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Chapter – 10 Gravitation

Multiple Choice Questions

Q1. Two objects of different masses falling freely near the surface of moon would

a) **Have same velocities at any instant**
b) **Have different accelerations**
c) **Experience forces of same magnitude**
d) **Undergo a change in their inertia**

Answer: Option a) Have same velocities at any instant

Objects having different masses falling freely near the surface of the moon have the same velocities because of same acceleration due to gravity.

Q2. The value of acceleration due to gravity

a) **Is same on equator and poles**
b) **Is least on poles**
c) **Is least on equator**
d) **Increase from pole to equator**

Answer: Option c) Is least on equator

It is least on equator and maximum at the poles because of the rotation of earth,

$$g' = g - \omega^2 R \sin\theta$$

At poles,

$$\theta = 0 \ (So, g \ maximum)$$

At equator,

$$\theta = 90^o \ (So, g \ maximum)$$

Q3. The gravitational force between two objects two objects is F. If masses of both objects are halved without changing distance between them, then the gravitational force would become

a) $\boldsymbol{F/4}$
b) $\boldsymbol{F/2}$
c) $\boldsymbol{F}$
d) $\boldsymbol{2F}$

Answer: Option a) F/4

Force of gravitation,

$$F = \frac{Gm_1m_2}{r^2}$$

G is the gravitational constant

Where, $m_1 \; and \; m_2$ are the masses of two objects,

r is distance between masses.

If the masses of both objects are halved,

$$m_1' = \frac{m_1}{2} \; and \; m_2' = \frac{m_2}{2}$$

the new force

$$F' = \frac{Gm_1' m_2'}{r^2}$$

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

$$= \frac{1}{4}\frac{Gm_1 m_2}{r^2} = \frac{F}{4}$$

$$where, \quad \frac{Gm_1 m_2}{r^2} = F$$

the new force

$$F' = \frac{F}{4}$$

The new gravitational force is $\frac{1}{4}$ times of its original gravitational force.

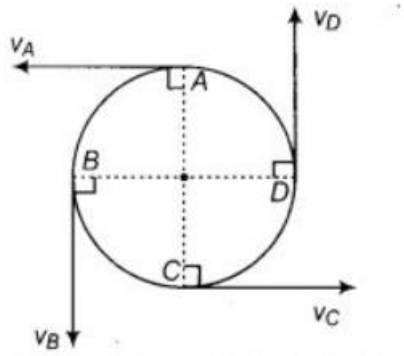
Q4. A boy is whirling a stone tied with a string in an horizontal circular path. If the string breaks, the stone

a) **Will continue to move in the circular path**
b) **Will move along a straight line towards the centre of the circular path**
c) **Will move along a straight line tangential to the circular path**
d) **Will move along a straight line perpendicular to the circular path away from the boy**

Answer: Option c) Will move along a straight line tangential to the circular path.

In a circular motion, the direction of velocity at a point always be along the tangent at that point.

If the string is broken, then the centripetal force acting on the stone becomes zero and it travel along a straight line tangential to the circular path.



V_A, V_B, V_C, V_D are the velocity points A, B, C, D in a circular path.

Q5. An object is put one by one in three liquids having different densities. The object floats with $\frac{1}{9}, \frac{2}{11}$ and $\frac{3}{7}$ parts of their volumes outside the liquid surface in liquids of densities d_1, d_2 and d_3 respectively. Which of the following statement is correct?

a) $d_1 > d_2 > d_3$
b) $d_1 > d_2 < d_3$
c) $d_1 < d_2 > d_3$
d) $d_1 < d_2 < d_3$

Answer: Option d)

Higher density liquid, maximum part of the object is outside the liquid. Because their volume outside the liquid is given by;

$$part\ of\ the\ body\ outside\ the\ liquid\ \propto densities\ of\ liquid$$

$$\frac{1}{9} < \frac{2}{11} < \frac{3}{7}$$

So, the order of densities in increasing order is

$$d_1 < d_2 < d_3$$

Q6. In the relation $F = GMm/d^2$, the quantity G

a) **Depends on the value of g at the place of observation**
b) **Is used only when the earth is one of the two masses**
c) **Is greatest at the surface of the earth**
d) **Is universal constant of nature**

Answer: Option d) Is universal constant of nature.

The G is universal constant applied to all the bodies in universe; a constant in Newton's universal law of gravitational.

The value of G is $6.67 \times 10^{-11}\ Nm^2\ kg^{-2}$.

Q7. Law of gravitation gives the gravitational force between

a) **The earth and a point mass only**
b) **The earth and the sun only**
c) **Any two bodies having some mass**
d) **Two charged bodies only.**

Answer: Option **c) Any two bodies having some mass**

Law of gravitation is applied to all the bodies which are having mass.

$$F = \frac{Gm_1m_2}{r^2}$$

Where,

F = Force of attraction of two bodies

m_1, m_2 = Mass of two bodies

G = Gravitational constant

r = distance of the two bodies

Q8. The value of quantity G in the law of gravitation

a) **Depends on mass of the earth only**
b) **Depends on radius of earth only**
c) **Depends on both mass and radius of the earth**
d) **Is independent of mass and radius of the earth**

Answer: Option d) Is independent of mass and radius of the earth

G is the constant of proportionality called as universal gravitational constant. It is independent of mass and radius of the earth.

Q9. Two particles are placed at some distance. If the mass of each of the two particle is doubled, keeping the distance between them unchanged, the value of gravitational force between them will be

$\boldsymbol{a)\ \frac{1}{4}\ times}$

$\boldsymbol{b)\ 4\ times}$

$\boldsymbol{c)\ \frac{1}{2}\ times}$

$\boldsymbol{d)\ unchanged}$

Answer: Option b) 4 times

Gravitational force,

$$F = G\frac{Mm}{r^2}$$

$$F' = New\ force\ when\ mass\ is\ doubled$$

When mass of each particle is doubled,

$$M = 2M\ and\ m = 2m$$

After substituting these values,

$$F' = G\frac{(2M)(2m)}{r^2}$$

$$F' = 4G\frac{Mm}{r}$$

$$F = G\frac{Mm}{r^2}$$

So,

$$F' = 4F$$

Q10. The atmosphere is held to the earth by

a) **Gravity**
b) **Wind**
c) **Clouds**
d) **Earth's magnetic field**

Answer: Option a) Gravity

The atmosphere around the earth is due to gravity.

Q11. The force of attraction between two-unit point masses separated by a unit distance is called

a) **Gravitational potential**
b) **Acceleration due to gravity**
c) **Gravitational field**
d) **Universal gravitational constant**

Answer: Option d) Universal gravitational constant.

The gravitational force,

$$F = G\frac{Mm}{r^2}$$

$$M = 1\ unit, m = 1\ unit\ and\ r = 1\ unit$$

$$F = G\frac{1 \times 1}{(1)^2}$$

$$F = G$$

So, the force of attraction two-unit point masses separated by a unit distance is called universal gravitational constant.

Q12. The weight of an object at the centre of the earth of radius R, is

a) **Zero**
b) **Infinite**
c) **R times the weight at the surface of the earth**
d) **$1/R^2$ times the weight at the surface of the earth**

Answer: Option a) Zero

Weight of an object is,

$$w = mg$$

At the centre of earth, g is zero.

$$g' = g(1 - \frac{h}{R})$$

h is the distance from surface of the earth to centre of the earth and at centre (h=R), that is,

$$g' = 0$$

$$w = m \times 0 = 0$$

Q13. An object weights 10 N in air. When immersed fully in water, it weighs only 8 N. the weight of the liquid displaced by the object will be

a) **2 N**
b) **8 N**
c) **10 N**
d) **12 N**

Answer: Option a) 2 N

Weight of an object in air = 10 N

Weight of an object in water = 8 N

So, the weight of the liquid displaced by the object,

$$F = 10 - 8 = 2\ N$$

According to the Archimedes' Principle, buoyancy force = weight of the liquid displaced by the body.

Q14. A girl stands on a box having 60 cm length, 40 cm breadth and 20 cm width in three ways. In which of the following cases, pressure exerted by the brick will be

a) **Maximum when length and breadth from the base**
b) **Maximum when breadth and width from the base**
c) **Maximum when width and length from the base**
d) **The same in all the above three cases**

Answer: Option b) Maximum when breadth and width from the base

When base is formed by breadth and width. Area is minimum, so the pressure is maximum.

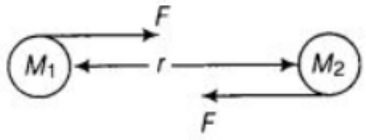
Q15. An apple falls from a tree because of gravitational attraction between the earth and apple. If F_1 is the magnitude of force exerted by the earth on the apple and F_2 is the magnitude of force exerted by apple on earth, then

a) **F_1 is very much greater than F_2**
b) **F_2 is very much greater than F_1**
c) **F_1 is only a little greater than F_2**
d) **F_2 and F_2 are equal**

Answer: Option **d) F_1 and F_2 are equal**

The Newton's universal law of gravitation, force exerted by one body to other is equal in magnitude,

$$F = \frac{Gm_1m_2}{r^2} \; in\ opposite\ direction.$$



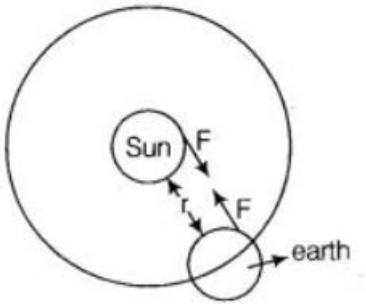
Short Answer Type Question

Q16. What is the source of centripetal force that a planet requires to revolve around the sun? On what factors does that force depends?

Answer:

The motion of the planet around the earth is because of the centripetal force. The gravitational force of planet and the sun provides centripetal force.

It depend on the mass of the sun and mass of the planet, and on the distance between sun and planet.



Q17. 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?

Answer:

Time taken by both the stone according to second equation of motion,

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

$s = h$

m = initial velocity in y-axis

a = g acceleration due to gravity

t = time displacement to time

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

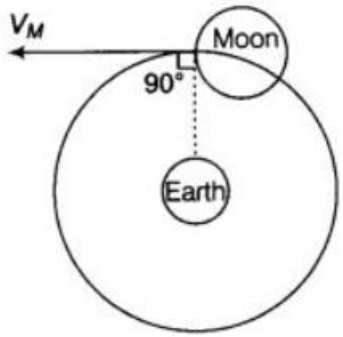
$$t = \sqrt{\frac{2h}{g}}$$

So, when the stone is dropped from a height, (h) , at the same time throw another stone in the horizontal direction, both the stone will strike the earth simultaneously at different places.

Q18. Suppose gravity of the earth suddenly becomes zero, then in which direction will the moon begin to move if no other celestial body affects it?

Answer:

If the gravity of the earth is zero, then the moon lies along the straight line which is a tangent to the circular path.



Q19. Identical packets are dropped from two aeroplanes, one above the equator and the other above the north pole, both at height h. Assuming all conditions are identical, will those packets take same time to reach the surface of earth. Justify your answer.

Answer:

No, the packets take time to reach the surface of the earth, as value of acceleration due to gravity (g) is different at poles and equator because of the rotation of the earth and it is ,

$$g' = g - \omega^2 \, sin\theta$$

And at poles $\theta = 0$ whereas at equator $\theta = 90^o$.

the value of g at equator is less compared to value of g at poles.

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

$$t \propto \frac{1}{g}$$

As g is greatest at the poles than at the equator. So, packet dropped above the north pole reach first at the surface of the earth.

Q20. The weight of any person on the moon is about $1/6$ times that on the earth. He can lift a mass of 15 kg on the earth. What will be the maximum mass, which can be lifted by the same force applied by the person on the moon?

Answer:

On earth: force applied by the man $(F) = m \times g$

On moon: g is equal to $g/6$, so by the same force a person can lift m_1, $g/6 = m$ as $0m = 15\ kg$ so, $m = \frac{15}{56} = 90\ kg$ as mass does not change at every place.

So, 15 kg is maximum mass which can be lifted by the same force applied by the person on the moon.

Q21. Calculate the average density of the earth of the earth in terms of g, G and R.

Answer:

$$g = \frac{GM}{R^2}$$

Where, M = Mass of the earth

R = Radius of the earth

mass of the earth,

$$M = \frac{gR^2}{G}$$

the earth as a sphere of radius R and of material of density ρ, then

Mass of the earth = volume of the earth × density

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

$$\frac{4}{3}\pi R^3 \rho = \frac{gR^2}{G}$$

$$\rho = \frac{3g}{4\pi GR}$$

Q22. The earth is acted upon by gravitation of the sun, even though it does not fall into the sun. Why?

Answer:

Earth revolves around the sun with the help of centripetal force which is provided by the gravitational force between the sun and earth and this gravitational force prevent the earth to fall into the sun.

Long Answer Type Questions

Q23. How does the weight of an object vary with respect to mass and radius of the 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 present value, then how would the weight of any object on the surface of the earth be affected?

Answer:

Suppose, the radius and the mass of the earth to be R, M respectively and mass of an object be m.

Weight of the object,

$$w = mg = \frac{GMm}{R^2}$$

The diameter of the earth is half of given value. So, radius also is half.

So,

$$R' = \frac{R}{2}$$

Mass of earth becomes 4 times,

$$M' = 4M$$

Weight of the object,

$$w' = \frac{G\,M'm}{R'}$$

$$R' = \frac{R}{2}\ and\ M' = 4M\ in\ the\ above\ formula$$

$$w' = \frac{G4Mm}{(R/2)^2}$$

$$= \frac{4GMm}{\frac{R^2}{4}}$$

$$= \frac{16GMm}{R^2}$$

the weight of the object,

$$w' = 16w$$

So, the weight of the object is 16 times of its original weight.

Q24. 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.

Answer:

The force of attraction between the two bodies of masses m_1 and m_2 are separated by distance r by the Newton's Universal law of gravitation,

$$F = \frac{Gm_1m_2}{r^2}$$

Where, G is the universal gravitational constant

The gravitational force is directly proportional to the product of masses of bodies and inversely proportional to the square of the distance between them.

All bodies having mass fall with the same acceleration due to gravity, represented by,

$$g = \frac{GM}{R^2}$$

Also, acceleration due to gravity depends on mass of earth, the radius of the earth.

So, the bricks tied together do not fall faster than a single brick. The hypothesis is incorrect.

Q25. 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 reason.

Answer:

second equation of motion,

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

$$h = \frac{1}{2}at^2$$

h = displacement

u = initial velocity

t = Time

g = acceleration due to gravity

$$gt^2 = 2h \implies t^2 = \frac{2h}{g}$$

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

time taken by first object of mass, m_1

$$t_1 = \sqrt{\frac{2h_1}{g}}$$

Time taken by second object of mass, m_2

$$t_2 = \sqrt{\frac{2h_2}{g}}$$

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

i) Acceleration due to gravity is independent of mass of falling body. So, ratio is same.

ii) If bodies are hollow, then ratio remain the same,

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

Q26.

i) A cube of side 5 cm is immersed in water and then in saturated salt solution. In which case will it experience a greater buoyant force. If each side of the cube is reduced to 4 cm and then immersed in water, what will be the effect on the buoyant force experienced by the cube as compared to the first case of water. Give reasons for each case.

ii) A ball weighing 4 kg of density 4000 kgm^{-3} is completely immersed in water of density 10^3 kgm^{-3}. Find the force of buoyancy on it. (Given, g = 10 ms^{-2})

Answer:

i) Buoyant force,

$$F = V\rho g$$

ρ = density of water

V = volume of water displaced by the body

Buoyant force always depends upon the volume and density as saturated salt solution have higher density than the water. So, in the saturated solution, cube experience a greater buoyant force

If each side of cube is reduced to 4 cm, then the volume of cube become less. As the buoyant force is directly proportional to the volume. So, the buoyant force is less.

ii) Magnitude of the buoyant force,

$$F = V\rho g$$

V = volume of body immersed in water or volume of water displaced

$\rho = density\ of\ liquid$

$$Volume\ of\ solid = \frac{Mass}{Density}$$

$$= \frac{4}{4000} = \frac{1}{1000}\ m^3$$

Buoyancy

$$F = V\rho g$$

$$= \frac{1}{1000} \times 1000 \times 10 = 10\ N$$