Std-10th
1. Gravitation
Extra

Q. 1) The acceleration due to gravity does not depend on the ……… of the body

Ans :– Mass.

Q. 2) According to Kepler's second law, the line joining the planet and the sun ……. In equal intervals of the time.

Ans :– Sweeps equal areas.

Q. 3) If the separation between two particles is doubled, the gravitational force between the particles becomes double the initial force. Is the following statement true of false?

Ans :– The following statement is false. If the separation between two particles is doubled, the gravitational force between the particles becomes $\frac{1}{4}$ times the initial force.

Q. 4) What is the acceleration due to gravity at a height h (= radius of earth) from the surface of the earth? (g = 9.8m/s^2)

Ans :– The acceleration due to gravity at a height h (= radius of earth) from the surface of the earth is 2.45 m/s^2

[Explanation g' = $\frac{GM}{(R+h)^2} = \frac{GM}{4R^2} = \frac{9}{4}$

$= \frac{9.8}{4}$ m/s^2 = 2.45 m/s^2 for h = R]

Q. 5) What is the gravitational force and gravitation?

Ans :– 1) In any two particles of matter present in the universe there is always a force of attraction, acting upon them. 2) This force of attraction depends only on the masses, of the particles and the separation between them. 3) This is the gravitational force. 4) The mutual attraction between them is called them is called gravitation.

Q. 6) What is the acceleration due to gravity?

Ans :– The acceleration produced in a body due to the gravitational force of the earth is called the acceleration due to gravity.

Q. 7) Define mass. State its CGS and SI units.

Ans :– The mass of a body is the amount of matter present in it. Its SI unit is the kilogram(kg) and (GS unit is the gram (g).

Q. 8) Define weight. State its SI and CGS units.

Ans :– The weight of a body is defined as the force with which the earth attracts it. Its SI unit is the newton and CGS unit is dyne.

Q. 9) Express escape velocity in terms of g and R.

Ans :– Escape velocity, $v_{esc} = \sqrt{\frac{2GM}{R}}$

We know that g = $\frac{GM}{R^2}$

$\therefore$ g = gR^2

$$\therefore V_{esc} \sqrt{\frac{2gR^2}{R}} = \sqrt{2gR}$$

Q. 10) Express escape velocity in terms of G, R and P (ρ = earth's density)

Ans :– Escape velocity, vesc = $\sqrt{\frac{2GM}{R}}$

The earth's density, $\rho = \frac{mass}{volume}$ g = $\frac{GM}{\left(\frac{4}{3}\right)\pi R^3}$

$$\therefore M = \frac{4}{3}\pi R^3 \rho$$

$$\therefore V_{esc} = \sqrt{\frac{2G\left(\frac{4}{3}\right)\pi R^3}{R}}$$

$$= \sqrt{\frac{2G\pi\rho}{3}}$$

Q. 11) Define the centripetal force.

Ans :– When body is in uniforms circular motion, the force acting on the body gets directed towards the center of the circle. This force is termed as the centripetal force.

Q. 12) What is the importance of the Newton's Universal law of gravitation

Ans :– 1) The force that binds the objects on the earth to the earth. 2) The motion of the moon and artificial satellites around the earth. 3) The motion of the planets, asteroids, comets etc. around the sun. 4) The tides of the sea duo to the moon and the sun.

Q. 13) What is escape velocity ?

Ans :– When a body is thrown vertically upward from the surface of the earth, the minimum initial velocity of the body for which the body is able to overcome the downward pull by the earth and can escape the earth forever is called the escape velocity.

Q.14) Assuming that the earth performs uniform circular motion around the sun, find the centripetal acceleration of the earth. [speed of the earth = 3×10^4 m/s, distance between the earth and the sun = 1.5×10^{11} m]

Ans :– Data v = 3×10^4 m/s , r = 1.5×10^{11} ,

Centripetal force = $\frac{mv^2}{r}$ = ma

∴ Centripetal acceleration of the earth,

$$a = \frac{v^2}{r} = \frac{(3 \times m/s)^2}{1.5 \times 10^{11}\, m} = \frac{3 \times 3}{1.5} \times 10^{-3} m/s^2$$

$= 6 \times 10^{-3} m/s^2$

It is directed towards the Centre of the earth.

Q. 15) Differentiate between mass and weight.

Ans :–

Mass	Weight
i) The mass of a body is the amount of the matter that is present in body.	i) The weight of the body is the force with which the earth attracts it.
ii) It has magnitude, but not direction.	ii) It has both magnitude and direction.

iii) Mass does not change from one place to another.	iii) Weight changes from place to place.
iv) Mass can never be zero.	iv) Weight is always zero at the center of the earth.

Q.16) A 50 kg bag of wheat is placed on a plant of wood. What is weight of the bag and what is the reaction force exerted by the plank ?

Ans :– Data : m = 50kg, g = 9.8 m/s^2,

W = ?, reaction force = ?

Magnitude of the weight,

W = mg = 50 kg × 9.8 m/s^2 = 490N.

The weight of the bag = 490N acting downward. The reaction force exerted by the plank on the bag = 490N, acting upward.

Q.17) Give reason – why is the value of g zero at the center of earth?

Ans :– 1) The formula, g = $\frac{GM}{R^2}$ = 9.77 m/s^2

2) When we go inside the earth, the value of 'g' goes on decreasing. Also the value of M decreases, as the part of earth

which contributes towards gravitational force felt by the object also decreases.

3) The value of r also decreases as we more towards centre of earth.

4) When an object is at he center of earth, the mass above and below the object also in front and behind is the same.

5) The gravitational forces cancel out each other.

6) At the ideal centre m = 0, and r = 0,

$\therefore$ g = 0 i.e. gravitational acceteration at ideal centre is zero.

Q.18) Calculate the escape velocity on the surface of moon, given the mass and radius of moon to be 7.34×10^{22} kg and 1.74×10^{6} m respectively.

Ans :– Solution,

$G = 6.67 \times 10^{-11}$ Nm^2/kg^2

Mass of moon = M = 7.34×10^{22} kg

Radius of moon = R = 1.74×10^{6} m

To find, Vesc = ?

Escape velocity = Vesc.

$$= \sqrt{\frac{2GM}{R}}$$

$$\therefore \text{Vesc} = \sqrt{\frac{2\times6.67\times10^{-11}\times7.34\times10^{22}}{1.74\times10^{6}}}$$

$\therefore$ Vesc = 7.5km/s

Escape velocity on moon is 7.5 km/s.

Q.19) The masses of earth and moon are 6 $\times 10^{24}$ kg and 7.4 $\times 10^{22}$ kg respectively. The distance between them is 3.84 $\times 10^{5}$ km. calculate the gravitational force of attraction between the two? G = 6.7 $\times 10^{-11}$ Nm^2 /kg^2

Ans :– Solution, M_E = 6 $\times 10^{24}$ kg

g = 6.7 $\times 10^{-11}$ kg

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

d = 3.84 $\times 10^{5}$ kg

To find, f = ?

From, newton's universal law of gravitation,

$$f = \frac{GMm_2}{d^2}$$

$$\text{Here } F = \frac{GM_E \times \text{Mm}}{d^2}$$

$$f = \frac{6.7 \times 10^{-11} \times 6 \times 10^{24} \times 7.4 \times 10^{22}}{(3.84 \times 10^{5})^{2}}$$

$$f = \frac{297.48}{14.74} \times 10^{25} = 2.018 \times 10^{24}$$

$\therefore f = 2 \times 10^{24}$ N

$\therefore$ The gravitational force of attraction between the earth and moon is 2×10^{24} N.

Q.20) If the value of g suddenly becomes twice its value, it will come two time more difficult to pull a heavy object along the floor. Why?

Ans :– 1) The weight of an object is the force with which the earth attracts the object.

2) Thus weight of an object is under the influence of gravitational force of object given by

w = mg ………………. (I)

3) In order to pull an object, we need to pull its weight.

4) If the value of 'g' suddenly becomes twice

Equation (i) w = m(2g)

i.e. w = 2mg …………….(II)

5) from equation (I) and (II) we say that if 'g' suddenly become twice the weight will also become twice, so it will become two times more difficult to pull a heavy object along the floor.

Q.21) Define free fall.

Ans :– when an object is moving under the influence of force of gravity alone, it is said, to be falling freely for free fall,

$u = 0$ and $a = g$

Q.22) The inverse square law of gravitation states that, the centripetal force, must be inversely proportional is the following statement true?

Ans :– The following statement is true.

Q.23) Pratik has thrown a ball vertically upwards. The higher will be initial velocity of the ball, more height will be reached by the ball. Give reason for the following condition.

Ans :– (1) When a ball is thrown upwards, its initial velocity decreases because of the gravitation of the earth.

(2) The maximum height of all is given by, $S = \frac{u^2}{2g}$

(3) From above equation, if the initial velocity is high, the ball will oppose the gravity of earth more and reach the height more.

(4) Thus, higher the initial velocity, the larger the height reached by ball.

Q.24) State the kepler's laws.

Ans :– I) **Kepler's first law** :- The orbit of a 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.

III) **Kepler's third law :-** The square of its period of revolution around the sun is directly proportional to cube of mean distance of planet from the sun.

Q.25) State the Newton's universal law of gravitation?

Ans :– Every object in the universe attracts every object with a definite force. This force is directly proportional to product of masses of two objects and is inversely proportional to square of the distance between them.

Q.26) Sanket has thrown a ball from a table and it reaches the floor in 1 sec. consider, g= 20m/s^2. What will be height of the table? Find out the speed of ball to reach the floor.

Ans :– t = 1 sec, g = 20 m/s^2

Calculate, v = ? height = s = ?

From Newton's first equation of motion,

v = u + at,

Here, u = 0 at height and,

a = g

∴ v = gt

∴ v = 20 × 1

∴ v = 20 m/s

From, Newton's second equation of motion

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

here, u = 0, and a = g

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

$$\therefore s = \frac{1}{2} \times 20 \times (1)^2$$

∴ s = 10m

∴ Speed of ball on reaching the ground, is 20m/s and the height of the table is 10m.

Q.27) Sanket has thrown a ball from a table and it reaches the floor in 1 sec. consider, g= 20m/s^2. What will be height of the table? Find out the speed of ball to reach the floor.

Ans :– Solution –

Wight of object = mg = m × $\frac{GM}{R^2}$

R_1 be the distance on the surface of earth, to centre of earth,

W_1 be the weight on the surface of the earth.

$W_1 = \frac{GMm}{R_1^2}$ ………………. (I)

W_2 is weight of the object on the ladder,

$W_2 = \frac{GMm}{(R_2)^2}$

Here,

R_2 = 4R given,

$W_2 = \frac{GMm}{4R_1^2} = \frac{GMm}{16R_1^2}$ ………………. (II)

Take the ratio of I and II,

$\frac{W_1}{W_2} = 16$

$\therefore W_2 = \frac{1}{16} W_1$

$\therefore$ The weight of object will reduce to $\frac{1}{16^{th}}$ if distance changes to 4R

Q.28) When an object is at a height 'h' from the surface of the earth, its potential energy is equal to where earth's radius is R

Ans :– $\frac{-GMm}{Rth}$

Q.29) Math the pairs.

(A)	(B)
1) Acceleration due to gravity	1) N
2) Mass	2) $\frac{GM}{R^2}$
3) Weight	3) kg
4) Gravitational force	4) $\frac{MV^2}{r}$
5) Centripetal force	5) $\frac{GMm}{R^2}$
	6) $\frac{GMm}{R+h}$

Ans :–

1) Acceleration due to gravity	→	$\frac{GMm}{R^2}$
2) Mass	→	kg
3) Weight	→	N
4) Gravitational force	→	$\frac{GMm}{R^2}$
5) Centripetal force	→	$\frac{MV^2}{r}$

Q.30) Why is 'G' called the universal gravitational constant? Explain.

Ans :– 1) The value of 'G' that is universal gravitational constant, always remains constant.

2) That means, the value of 'G' does not change with the nature, mass or the size of the object.

3) It does not yet affected by the distance between the two objects, nor the nature of the medium between the two objects.

4) Hence 'G' is called the universal gravitational constant.

Q.31) Explain the following – Earth attracts moon and artificial satellites towards itself, but they do not fall towards earth.

Ans :– 1) The gravitational force due to the earth, is acting on the moon at the same time on the artificial satellites that orbit the earth. 2) The gravitational force exerted by the earth always moon and the artificial satellites is always perpendicular to the velocity of moon and the artificial satellites. 3) Hence because of the velocity of the moon and the satellites along their orbits that do not fall towards earth.

Q.32) Derive the relation between 'G' and 'g'

Ans :– consider an apple of mass m falling from a tree. The apple is acted upon by gravitational force due to earth, and hence, it is attracted towards the earth. From Newton's law of gravitation, the gravitational force acting on the apple is given by.

$$F = \frac{GMm}{R^2}$$

Where M is the mass of the earth and R is the radius of the earth.

From Newton's second law, the apple is accelerated towards the centre of the earth due to gravitational force.

$$\therefore F = mg$$

From equations (2.23) and (2.24), we get,

$$Mg = \frac{GMm}{R^2} \text{ or } g = \frac{GM}{R^2}$$

This equation shows the relation between g and G and it shows that g is independent of mass of the body, i.e. all bodies irrelevant of their masses are accelerated to the same extent. Thus, when we drop a wooden ball and a said iron ball of different masses simultaneously from the same height, both reach the earth at the same time.

From the relation $g = \frac{GM}{R^2}$ the value of g can be found out.

Mass of the earth = 6×10^{24}

Radius of the earth = 6.4×10^3 km = 6.4×10^6 m.

$$\therefore g = \frac{GM}{R^2} = \frac{6.67 \times 10^3 km \times 10^6 m}{(6.4 \times 10^6)^2} = 9.77\ ms^{-2}$$

The value of 'g' calculated above is near the equator at sea level. The value of 'g' varies with height, depth and latitude.

Q.33) What is the relation between Orbital velocity and Escape velocity?

Ans :– Orbital velocity of a satellite orbiting close to earth's surface is given by

$V_o = \sqrt{gR}$ ………. (I)

Escape velocity of a body on the surface of the earth is given by,

$V_e = \sqrt{2gR}$ ………. (II)

Where R is the radius of the earth.

From equation I and II,

$Ve = \sqrt{2} . \sqrt{gR}$

$Ve = \sqrt{2vo}$

$Vo = \frac{Ve}{\sqrt{2}}$

Q.34) Write a note on Escape velocity (Ve)

Ans :– It is the minimum velocity required for a satellite or any body to escape the earth's gravitational pull. For any satellite to escape the earth's gravitational pull work has to done against gravitational force. This work done appears as kinetic energy of the satellite. Thus, kinetic energy given to the satellite is equal to work done on the satellite against gravitational force.

(Here, $\frac{GMm}{R^2}$ × 12 and so equal to P.E of the body W.r.t. earth centre)

$\frac{1}{2} MV_e^2 = \frac{GMm}{R^2} \times R$ (work = force × displacement)

Where Ve is the escape velocity M is the mass of the planet and R is the radius of the planet.

∴ Vo = $\sqrt{\frac{GM}{R}}$

Or

Ve = $\sqrt{2gr}$ (∵ g = $\frac{GMm}{R^2}$)

Where g is acceleration due to gravity on the surface of the planet. Thus, the escape velocity is the same for all bodies because it is independent of mass of the body.

Substituting the value of g = 9.8 ms^{-2} and radius of the earth, R = 6400 km, it is found that, the escape velocity of a body on the earth is 11.2 per second. That is in, order to escape, from Earth's gravitational pull, an object should posses a minimum speed of 11.2 km S^{-1}

∴ Ve on the earth surface = 11.2 km S^{-1}

Q.35) What is the acceleration due t gravity on the top of mount Everest, whose height is 8848m, if acceleration due to gravity on the surface of the earth is 9.8 ms^{-2}?

Ans :– In the given problem, height h = 8848m

= 8.848km

Acceleration due to gravity $g^1 = g\left(1 - \frac{2h}{R}\right)$

$g^1 = 9.8\left(1 - \frac{2 \times 8.48 \times 10^3}{6400 \times 10^3}\right)$

$g^1 = 9.8\ (1 - 0.0028) = 9.8 \times 0.9972$

$g^1 = 9.77\ ms^{-2}$

Q.36) The centre of mass of an object is point inside or outside the object at which the total mass of the object can be assumed to be …

Ans :– Concentrated.

Q.37) Write a note Gravitational potential Energy

Ans :– 1) The gravitational potential energy is the energy that an object possesses because of its position or state in earth's gravitational field. This energy is stored in the object. 2) The gravitational potential energy increases, as the object moves above the earth's surface, the height of the object increases. 3) The gravitational potential energy of an object is sown as-

$$g = \frac{GMm}{R+h}$$

The mass of an object is m, height of object = h from the surface of the earth.

Q.38) Write a note on weightlessness -

Ans :– 1) The weight of the body is the gravitational force that attracts body towards the centre of earth. 2) When an astronaut is on the surface of the earth, the gravitational force is acting on him. This gravitational force is the weight of astronaut, and astronaut exerts this force on the surface of the earth. The surface of the earth exerts an equal and opposite reaction and due to this reaction, the astronaut can feel his weight on the earth. 3) For an astronaut in an orbiting satellite, the satellite and astronaut both have same acceleration due to gravity of earth. 4) The surface of the satellite does not exert any force of reaction on the astronaut. Nor the astronaut exerts any pressure. On the surface of the satellite. As there is no reaction, the astronaut has a feeling of weightlessness.

Q.39) Give reason for the following – The weight of a body at the poles move than the weight at the equator.

Ans :– 1) Earth is constantly rotating, shape of the earth is not circular. 2) The shape of earth is bulgy at the equator and is flat at the poles. 3) Hence its radius is largest at the equator and smallest at the poles. 4) Acceleration due to gravity is given by $g = \frac{GMm}{R^2}$

As g = $\mathbf{R}_{equator} > \mathbf{R}_{poles}$

$\mathbf{g}_{equator} < \mathbf{g}_{poles}$

$mg_{equator} < mg_{poles}$

$\text{Weight}_{equator} < \text{weight}_{poles}$

Q.40) If the weight of a body on the surface of the moon is 100 N ,What is its mass ?

Ans :– Given – W=100 N , g =1.63 m/s^2 ,m=?

$W = mg \therefore m = \frac{W}{g} = \frac{100N}{1.63m/s^2} = 61.35$ kg

The mass of the body =61.35 kg

Q.41) Write a note on High tides and low tides.

Ans :– The combined effects of the gravitational forces exerted b the moon and the sun and the rotation of the Earth produces high tides and low tides. The water in the oceans is pulled by the moon's gravitational force. Hence there are bulges in the oceans on both sides of the planet. A bulge is caused towards the moon, as water is pulled by the moon towards itself. The bulge on the side of the earth opposite to the moon is caused by the moon "pulling the Earth away" from the of high tide, the level of water is minimum and low tides occur. During the day, the Earth rotates 180 degrees in 12 hours. The moon, meanwhile, rotates 6 degrees around the earth in 12 hours. The twin bulges and the moon's rotation mean that any given coastal city experiences a high tide every 12 hour.

Q.42) Let the period of revolution of a planet at a distance R from a star be T . prove that if it was at a distance of 2R from the Sar, its period of revolution will be $\sqrt{8}$T

Ans :– $T_1 = \frac{2\pi}{\sqrt{GM}} R^{3/2}$, where T= period of revolution of a planet around the sun , M= mass of the sun , G= gravitational constant and r= radius of the orbit assumed to be circular = distance of the planet from the sun.

For r=R, $T=T_1$.

$\therefore\ T_1 = \frac{2\pi}{\sqrt{GM}} R^{3/2}$

For r = 2R , $T = T_2$

$\therefore\ T_1 = \frac{2\pi}{\sqrt{GM}} (2R)^{3/2}$

$\therefore\ T_2 = \frac{2\pi}{\sqrt{GM}} R^{3/2} \times 2^{3/2} = T_1\, 2^{3/2}$

$\therefore\ T_2 = T_1 \sqrt{8} = \sqrt{8}\, T$

Q.43) A tennis ball is thrown up and reaches a height of 0.8m before coming down. What was its initial velocity? How much total time will it take to come down? Assume g = 10m/s^2

Solution – for the upward motion of the ball, the final velocity of the ball,

= V = 0

Distance travelled by the ball = 0.8m,

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

Using Newton's third equation, of motion,

$V^2 = u^2 + 2as,$

$0 = u^2 + (-10) \times 0.8$

$\therefore u^2 = 16$

u = 4m/s

The initial velocity of the ball is 4m/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 = 0.8m. As the velocity and acceleration are in the same direction,

a = g = 10m/s.

According to Newton's second equation of motion

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

$0.8 = 0 + \frac{1}{2}10^2$

$\therefore t^2 = \frac{0.8}{2} = 0.4t = 0.2s$

The ball will take 0.25 to reach the ground. It will take the same time to go up. Thus, the total taken = 2 × 0.2 = 0.4s

Q.44) What will be the weight of man whose mass is 50kg

Ans :–

Given - Mass = 50kg, g = 9.8 m/s^2

F = mg

W = 50 × 9.8 = 490N.

Q.45) What will be the weight of man whose mass is 50kg

Ans :– When the object will be placed at the centre of the earth, the weight of the object will be zero, because g = 0. Now the object slowly starts moving away from the centre of the earth. The weight of the object will start increasing as its position is not at centre, this happens due to increase in g. On the Earth's surface, the weight of any object will always be maximum. Now the object is moving from the earth's surface towards the moon, the height of the object from the earth to the moon increases, and hence the value of 'g' decreases as it is going away from the centre of earth. Resulting in decrease of weight. On moon the value of any object is different from that on the earth, because on the moon the value of g is $\frac{1}{6^{th}}$ that of the earth. Hence the weight of the body is also $\frac{1}{6^{th}}$ that on the earth's surface.

Q.46) An object thrown vertically upwards reaches a height of 500 m . What was its initial velocity ? How long will the object take to come back to the earth ? Assume g= 10 m/s^2

Ans :– Data : h= 500 m , g= 10 m/s^2 , v=0 m/s , u= ? (for the object going coming down)=?

As the object moves upward,

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

$= u^2+2 (-g)h$ ($\therefore a = -g$)

Now , v= 0 m/s

$\therefore u^2= 2gh= 2\times10\ m/s^2\times 500\ m$

$\therefore u^2=(100\times100)\ m/s^2$

$\therefore$u= 100 m/s (initial velocity of the body)

Also , v=u + at= u-gt

For v=0 m/s , u=gt

$\therefore$ 100 m/s = 10 $m/s^2\times$ t

$\therefore$ t (for the object going up)=10 s

Now , t (For the object coming down)= t (for the object going up)

∴ t(for the object going up)+ t(for the object coming down)

= 10 s + 10 s= 20 s

It will take 20 s for the object to come back to the earth.

Q.47) What would be the value of g on the surface of the earth if its mass was twice as large and its radius half of what it is now?

Ans :– Solution – g = $\frac{GM}{R^2}$

$\therefore g_1 = \frac{GM_1}{R_1^2}$ and $g_2 = \frac{GM_1}{R_2^2}$

$\therefore \frac{g_2}{g_1} = \left(\frac{M_2}{M_1}\right)\left(\frac{R_1}{R_2}\right)^2 = 2\ (2)^2 = 8$

$\left(\because M_2 = 2M_1\ and\ R_2\frac{R_1}{2}\right)$

$\therefore g_2 = 891$

Thus the value of g on the surface of the earth would be eight times the present value.

Q.48) Explain why the value of g is zero at the centre of the earth.

Ans :– The value of g changes when an object is moving inside the earth. As the object is moving towards the centre of the earth, from the earth's surface, the value of g. goes on decreasing. We assume that earth has uniform density. Let us consider an object of mass m at point A at a distance (R- d) from the earth's centre, where R is the radius of the earth and d is depth below the earth's surface, the gravitational force on the object due to the earth is,

$F = \frac{GmM^1}{(R-d)^2}$ M is the mass of the sphere, of radius (R-d).

$M^1 = \frac{4}{3}\pi(R-d)^2 \times \frac{M}{\frac{4}{3}\pi R^3} = \frac{M(R-d)^3}{R^3}$

This is because the outer spherical shell is not effective. Here, the acceleration due to gravity is

$g = \frac{F}{M} = \frac{G}{(R-d)^2}, \frac{M(R-d)^3}{R^3} = \frac{GM\,(R-d)}{R^3}$

M is the mass of the earth. Thus, g decreases as d increases. It is less than that at the earth's surface $\left(\frac{GM}{R^2}\right)$ At the centre of the earth,

$$d = R \qquad \therefore\ g = 0$$

Q.49) Using the law of conservation of energy, obtain the expression for the escape velocity.

Ans :– Suppose an object of mass M is thrown vertically up from earth surface. The escape velocity (Vesc) will be the initial velocity of the object.

When the object will be n the surface of the earth, then its total energy = ?

Total energy E_1 = kinetic energy + potential energy.

$$= \frac{1}{2} MV_{esc}^2 + \left(-\frac{GmM}{R}\right)$$

G = Universal gravitational constant,

M = Mass of the earth and

R = radius of the earth.

Hence, $E_1 = \frac{1}{2}\ MV_{esc}^2$ ______ $\frac{GmM}{R}$

The total energy when object moves to infinity and comes to rest will be,

$$E_2 = \frac{1}{2}m\,(zero)^2 + \left(\frac{-GmM}{R}\right) = 0 + 0 = 0$$

According to, the law of conservation of energy,

$E_1 = E_2$

$$\therefore \frac{1}{2}\,MV_{esc}^2 \;\_\_\_\_\_\_\_\; \frac{GmM}{R} = 0$$

$$\therefore \frac{1}{2}\,V_{esc}^2 = \frac{GM}{R} = 0$$

$$\therefore \text{Vesc} = \sqrt{\frac{2GM}{R}}$$

Q.50) An object is released from the top of a building of height 19.6m. find the velocity with which the body hits the ground.

Ans :– solution – h = 19.6m , u = 0 m/s

$g = 9.8 m/s^2$, s = 19.6m, v = ?

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

$= 2gs$

$= 2 \times 9.8\ m/s^2 \times 19.6m$

$= (19.6 \text{ m/s})^2$

∴ v = 19.6 m/s [downward velocity]

The velocity with which the body hits the ground = 19.6 m/s (downward)

Q.51) If the weight of a body on the surface of the moon is 100 N, What is its mass? ($g = 1.63 m/s^2$)

Ans :- Data : W = 100N, $g = 1.63 m/s^2$ m = ?

∴ W = mg

∴ $m = \frac{W}{g} = \frac{100N}{1.63 m/s^2} = 61.35$ kg

The mass of the body = 61.35 kg.

Q.52) An object thrown vertically upwards reaches a height of 500 m what was its initial velocity? How long will the object take to come back to the earth? Assume $g = 10 m/s^2$

Ans :- Data : h = 500 m, g = 10m/s2

V = 0 m/s, u = ?, t = (for the object going up) + t (for the object coming down) =?

As the object moves upward,

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

= u^2 + 2 (-g) h (∵ a = -g)

Now, v = 0 m/s

∴ $u^2 + 2gh = 2 \times 10 m/s^2$ × 500m

∴ $u^2 = (100 \times 100) m/s^2$

∴ u = 100m/s (initial velocity of the body)

Also, v = u + at = u – gt

For v = 0 m/s, u = gt

∴ 100m/s = $10 m/s^2 \times t$

∴ t (for the object going up) = 10s

Now, t (for the object coming down) =

T t (for the object going up) + t (for the object coming down)

= 10s + 10s = 20s

It will takes 20s for the object to come back to the earth.

Q.53) Let the period of revolution of a planet at a distance R from a star be T. Prove that is was at a distance of 2R from the star, its period of revolution will be $\sqrt{8}$ T.

Ans :- $T = \frac{2\pi}{\sqrt{GM}} \; r^{3/2}$, Where T = period of revolution of a planet around the Sun M = mass of the Sun, G = gravitational constant and r = radius of the orbit assumed to be circular = distance of the planet from the sun.

For r = R, T = T_1

∴ $T_1 = \frac{2\pi}{\sqrt{GM}} \; R^{3/2}$

For r = 2R, T = T_2

∴ $T_2 = \frac{2\pi}{\sqrt{GM}} \; r^{3/2} = \frac{2\pi}{\sqrt{GM}} \; r^{3/2 \times 2^{3/2}} = T_1 \, R^{3/2}$

∴ $T_2 = T1 \sqrt{8} = \sqrt{8} \, T$

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