

Chapter - 10

Gravitation

Multiple Choice Questions

1. 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**

Soln:

Answer is (a) have same velocities at any instant

Explanation:

Acceleration of an object depends on acceleration due to gravity irrespective of its mass. Hence object under free fall have the same velocities.

2. 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) increases from pole to equator**

Soln:

Answer is (c) is least on equator

Explanation:

The value of acceleration due to gravity is least on equator because distance between surface of the earth and its centre is more on equator than in poles.

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

- (a) $F/4$**
- (b) $F/2$**
- (c) F**
- (d) $2F$**

Soln:

Answer is (a) $F/4$

4. 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

Soln:

Answer is (c) will move along a straight line tangential to the circular path

Explanation:

At any instance of time object in circular motion tend to be in rectilinear motion. Object keeps on moving due to centripetal force and it moves along a straight line tangential to the circular path when strings breaks.

5. An object is put one by one in three liquids having different densities. The object floats with $\frac{1}{2}$, $\frac{3}{4}$, and $\frac{9}{11}$ 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) $d_1 < d_2 < d_3$

Soln:

Answer is (d) $d_1 < d_2 < d_3$

6. In the relation $F = G \frac{M m}{d^2}$, 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

Soln:

Answer is (d) is universal constant of nature

Explanation:

G is called as Newton's constant. It is the force of gravity on a body. Value of G is $6.66 \times 10^{-11} \text{ Nm}^2\text{kg}^{-2}$

7. Law of gravitation gives the gravitational force between
- (a) the earth and a point mass only
 - (b) the earth and Sun only
 - (c) any two bodies having some mass
 - (d) two charged bodies only

Soln:

Answer is (c) any two bodies having some mass

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

- (a) depends on mass of earth only
- (b) depends on radius of earth only
- (c) depends on both mass and radius of earth
- (d) is independent of mass and radius of the earth

Soln:

Answer is (d) is independent of mass and radius of the earth

Explanation:

G is an universal constant hence it is independent of mass and radius of the earth.

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

- (a) 1 4 times
- (b) 4 times
- (c) 1 2 times
- (d) unchanged

Soln:

Answer is (b) 4 times

Explanation:

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

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

$$F = 4 \times G \times \frac{m_1 \times m_2}{r^2}$$

10. The atmosphere is held to the earth by

- (a) gravity
- (b) wind
- (c) clouds
- (d) earth's magnetic field

Soln:

Answer is (a) gravity

11. 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**

Soln:

Answer is (d) universal gravitational constant

Explanation:

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

Here point masses are separated by unit distance

Hence m_1 , m_2 and $r = 1$

Hence $F = G$ which is a universal constant hence answer is universal gravitational constant

12. 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 surface of the earth**

Soln:

Answer is (a) zero

Explanation:

At the centre of the earth acceleration due to gravity is zero . Since weight is the product of mass and gravity. Weight of object at the centre of the earth will be zero.

13. An object weighs 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**

Soln:

Answer is (a) 2 N

Explanation:

Object of weight displaced by liquid = weight in air - weight in liquid

$$= 10\text{N} - 8\text{N}$$

$$= 2\text{N}$$

14. 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 form the base**
- (b) maximum when breadth and width form the base**
- (c) maximum when width and length form the base**
- (d) the same in all the above three cases**

Soln:

Answer is (b) maximum when breadth and width form the base

Explanation:

Surface area and pressure are inversely proportional. Pressure will be maximum when surface area is minimum hence the answer is maximum when breadth and width form the base.

15. 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_1 and F_2 are equal**

Soln:

Answer is (d) F_1 and F_2 are equal

Explanation:

Newton's third law of motion states that for every action there is equal and opposite reaction. Hence F_1 and F_2 are equal.

Short Answer Questions

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

Soln:

Gravitational force is the source of centripetal force required to revolve around the sun. This force depends on distance between the planet and sun along with their masses.

17. 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?

Soln:

Both the stones reach the ground simultaneously as they are dropped from same height and their initial velocity will be same .

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

Soln:

If there is no gravitational pull from the earth moon start to move in a straight line tangent to its circular path.

19. 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.

Soln:

Value of g is greater than value of g in poles . Since packets are thrown from same height packet thrown from poles reaches the earth first.

20. 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?

Soln:

Weight of person is = $\frac{1}{6}$ th of weight on earth

This proves acceleration due to gravity on moon is $\frac{1}{6}$ th of acceleration due to gravity on earth. Hence the person can lift a mass 6 times heavier on moon than on earth.

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

Soln:

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

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

$$\text{Density of earth } D = \frac{\text{Mass}}{\text{Volume}}$$

$$= \frac{Gr^2}{G \times V_e}$$

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

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

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

Soln:

Sun provides enough centripetal force to keep earth in its orbit and the earth provides centrifugal force due to its motion. These two force balance each other which prevents earth from falling into sun.

Long Answer Questions

23. 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?

Soln:

Let R and M be the radius and mass of the earth

Then

$$\text{Weight of the object} = \frac{M}{R^2}$$

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

Hypothetically 4m and R becomes $\frac{R}{2}$

$$\text{Then, weight} = mG \frac{4M}{\left(\frac{R}{2}\right)^2}$$

$$= (16m g) \frac{M}{R^2}$$

$$= 16W_0$$

Weight will be 16 times.

24. 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.

Soln:

Force of attraction between two masses separated by distance r is given by Newton law of gravitation where $F = \frac{Gm_1m_2}{R^2}$. Where G is gravitational force and it is an universal constant.

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

Bodies thrown from same height fall with same speed irrespective of their mass. This is due to acceleration due to gravity.

$g = \frac{GM}{R^2}$ Where M is mass R is radius of the earth

This equation shows that acceleration due to gravity depends on mass of the earth and radius of the earth. Hence two brick tied will not fall faster than single one.

25. 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.

Soln:

$$h_1 = \frac{1}{2}gt^2_1$$

$$h_2 = \frac{1}{2}gt^2_2$$

as $x = 0$

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

As the acceleration remain same ratio between two objects remain same. In this case acceleration does not depend upon mass and size.

26. (a) 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 for water. Give reason for each case.

(b) A ball weighing 4 kg of density 4000 kg m^{-3} is completely immersed in water of density 103 kg m^{-3} . Find the force of buoyancy on it. (Given $g = 10 \text{ m s}^{-2}$.)

Soln:

i) Buoyant force, $F = V\rho g$

ρ = Density of water, V = Volume of water displaced by the body

Volume and density of an object decides its Buoyancy. Cube will experience a greater buoyancy in saturated solution. If cube is reduced to 4 cm on each side, volume of cube becomes less as the buoyancy will be reduced as buoyant force is directly proportional to volume.

(ii) The magnitude of the buoyant force given by $F = V\rho g$

where V = Volume of body immersed in water or volume of water displaced, ρ = Density of liquid.

[$\therefore$ Given, mass of a ball = 4 kg, density = 4000 kgm^{-3}].

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

$$= \frac{4}{4000}$$

$$= \frac{1}{1000}$$

$$\text{Buoyancy } F = V\rho g$$

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

10N