Gravitation

Periodic Test

Q.1. Define Gravity

Answer: The force of attraction applied by earth is called its gravity.

The earth attracts (or pulls) all the objects towards its centre. The force with which it pulls objects towards itself is called gravitational force of earth or gravity.

Example:

A stone dropped from a height falls towards earth because the earth exerts a force of attraction (called gravity) on the stone and pulls it down.

Q.2. Define Gravitation

Answer: According to Newton, every object in this universe attracts every other object with a certain force. The force with which two objects attract each other is called gravitation.

The gravitation acts between two objects even if the two objects are not connected by any means.

If the mass of the objects (or bodies) are small, then the gravitational force between them is also very small (which cannot be detected easily).

Q.3. Define acceleration due to gravity

Answer: When an object is dropped from some height, a uniform acceleration is produced in it by the gravitational pull of earth and this acceleration does not depend upon the mass of falling body. This uniform acceleration is called acceleration due to gravity.

The acceleration due to gravity is represented by ‘g’ and its value is 9.8 ms^{-2}.

The value of g changes slightly from place to place.

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

Where, G = Gravitational Constant

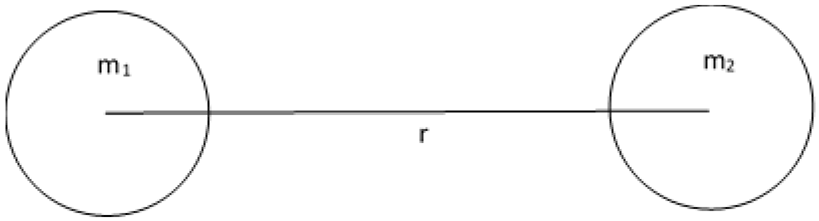
M = Mass of Earth

R = Radius of Earth

Q.4. State Newton's Law of Gravitation

Answer: Universal Law of Gravitation given by Newton is called Newton's Law of Gravitation. This law states that, "Every object in the universe attracts every other object with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them."

Suppose two bodies A and B of mass m_1 and m_2 be at distance r from each other.



So, according to Newton's law of gravitation,

$F \propto m_1 \times m_2$ ….1

And $F \propto \frac{1}{r^2}$ ….2

Thus, combining equations 1 and 2 we get,

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

Where, G = Universal Gravitational Constant

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

Q.5. What is weight?

Answer: The earth attracts every object towards its centre with a certain force which depends on the mass of the body and the acceleration due to gravity at that place

The weight of the body is the force with which it is attracted towards the centre of the earth.

Force = Mass × Acceleration

Where, Force = Weight = W

Acceleration = Acceleration due to gravity = g

And, Mass = m

Thus, W = m × g

Also, weight is a vector quantity that is it has both magnitude as well as direction.

Q.6. Give Reasons for the Following:

The weight of a body is zero at the centre of the earth

Answer: The weight of the body is the force with which it is attracted towards the centre of the earth.

W = m × g

Weight of the body changes from place to place, as the value of g changes from place to place.

Acceleration due to gravity g is zero at the centre of earth, as at the centre of earth we are surrounded by equal masses in all the direction, hence equivalent gravitational force acting on us due to earth is zero and thus making acceleration due to gravity to zero.

So, W = m × g = 0

Hence, weight at the centre of earth is zero.

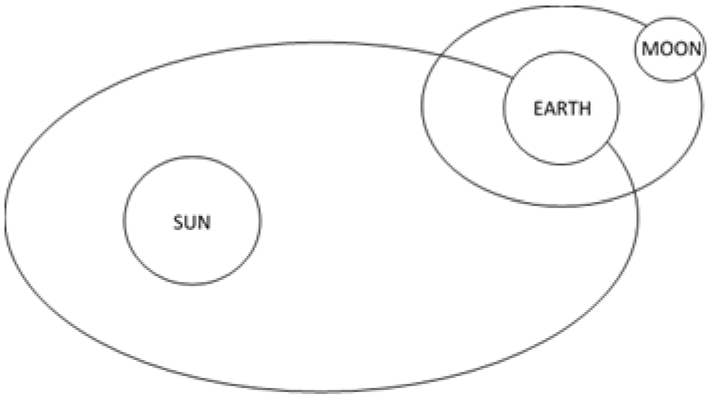
Q.7. Give Reasons for the Following:

Why does the moon not actually fall on the surface of the earth?

Answer: The moon never actually falls on the surface of earth.

Now, to understand this, we first need to understand the nature of the force between the moon and earth and also the movement of moon under this force.

So, the gravitational force is the force that acts between the earth and the moon and the moon moves in the circular orbital due to the centripetal force generated by the gravitational force. Similarly, earth and sun also experience this gravitational force between themselves.



So, yes moon does fall towards earth, but earth also moves in its orbit and covers more distance away from the moon relative to the distance covered by the moon. Hence, moon never falls on the surface of the earth.

Q.8. Give Reasons for the Following:

Why is the weight of an object on the moon one-sixth its weight on the earth?

Answer: Suppose we have an object of mass = m also let the weight on moon be W_m and weight on earth be W_e.

Now, weight of object on moon will be:

$$W_m = G\frac{M \times m}{r^2} \quad \text{....1}$$

Now the weight is actually the force with which moon attract the object.

M = Mass of Moon

r = radius of Moon

Now, we know

Mass of earth = 100 times mass of moon

Radius of earth = 4 times radius of moon

So, weight of object on earth will be given by:

$$W_e = \frac{G \times 100 \times M \times m}{(4 \times r)^2} \quad \text{....2}$$

Now, dividing equation 1 by 2, we get,

$$\frac{W_m}{W_e} = \frac{\text{Weight on Moon}}{\text{Weight on Earth}} = \frac{16}{100} \sim \frac{1}{6}$$

Thus, we can say that weight of an object on the moon one-sixth its weight on the earth.

Q.9. Give Reasons for the Following:

As we go higher above the surface of the earth the weight of the body decreases

Answer: We know that weight of a body is the force with which the body is attracted towards the center of earth.

W = m × g

Where, m = Mass of the body

And, g = Acceleration due to gravity

The mass of a body or object is constant and does not change from place to place.

But acceleration due to gravity is inversely proportional to the square of the distance from the center of earth. So, as we go up from surface of the earth, the distance from the center of earth increases and hence value of g decreases.

Since, W = m × g

So, as the g decreases, weight of the body also decreases with increase in height above the earth. Thus, as we go higher above the surface of the earth the weight of the body decreases.

Q.10. Give Reasons for the Following:

If the force of gravity acts on all bodies proportional to their masses, why does a heavy body not faster than a light body?

Answer: Force on an object of mass m falling freely under gravitation by the earth is given by Universal Law of Gravitation:

F = $G\frac{M \times m}{r^2}$ or, F $\propto$ m

Now, clearly from above we can see that F depends on mass of the object.

Since, M = Mass of earth

r = Radius of earth

G = 6.67×10^{-11} Nm^2kg^{-2} are constants

If g is the acceleration due to gravity on an object of mass m then,

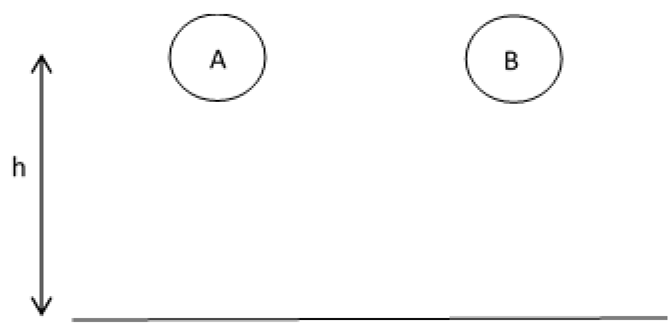
F = m × g

Or, $g = \frac{F}{m}$

Or, $g = G\frac{M}{r^2}$

Thus, g is independent of mass of the object.

Now, let two objects A of mass m_1 and B of mass m_2 fall from height h such that



Now, using the following equation of motion,

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

Here, u = 0, s = h and a = g

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

Or, $t = \sqrt{\frac{2 \times h}{g}}$

Now, from above, since time depends on both h and g, which are both independent of masses, so both A and B come down at same time.

Q.11.Differentiate between mass and weight.

Answer:

Mass	Weight
The mass of a body is the quantity of matter contained in it.	The force with which the body is attracted towards the centre of earth is called weight.
Mass is a scalar quantity, that is it has only magnitude	Weight is a vector quantity that is it has both magnitude as well as direction. It is always directed towards the centre of earth.
Mass of an object is constant and does not change from place to place	Weight of a body changes from place to place and is not constant
Mass can be determined via ordinary balance	Weight of a body is measured via a spring balance
SI unit of mass is kilogram (kg)	SI unit of weight is Newton (N)

Q.12. Under what conditions a body becomes weightless?

Answer: Weight of a body is nothing but the force with which it is attracted towards the centre of earth.

Force = Mass × Acceleration

W = m × g

Since, we have Force = Weight = W and acceleration is acceleration due to gravity or g.

A body becomes weightless when g becomes zero and this happens when acceleration due to gravity becomes zero and thus body becomes weightless.

Example:

At centre of earth, far away from earth's surface, freely falling body

Q.13. If we go deeper inside the earth, what will change: weight or mass or both, why?

Answer: As we go deeper inside the earth weight of object changes and mass remains invariant.

Since, mass of an object is the amount of matter contained in the object and as we know that going deep inside the earth will not change the amount of matter contained in the object, so mass remains constant. In fact, mass of an object always remains constant and does not change from one place to another.

On the other hand, weight of an object is the force with which earth pulls an object towards its centre.

$W = m \times g$

From above, as we know that g decreases as we go deep inside the earth, so the value of the weight of the object also decreases.

Q.14. Give at least two points of difference between G and g.

Answer:

Acceleration due to Gravity (g)	**Universal Gravitational Constant (G)**
An acceleration produced on a freely falling body due to the gravitational force of earth is known as acceleration due to gravity.	Gravitational constant G is numerically equal to the force of gravitation that exists between two bodies of unit mass kept at a unit distance from each other.
Value of g near earth's surface is 9.8 ms^{-2}. It may vary from place to place.	Value of G is 6.67×10^{-11} Nm^2kg^{-2} and it is an universal constant
Depends upon the distance between the masses	Independent of the distance between the masses
SI unit is ms^{-2}	SI unit is Nm^2kg^{-2}

Q.15. A body is taken from the surface of the earth to the moon. Will its weight increase or decrease? Justify your answer.

Answer: When a body is taken from earth to the moon, then its weight will decrease to one – sixth its weight on earth.

Explanation:

Suppose we have an object of mass = m also let the weight on moon be W_m and weight on earth be W_e.

Now, weight of object on moon will be:

$$W_m = G\frac{M \times m}{r^2} \quad ....1$$

Now the weight is actually the force with which moon attract the object.

M = Mass of Moon

r = radius of Moon

Now, we know

Mass of earth = 100 times mass of moon

Radius of earth = 4 times radius of moon

So, weight of object on earth will be given by:

$$W_e = \frac{G \times 100 \times M \times m}{(4 \times r)^2} \quad ....2$$

Now, dividing equation 1 by 2, we get,

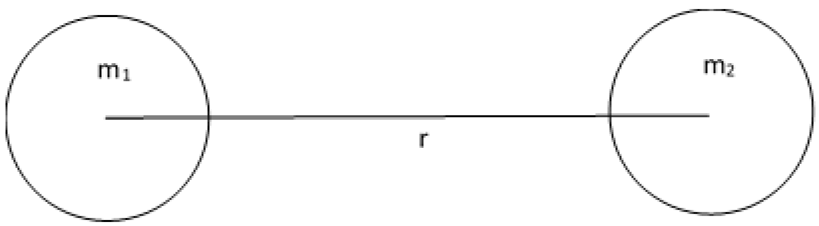
$$\frac{W_m}{W_e} = \frac{\text{Weight on Moon}}{\text{Weight on Earth}} = \frac{16}{100} \sim \frac{1}{6}$$

Thus we can say that weight of an object on the moon one-sixth its weight on the earth.

Q.16. State Newton's law of gravitation. Explain it.

Answer: Universal Law of Gravitation given by Newton is called Newton's Law of Gravitation. This law states that, "Every object in the universe attracts every other object with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them."

Suppose two bodies A and B of mass m_1 and m_2 be at distance r from each other.



So, according to Newton's law of gravitation,

$F \propto m_1 \times m_2$ ….1

And $F \propto \frac{1}{r^2}$ ….2

Thus, combining equations 1 and 2 we get,

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

Where, G = Universal Gravitational Constant

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

Newton's law of gravitation is called universal law of gravitation because it is applicable to all bodies having mass: whether big or small; whether the bodies are terrestrial (which are on earth) or celestial (which are in outer space) such as stones, planets and satellites.

Q.17. Derive an expression for the acceleration due to gravity on the surface of the earth. State the factors on which g depends. How does it vary with depth? Where is it maximum on the surface of the earth?

Answer: The acceleration produced in a freely falling body by the gravitational pull of the earth is called the acceleration due to gravitation.

We know that,

Force = Mass × Acceleration

F = m × a

$a = \frac{F}{m}$ ….1

Where F is the force on the object of mass m dropped from a distance r from the centre of earth of mass M.

So, force exerted by the earth on the object is

$F = G\frac{M \times m}{r^2}$ ….2

M = Mass of Earth

m = mass of object

r = distance of object from centre of earth

Now, from equation 1 and 2,

a = $G\frac{M \times m}{r^2 \times m}$

a = $G\frac{M}{r^2}$

Now, from above,

a = g = Acceleration due to gravity

We also see that, although force is depending on the mass of the object,

F = $G\frac{M \times m}{r^2}$

But acceleration due to gravity is independent of the mass.

g = $G\frac{M}{r^2}$

Factors on which g depends are:

(i) Value of gravitational constant (G)

(ii) Mass of Earth (M)

(iii) Radius of Earth (r)

As gravitational constant G and mass of earth M are always constant, so the value f acceleration due to gravity g is constant as long as the radius of earth remains constant.

At the surface of earth also, the value of g is not constant. ($g \propto \frac{1}{r^2}$)

At the poles, radius of earth is minimum, hence the g is maximum. Similarly, at the equator, the radius of earth is maximum, and hence the value of g is minimum. Also, as we go up from the surface of the earth, distance from the centre of the earth increases and hence value of g decreases.

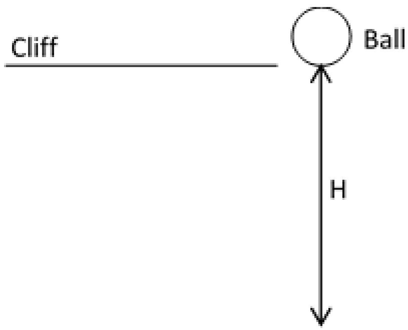
The value of g also decreases as we go inside the surface of earth and g is zero at the centre of earth, as at the centre of the earth the object has mass around it, so net force cancels and thus net acceleration becomes zero.

Q.18. A boy drops a stone from a cliff which reaches on the ground in B seconds. Calculate

(i) height of cliff

(ii) final velocity of the stone

Answer: Let H be the height of the cliff.



Now, ball is initially at rest

So, u = initial velocity = 0

a = acceleration = g

v = final velocity

t = B seconds

(i) From the equations of motion, we know that,

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

$$H = 0 + \frac{1}{2} gB^2$$

$$H = \frac{1}{2} gB^2$$

(ii) Now, we also know that,

v = u + at

v = 0 + gB

v = gB

Q.19. A stone thrown vertically upwards takes 3 seconds to attain maximum height, calculate

(i) initial velocity of stone

(ii) maximum height attained by the stone

Answer: Let,

u = Initial velocity of stone

H = Maximum height attained by the stone

v = final velocity at maximum height = 0

t = time taken to attain maximum height = 3 s

a = -g = acceleration due to gravity

(i) We know that,

v = u + at

0 = u – g × 3

u = 3g = 3 × 9.8 ms^{-2}

u = 29.4 ms^{-1}

(ii) From the equations of motion, we know that,

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

$$H = 29.4 \times 3 + \frac{1}{2} 9.8 \times 9$$

$$H = 88.2 + 44.1$$

H = 132.3 m

Q.20. Prove that if a body is thrown vertically upwards, then the time of ascent is equal to the time of descent.

Answer: Let,

u = Initial velocity

v = Final velocity

h = Height attained

a = acceleration

t = time

Ascent:

Ball thrown upward with velocity u. So, v = 0 at maximum height h. Also, a = -g

Now, using v = u + at

$0 = u - gt_a$

$t_a = \frac{u}{g}$ ….1

Where t_a = time of ascent

Also, by using $v^2 = u^2 + 2as$

$0 = u^2 - 2gh$

$u = \sqrt{2gh}$ ….2

From equations 1 and 2, we get,

$t_a = \sqrt{\frac{2h}{g}}$ …. A

Descent:

Ball comes down from height h. So, u = 0 and a = g.

So, using v = u + at

$v = gt_d$ …..3

Where t_d = Time of descent

Now, using $v^2 = u^2 + 2as$

$v^2 = 0 + 2gh$

v = $\sqrt{2gh}$ ….4

From equations 3 and 4, we get,

$t_d = \sqrt{\frac{2h}{g}}$ …. B

From equations A and B, we see that,

$t_a = t_d$

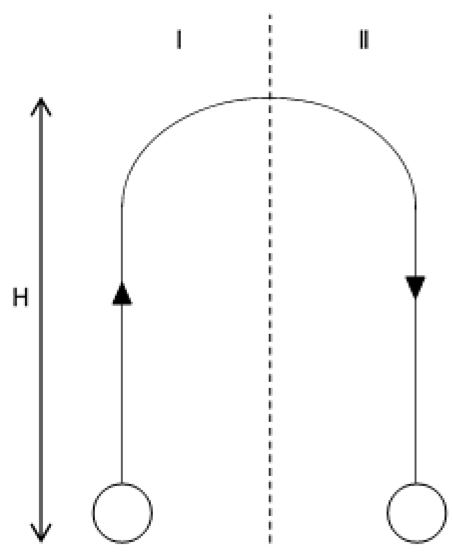
Q.21. A ball is thrown vertically upwards with a velocity u. Calculate the velocity with which it falls to the earth again.

Answer: Given:

u = Initial velocity

Ball is thrown up

Ball goes up and attains a maximum height H and then again comes down.



Let

u = Initial Speed

v = Final Speed

t = time

a = acceleration

s = distance

Case – I

Ball is going upward

a = -g

u = u

v = 0

s = H

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

$0 = u^2 - 2gH$

H = $\frac{u^2}{2g}$ ….1

Case – II

Ball comes downward

So, u = 0

v = Final Speed

a = g

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

$v^2 = 0 + 2gH$

H = $\frac{u^2}{2g}$ ….2

From equations 1 and 2, we see that,

v = u

Q.22. What is the mass of an object whose weight is 98 N?

Answer: Let the mass of the object be m.

Now, it is given that weight of the object = 98 N.

Also, we know that,

Weight = Mass × Acceleration

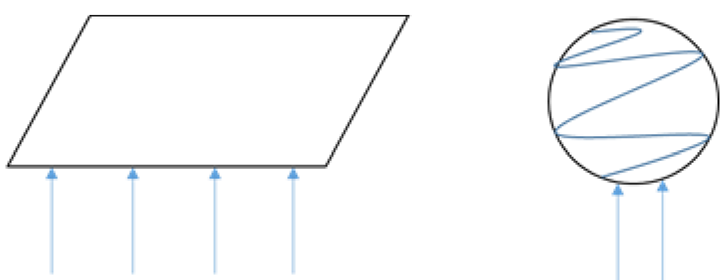
W = m × g

$$m = \frac{w}{2}$$

$$m = \frac{98}{9.8} = 10 \text{ kg}$$

Q.23. Why will a sheet of paper fall slower than one that is crumpled into a ball?

Answer: A sheet of paper falls slower than the one crumpled into a ball since the sheet of paper has the larger surface area. The air introduces a resistance to the falling paper. Since the sheet of paper has more surface area than the crumpled paper, so sheet of paper experiences more air resistance than that of the crumpled paper.



If there was no air resistance (friction), then both the sheet of paper and crumpled ball of paper would have fallen at the same time.

Q.24. If the force of gravity somehow vanished away, why would we be sent flying into space?

Answer: Force of gravity or the gravitational force of earth is the force that we experience towards the centre of the earth.

The gravitational force (pull) of earth is responsible for holding everything near earth's surface, it keeps us firmly on the ground.

If the force of gravity is somehow vanished away, then we would no longer be bound to the earth's surface and would be sent flying into the space.

Q.25. Where will you weigh more: at the equator or at the poles?

Answer: I will weigh more at poles and weigh less at the equator since weight is the amount of force with which an object is pulled towards the center of earth.

$W = m \times g$ ….1

Where, W = Weight

m = mass

g = Acceleration due to gravity

Since, mass is constant all the time, so,

$W \propto g$ ….2

And we also know that,

$g = G\frac{M}{R^2}$

Where, G = Gravitational Constant

R = Radius of earth

M = Mass of earth

So, $g \propto \frac{1}{R^2}$ ….3

From equations 2 and 3, we get,

$W \propto \frac{1}{R^2}$

Since R is minimum at poles, so weight is maximum at poles and similarly since R is maximum at equator, so weight is minimum at equator.

Hence, we weigh more at poles than at equator.

Q.26. Is the acceleration due to gravity same everywhere on the surface of the earth?

Answer: We know that earth is not a perfect sphere. So, the value of R is not the same at all places.

So, the value of acceleration due to gravity g is not constant at all places on the surface of earth.

$$g = G\frac{M}{R^2}$$

Where, G = Gravitational Constant

M = Mass of Earth

R = Radius of Earth

Since, G and M are constant, so g depends on the radius of earth.

So, from the above we can say that,

$$g \propto \frac{1}{R^2}$$

Now, radius of earth is minimum at poles. So, acceleration due to gravity is maximum at poles.

But radius at equator is maximum, so acceleration due to gravity is minimum at equator.

Q.27. Does acceleration due to gravity depend upon the mass of the body?

Answer: No, acceleration due to gravity do not depend on the mass of the body.

Explanation: The acceleration produced in a freely falling body by the gravitational pull of the earth is called the acceleration due to gravitation.

We know that,

Force = Mass × Acceleration

F = m × a

$a = \frac{F}{m}$ ….1

Where F is the force on the object of mass m dropped from a distance r from the centre of earth of mass M.

So, force exerted by the earth on the object is

F = $G\frac{M \times m}{r^2}$ ….2

M = Mass of Earth

m = mass of object

r = distance of object from centre of earth

Now, from equation 1 and 2,

a = $G\frac{M \times m}{r^2 \times m}$

a = $G\frac{M}{r^2}$

Now, from above,

a = g = Acceleration due to gravity

We also see that, although force is depending on the mass of the object,

F = $G\frac{M \times m}{r^2}$

But acceleration due to gravity is independent of the mass.

g = $G\frac{M}{r^2}$

Comprehensive Exercises (MCQ)

Q.1. Force of gravitation between two bodies varies r with as:

A. r

B. r

C. $\frac{1}{r}$

D. $\frac{1}{r^2}$

Answer: Newton’s law of gravitation states that: Every object in the universe attracts every other object with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

$$F \propto \frac{1}{R^2}$$

Hence, option D is correct.

Q. 2. At maximum of the locations the value of ‘g’ is a maximum:

A. On the top of Mount Everest

B. On the top of Qutab Minar

C. At any place on the equator

D. A camp site in Antarctica

Answer: We know that the value of g is inversely proportional to the square of radius or $g \propto \frac{1}{R^2}$.

Radius of earth is minimum at poles, so acceleration due to gravity is maximum at poles. Similarly, radius of earth is maximum at equator, so acceleration due to gravity is minimum at equator. Also, acceleration due to gravity decreases as we go higher from the earth surface.

Hence, option D is correct.

Q.3. A stone is dropped from the top of the tower. Its speed after it has fallen 20 m is (Take g = 10 ms^{-2})

A. -10 ms^{-1}

B. 10 ms^{-1}

C. -20 ms^{-1}

D. 20 ms^{-1}

Answer: Here,

u = Initial velocity = 0

v = Final velocity

s = Distance travelled = 20 m

a = acceleration = g = 10 ms^{-2}

Now, we know from the equations of motion that,

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

$$v = \sqrt{u^2 + 2as}$$

$$v = \sqrt{0 + 2 \times 10 \times 20}$$

$$v = \sqrt{400}\ ms^{-1}$$

v = 20 ms^{-1}

Hence, option D is correct.

Q.4. A ball is thrown vertically upward, acceleration due to gravity is:

A. in the direction opposite to the direction of motion

B. in the direction same as the direction motion

C. increases as it comes down

D. becomes zero at the highest point

Answer: When a ball is thrown vertically upward, then acceleration due to gravity is directed opposite to the direction of motion since the ball experiences a force of attraction directed towards the center of earth due to earth's gravity.

Direction of acceleration is in the direction of force as,

$$a = \frac{F}{m}$$

So, from above, we can conclude that acceleration is also directed towards the centre of earth which is opposite to the vertically upward motion of the ball.

Hence, option A is correct.

Q.5. At the top of its path a projectile:

A. has no acceleration

B. has acceleration in the upward direction

C. has acceleration in the down direction

D. has acceleration in the horizontal direction

Answer: At the top of its path in a projectile, the acceleration is in downward direction.

$$a = \frac{F}{m}$$

This acceleration is the acceleration due to gravity and is directed towards the centre of earth.

Hence, option C is correct.

Q.6. Consider earth to be a homogeneous sphere, Scientist A goes deep down in a mine and scientist B goes high up in a balloon. The acceleration due to gravity as measured by:

A. A goes on decreasing. B goes on increasing

B. B goes on decreasing, A goes on increasing

C. each remains unchanged

D. each goes on decreasing

Answer: The acceleration due to gravity goes on decreasing for both the scientists A and B.

For scientist B,

Since, $g \propto \frac{1}{r^2}$

So, as the distance from the center of earth increases, the value of g decreases.

For scientist A,

Let scientist A be at a depth d. Then only attraction is due to the sphere (R – d), where R is the radius of earth. As the attraction due to rest of the earth cancels out, so the value of g decreases.

Hence, option D is correct.

Q.7. Which of the following is the evidence to show that there must be a force acting on the earth and directed towards the sun?

A. deviation of falling bodies towards the east

B. revolution of the earth around the sun

C. phenomenon of day and night

D. apparent motion of sun around the earth

Answer: The revolution of earth around the sun shows that there must be a force acting on the earth and directed towards the sun.

Since revolution requires a centripetal force and this centripetal force has provided the gravitational force between the earth and sun.

Hence, option B is correct.

Q. 8. If the earth stops rotating the value of 'g' at the equator will:

A. increase

B. remains same

C. decrease

D. none of these

Answer: If the earth stops rotating, then the value of g at the equator increases and becomes equal to the value at poles. This is because, if the earth will stop rotating, then the equatorial bulge will vanish and earth will have a uniform radius and since, $g \propto \frac{1}{r^2}$ so g is same through the surface of earth now.

Hence, option A is correct.

Q.9. It is found that weight of an object is more at the poles than at the equator. So, it is beneficial to purchase goods at the equator and sell them a the poles, provided:

A. an equal beam balance is used

B. a spring balance is used

C. a beam balance or a spring balance is used

D. the statement is false

Answer: Since weight of object is more at poles than at the equator, so it is beneficial to purchase goods at equator and sell at poles provided a spring balance is used as a spring balance measures the weight of an object whereas equal beam balance measures mass and mass is constant and does not change from place to place.

Hence option B is correct.

Q.10. The value of gravitational constant depends upon:

A. temperature of the atmosphere

B. masses

C. distance between the masses

D. none of these

Answer: The gravitational constant is a universal constant. It remains as it is in any condition. It does not depend on any of the factors like the temperature, mass, distance between the masses.

Value of G is 6.67×10^{-11} Nm^2 kg^{-2}.

Hence, option D is correct.

Q.11. The acceleration due to gravity on the surface of a planet whose mass and radius are both one-third of the Earth (acceleration due to gravity on the earth is g):

A. g

B. 3g

C. $\frac{g}{3}$

D. $\frac{2}{3}g$

Answer: We know that, $g = G\frac{M}{R^2}$ where M is mass of earth and R is radius of earth.

Now, from the question,

M’ = $\frac{M}{3}$

R’ = $\frac{R}{3}$

So, the g’ will be:

$$g' = G\frac{M'}{R'^2}$$

$$g' = G\frac{M}{3 \times \frac{R}{3^2}^2}$$

$$g' = 3G\frac{M}{R^2}$$

$$g' = 3g$$

Hence, option B is correct.

Q.12. In vacuum all freely falling objects:

A. have the same speed

B. have the same velocity

C. have the same acceleration

D. have the same force

Answer: In vacuum all falling objects will have same acceleration.

The constant acceleration is due to gravitational force of earth and is known as acceleration due to gravity given by: $g = G\frac{M}{R^2}$

Where,

G = Gravitational Constant = 6.67×10^{-11} Nm^2kg^{-2}

M = Mass of Earth

R = Radius of Earth

From above, we see that all variables in the equation are constant. Thus g doesn’t depend on any other factors, and hence is constant.

Hence, option C is correct.

Q.13. When a spaceship is two earth radii distant from the centre of the earth, its gravitational acceleration is:

A. 19.6 ms^{-2}

B. 9.8 ms^{-2}

C. 4.9 ms^{-2}

D. 2.45 ms^{-2}

Answer: We know that,

$$g = G\frac{M}{R^2}$$

Where,

G = Gravitational Constant = 6.67×10^{-11} Nm^2kg^{-2}

M = Mass of Earth

R = Radius of Earth

Now, the spaceship is at a distance R’ = 2R

So, g will be:

$$g' = G\frac{M}{R'^2}$$

$$g' = G\frac{M}{4R^2} = \frac{g}{4} = \frac{9.8}{4} = 2.45\ ms^2$$

Hence, option D is correct.

Q.14. If a planet existed whose mass and radius were both half that of the earth, the acceleration due to gravity at its surface would be:

A. 19.6 ms^{-2}

B. 9.8 ms^{-2}

C. 4.9 ms^{-2}

D. 2.45 ms^{-2}

Answer: We know that,

$g = G\frac{M}{R^2}$ For earth

Now, for the new planet we have,

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

So, g' will be calculated as:

$$g' = G\frac{M'}{R'^2} = G\frac{\frac{M}{2}}{\frac{R^2}{2^2}} = 2G\frac{M}{R^2} = 2g = 2 \times 9.8 = 19.6$$ ms^{-2}

Hence, option A is correct.

Q. 15. A stone is dropped from a cliff. Its speed after it has fallen 100 m is:

A. 9.8 ms^{-1}

B. 44.2 ms^{-1}

C. 19.69 ms^{-1}

D. 98 ms^{-1}

Answer: The stone is dropped from the cliff. So,

Initial Speed = u = 0

Distance = s = 100 m

Final Speed = v

Acceleration = a = g = 9.8 ms^{-2}

Now,

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

$$v^2 = 0 + 2 \times 9.8 \times 100$$

$$v = \sqrt{2 \times 9.8 \times 100}$$

v = 44.27 ms^{-1}

Hence, option B is correct.

Q.16. A ball is thrown up and attains a maximum height of 100 m, it is thrown upwards with a speed of:

A. 9.8 ms^{-1}

B. 44.2 ms^{-1}

C. 19.69 ms^{-1}

D. 98 ms^{-1}

Answer: A ball is thrown upward. So,

Initial Speed = u

Distance = s = 100 m

Final Speed = v = 0

Acceleration = a = g = -9.8 ms^{-2} (negative, since acceleration is opposite the motion)

Now,

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

$$0 = u^2 - 2 \times 9.8 \times 100$$

$$u = \sqrt{2 \times 9.8 \times 100}$$

u = 44.27 ms^{-1}

Hence, option B is correct.

Q.17. A stone dropped from a certain height takes 4 second to reach the ground. The height is:

A. 19.6 m

B. 39.2 m

C. 156.8 m

D. 78.4 m

Answer: Let the height be H

Time taken = t = 4 seconds

Initial Velocity = u = 0

Acceleration = a = g = 9.8 ms^{-2}

Now,

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

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

$$H = \frac{1}{2} \times 9.8 \times 4^2$$

$$H = 78.4 \text{ m}$$

Hence, option D is correct.

Q.18. The weight of an object:

A. is the quantity of matter it contains

B. refers to its inertia

C. is the force as its mass but expressed in different units

D. is the force with which it is attracted towards the earth

Answer: Weight of an object is the force with which it is attracted towards the earth.

The quantity of the matter present in an object is called the mass and it is related with the object's inertia whereas weight is written as $W = m \times g$, where g is acceleration due to gravity.

Hence, option D is correct.

Q.19. The equation is valid only for:

A. linear bodies

B. spherical bodies

C. elliptical bodies

D. circular bodies

Answer: The equation is valid for spherical bodies.

The gravitational equations are valid for point masses. For spherical bodies the center of mass can be conveniently chosen at the center and mass is evenly distributed about the center.

Hence, option B is correct.

Q. 20. If the distance between two objects is doubled, the gravitational force between them:

A. remains the same

B. gets doubled

C. gets halved

D. becomes one – fourth

Answer: If the distance between two objects is doubled the gravitational force becomes one fourth since,

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

Where R is the distance between the bodies.

So, if R' = 2R, then

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

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

Hence, option D is correct.

Q.21. A bomb is released from an aircraft. Its trajectory is:

A. a straight line

B. parabola

C. an arc of a circle

D. a zigzag path

Answer: Let the aircraft be moving horizontally with speed u. Now, when the bomb is released, it experiences gravitational force on it and thus acceleration due to gravity in vertically downward direction.

Initially:

	X Axis	**Y Axis**
Speed	$u_x = u$	$u_y = 0$
Acceleration	$a_x = 0$	$a_y = g$
Time	t	t

Finally:

Speed $= v_x$ $v_x = u_x + a_x t$ $v_x = u$ $s_x = x = u_x t + \frac{1}{2} a_x t^2$ $x = ut$ $t = \frac{x}{u}$ 1	Speed $= v_y$ $v_y = u_y + a_y t$ $v_y = gt$ $s_y = y = u_y t + \frac{1}{2} a_y t^2$ $y = \frac{1}{2} g t^2$ 2

Substituting equation 1 in 2, we get,

$$y = \frac{1}{2} g \frac{x^2}{u^2}$$

The above equation is an equation of parabola.

Hence, option B is correct.

Q. 22. A soft drink bottle is dropped by a water from the top of a hotel whose height is 100 m. It takes T second to reach the ground. Where will it be at T/2 second?

A. 50 m from top

B. 75 m from bottom

C. 25 m from bottom

D. 40 m from top

Answer: Given:

Height of Tower = 100 m

Time taken to reach ground = T seconds

Acceleration = a = g = 9.8 ms^{-2}

Initial Speed = u = 0

Final Speed = v

Now, we know that,

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

$100 = \frac{1}{2}gT^2$ At t = T and s = 100 m …..1

Let t = $\frac{T}{2}$ and s = x

Then, $x = \frac{1}{2}a\frac{T^2}{2}$ …..2

So, dividing equation 1 by 2, we get,

$$\frac{100}{x} = 4$$

x = 25 m

So, 25 m from the top at t = $\frac{T}{2}$ seconds or (100 – 25) m, that is 75 m from the bottom at $\frac{T}{2}$ seconds.

Hence, option B is correct.

Q.23. Two bodies, one held 1 m vertically above the other, are released simultaneously and fall freely under gravity. After 2 second, the relative separation of the bodies will be:

A. 4.9 m

B. 9.8 m

C. 19.6 m

D. 1 m

Answer: Now, initial separation = 1 m

Body 1:

Initial Speed = 0

Acceleration = 9.8 ms^{-2}

Time = 2 seconds

Now, we know that,

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

So, $s_1 = \frac{1}{2} \times 9.8 \times 4$

$s_1 = 19.6$ m

Body 2:

Initial Speed = 0

Acceleration = 9.8 ms^{-2}

Time = 2 seconds

Now, we know that,

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

So, $s_2 = \frac{1}{2} \times 9.8 \times 4$

s_2 =19.6 m

Since $s_1 = s_2$, so final separation is also 1 m.

Hence, option D is correct.

Comprehensive Exercises (T/F)

Q.1. Write true or false for the following statements:

The force of attraction between two bodies is called gravity.

Answer: False

Explanation: Force of attraction between two bodies is called gravitation.

Gravity is the force of attraction on any object by the earth that is a gravitational pull towards the centre of earth.

Q.2. Write true or false for the following statements:

The value of G depends upon the mass of two objects.

Answer: False

Explanation: G is also known as Universal Gravitational Constant. Value of G is 6.67×10^{-11} Nm^2kg^{-2}. The value of G is independent of mass of object and the distance between them.

Q. 3. Write true or false for the following statements:

If a spring balance, holding a heavy object is released, it will read zero weight.

Answer: True

Explanation: Spring Balance gives the weight of the object.

$W = m \times g$

If the heavy object is released, then it will read zero, since no mass implies no weight.

Q.4. Write true or false for the following statements:

The value of G is high if the radius of the body is more and less if radius is less.

Answer: False

Explanation: G is universal gravitational constant and is always constant.

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

It does not change with radius of the body and thus is independent of it.

Q.5. Write true or false for the following statements:

The centre of mass and centre of gravity for a small body lie at the same point.

Answer: True

Explanation: Centre of mass means the mean position of all the matter in the body.

Centre of Gravity is a point at which the weight of body is considered.

If the object is small then gravitational field is uniform and both lie at the same point.

Q.6. Write true or false for the following statements:

The gravitational force between two bodies' changes if a material body is placed between them.

Answer: False

Explanation: Gravitational Force between two bodies does not change if a material body is placed between them, since according to Newton's law,

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

Where, G = Universal gravitational Constant

m_1, m_2 = Masses of bodies

R = Distance between two bodies

Here, F does not depend on the material medium and hence it will not change due to change in medium.

Q.7. Write true or false for the following statements:

The acceleration of a body thrown up is numerically the same as the acceleration of a downward falling body but opposite in sign.

Answer: True

Explanation: When a body is thrown up and when a body comes down, in both the cases the only force acting on the body is the gravitational force attraction that acts towards the centre of the earth.

$F = m \times a$

$$a = \frac{F}{m}$$

Since, F and m both are same in both the cases, hence acceleration is also same.

They are opposite in sign since, when a body comes down, then the acceleration is in direction of motion and hence positive, whereas when body is thrown up, then the acceleration is in opposite direction of motion and hence negative.

Q. 8. Write true or false for the following statements:

The value of g is zero at the centre of the earth.

Answer: True

Explanation: The value of g is zero at the centre of earth. This is because at the centre of earth the object is surrounded from masses from all sides. The total force acting on the object is thus zero and thus acceleration due to gravity is also zero.

Q.9. Write true or false for the following statements:

The inertia of an object depends upon its mass.

Answer: True

Explanation: Yes, the inertia of the system depends on its mass.

Inertia is the property to resist the change in motion. The more the mass of the object, the more is the resistance to the change in velocity.

$F = m \times a$

For same force, if mass is more, then acceleration is less and thus mass is the measure of inertia.

Q.10. Write true or false for the following statements:

All objects attract each other along the line joining their centre of mass

Answer: True

Explanation: Yes, all objects attract each other along the line joining their centre of mass.

The force of attraction is the gravitational force of attraction and is given as,

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

Where, G = Universal gravitational Constant

m_1, m_2= Masses of bodies

R = Distance between two bodies

Gravitational force acts only along the line joining the two masses.

Q.11. Write true or false for the following statements:

Acceleration due to gravity is expressed as

g = $G\frac{M}{r^2}$

Where, symbols have their usual meanings.

Answer: True

Explanation: The acceleration produced in a freely falling body by the gravitational pull of the earth is called the acceleration due to gravitation.

We know that,

Force = Mass × Acceleration

F = m × a

a = $\frac{F}{m}$ …..1

Where, F is the force on the object of mass m dropped from a distance r from the centre of earth of mass M.

So, force exerted by the earth on the object is

F = $G\frac{M \times m}{r^2}$ …..2

M = Mass of Earth

m = mass of object

r = distance of object from centre of earth

Now, from equation 1 and 2,

$a = G\frac{M \times m}{r^2 \times m}$

$a = G\frac{M}{r^2}$

Now, from above,

a = g = Acceleration due to gravity

Hence,

$g = G\frac{M}{r^2}$