G}$

$\Longrightarrow$ Average density of the earth, $D = \frac{Mass}{Volume} = \frac{gR^2}{G \times Ve}$

(Where V_e is the volume of the earth)

or $D = \frac{gR^2}{G\frac{4}{3}\pi R^3} = \frac{3g}{4\pi GR}$

Q. 6. Prove that if a body is thrown vertically upward, the time of ascent is equal to the time of descent.

Ans. Upward motion

$$v = u - gt_1$$
$$0 = u - gt_1$$
$$t_1 = \frac{u}{g} \quad \ldots (1)$$

Downward motion

$$v = u + gt_2$$
$$v = 0 + gt_2$$

As the body falls back to the earth with the same velocity it was thrown vertically upwards.

$\therefore$ $v = u$

$$v = 0 + gt_2$$
$$t_2 = u/g \quad \ldots (2)$$

From (1) and (2), we get $t_1 = t_2$

$\Longrightarrow$ Time of ascent = Time of descent

Q. 7. Two objects of masses m_1 and m_2 having the same size are dropped simultaneously from heights h_1 and h_2, respectively. Find out the ratio of time they would take in reaching the ground. Will this ratio remain the same if *(i)* one of the objects is hollow and the other one is solid; and *(ii)* both of them are hollow, size remaining the same in each case? Give reasons.

Ans. As u = 0, $h_1 = \frac{1}{2} g t_1^2$

$$h_2 = \frac{1}{2} g t_2^2,$$

$$\frac{t_1}{t_2} = \sqrt{\frac{h_1}{h_2}}$$

Ratio will not change in either case because acceleration remains the same. In case of free fall acceleration does not depend upon mass and size.

Long Answer Type Questions

[5 marks]

Q. 1. Derive expression for force of attraction between two bodies and then define gravitational constant.

Ans. "Everybody in the universe attracts every other body with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them." Let us consider two bodies A and B of masses m_1 and m_2 which are separated by a distance *r*. Then the force of gravitation (F) acting on the two bodies is given by

$$F \propto m_1 \times m_2 \quad \ldots (1)$$

and $$F \propto \frac{1}{r^2} \quad \ldots (2)$$

Combining (1) and (2), we get

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

Or $$F = G \times \frac{m_1 m_2}{r^2} \quad \ldots (3)$$

where G is a constant known as universal gravitational constant.
Here, if the masses m_1 and m_2 of the two bodies are of 1 kg and the distance (r) between them is 1 m, then putting m_1 = 1 kg, m_2 = 1 kg and r = 1m in the above formula, we get

G = F

Thus, the gravitational constant G is numerically equal to the force of gravitation which exists between two bodies of unit masses kept at a unit distance from each other.

Q. 2. Define acceleration due to gravity. Derive an expression for acceleration due to gravity in terms of mass of the earth (M) and universal gravitational constant (G).

Ans. The acceleration produced in the motion of a body falling under the force of gravity is called acceleration due to gravity. It is denoted by 'g'

The force (F) of gravitational attraction on a body of mass m due to earth of mass M and radius R is given by

$$F = G \frac{mM}{R^2} \quad \ldots (1)$$

We know from Newton's second law of motion that the force is the product of mass and acceleration.

$\therefore$ $F = ma$

But the acceleration due to gravity is represented by the symbol g. Therefore, we can write

$F = mg$ … (2)

From the equation (1) and (2), we get

$mg = G\frac{mM}{R^2}$ or $g = \frac{GM}{R^2}$ … (3)

When body is at a distance '*r*' from centre of the earth then $g = \frac{GM}{R^2}$.

Q. 3. Show that the weight of an object on the moon is th of its weight on the earth.

Ans. Suppose the mass of the moon is M_m and its radius is R_m. If a body of mass *m* is placed on the surface of moon, then weight of the body on the moon is

$W_m = \frac{GM_m m}{{R_m}^2}$ … (1)

Weight of the same body on the earth's surface will be

$W_e = \frac{GM_e m}{{R_e}^2}$ … (2)

where M, = mass of earth and R_e radius of earth.

Dividing equation (1) by (2), we get

$\frac{W_m}{W_e} = \frac{M_m}{M_e} \times \frac{{R_e}^2}{{R_m}^2}$ … (3)

Now, mass of the earth, $M_e = 6 \times 10^{24}$ kg
mass of the moon, $M_m = 7.4 \times 10^{22}$ kg
radius of the earth, $R_e = 6400$ km
and radius of the moon, $R_m = 1740$ km
Thus, equation (3) becomes,

$$= \frac{W_m}{W_e} = \frac{7.4 \times 10^{22}\text{kg}}{6 \times 10^{24}\text{kg}} \times \left(\frac{6400\text{ km}}{1740\text{ km}}\right)^2$$

Or $\frac{W_m}{W_e} \approx \frac{1}{6}$ or $W_m \approx \frac{W_e}{6}$

The weight of the body on the moon is about one-sixth of its weight on the earth.

Q. 4. How does the weight of an object vary with respect to mass and radius of earth? In a hypothetical case, if the diameter of the earth becomes half of its present value and its mass becomes four times of its presents value, then how would the weight of any object on the surface of the earth be affected?

Ans. Weight of an object is directly proportional to the mass of earth and inversely proportional to the square of the radius of the earth. *i.e.,*

Weight of a body $\propto \frac{M}{R^2}$

Original weight, $W_0 = mg = m\,G\,\frac{M}{R^2}$

When hypothetically M becomes 4 M and R becomes $\frac{R}{2}$.

Then weight becomes $W_n = m\,G\,\frac{4M}{\left(\frac{R}{2}\right)^2} = (16\ m\ G)\,\frac{M}{R^2} = 16 \times W_0$

The weight will become 16 times.

HOTS (Higher Order Thinking Skills)

Q. 1. Why does formation of tides takes place in sea or ocean?

Ans. The tides in the sea formed by the rising and falling of water level in the sea are due to the gravitational force of attraction which the sun and the moon exert on the water surface in the sea.

Q. 2. Why does a body orbiting in space possess zero weight with respect to a spaceship?

Ans. The astronaut and the spaceship are orbiting with same acceleration hence, the body does not exert any force on the sides of the spaceship. Therefore, the body appears to be floating weightlessly. It also implies that a body orbiting in space has zero weight with respect to a spaceship.

Q. 3. Identical packets are dropped from two aeroplanes-one above the equator and other above the north pole, both at height h. Assuming all conditions to be identical, will those packets take same time to reach the surface of earth? Justify your answer.

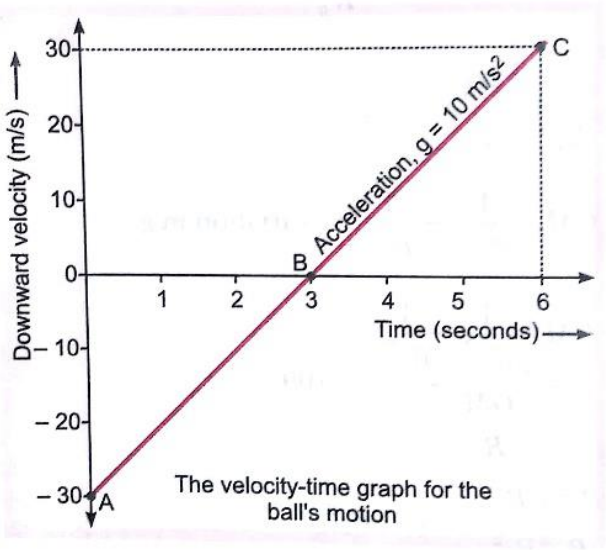
Ans. The value of 'g' at the equator of the earth is lesser than that at poles. Therefore, the packets fall slowly at equator in comparison to the poles. Thus, the packets will remain in air for longer time interval, when it is dropped at the equator.

Q. 4. How does the force of attraction between the two bodies depend upon their masses and distance between them? A student thought that two bricks tied together would fall faster than a single one under the action of gravity. Do you agree with his hypothesis or not? Comment.

Ans. $F \propto m_1 m_2$ and $F \propto \frac{1}{r^2}$

This hypothesis is not correct. The two bricks like a single body, fall with the same speed to reach the ground at the same time in case of free fall. This is because acceleration due to gravity is independent of the mass of the falling body.

Q. 5. Velocity-time graph for the ball's motion is shown in figure.



The velocity-time graph for the ball's motion

Observe the graph and answer the following questions.
Assume that g = 10 m/s^2 and that there is no air resistance.
(a) In which direction is the ball moving at point C?
(b) At which point is the ball stationary?
(c) At which point is the ball at its maximum height?
(d) what is the ball's acceleration at point C?
(e) What is the ball's acceleration at point A?
(f) What is the ball's acceleration at point B?
(g) At which point does the ball have the same speed as when it was thrown?

Ans. (a) Downward
(b) At point B
(c) At point B
(d) Acceleration =10 ms^{-2}
(e) Acceleration = -10 ms^{-2}
(f) Acceleration =10 ms^{-2}
(g) At point C

Value Based Questions

1. A boy tries to hit a bird by throwing a stone vertically upward but the stone misses the bird. The stone goes upwards in the air for 3 s. While returning after 1 second the stone hits the bird.

Answer the following questions based on the information given:

(i) Find the maximum height reached by the stone.

(ii) At what height was the bird hit?

(iii) What value is not shown by the boy?

Ans. (i) Time of ascent = 3s

Initial velocity = u

Final velocity, v = 0 m/s

Acceleration, a = g = - 9.8 m/s^2

$\therefore$ v = u+ at

$\Longrightarrow$ 0 = u + (- 9.8) x 3

$\Longrightarrow$ 0 = u - 29.4

$\therefore$ u = 29.4 m/s

$\therefore$ Maximum height of the stone reached = $\frac{v^2-u^2}{2a}$ [$\therefore$ $v^2-u^2=$ 2as]

$= \frac{(0)^2-(29.4)^2}{2\times(-9.8)} = \frac{-864.4}{-19.6}$ = **44.1 m**

(ii) The bird was hit after a second while returning.

$\therefore$ Initial velocity, u = 0 m/s

Distance travelled = s

Time taken = 1 s

Acceleration, a = g = 9.8 m/s^2

s = $ut + \frac{1}{2}gt^2$

= 0 x 1 + $\frac{1}{2}$x 9.8 x (1)^2 m = 0 + $\left(\frac{1}{2}\times 9.8\right)$ = **4.9 m**

The height of the bird from the ground = 44.1 m - 4.9 m 39.2 m

(iii) Each and every living organism is a part and parcel of our life, because living organisms maintain biodiversity on earth. Therefore, we should treat the living beings in a polite way. This value is not shown by the boy as he hits the bird.