CLASS IX: SCIENCE
Chapter 9: Gravitation

Questions and Solutions | Page NO. 102 - NCERT Books

Q1. State the universal law of gravitation.

Ans. Every body in this universe attracts every other body with a force, which is directly proportional to the product of their masses and inversely proportional to the square of distance between their centres.

Q2. Write the formula to find the magnitude of the gravitational force between the earth and an object on the surface of the earth.

Ans. $F_g = \frac{GMm}{R^2}$

Where G is gravitational constant, M is the mass of the earth, m is the mass of the object, R is the distance between the centre of the object and the centre of the earth ≈ radius of earth.

Questions and Solutions | Page NO. 104 - NCERT Books

Q1. What do you mean by free fall ?

Ans. When an object moves with a constant acceleration, under the influence of force of gravitation of the earth only, the object is said to have free fall.

Q2. What do you mean by acceleration due to gravity?

Ans. The acceleration produced in a body due to force of gravity is called acceleration due to gravity. It is denoted by g. The value of acceleration due to gravity is taken as 9.8 ms^{-2} at the sea level.

Questions and Solutions | Page NO. 106 - NCERT Books

Q1. What are the differences between the mass of an object and its weight ?

Ans.

Mass	Weight
1. It is the amount of matter contained in a body.	1. It is the force of gravity acting on a body.
2. It is measured by a physical balance.	2. It is measured by a spring balance.
3. It is constant at all the places in universe.	3. It is variable and changes with the change in acceleration due to gravity.
4. Its S.I. unit is kilogram.	4. Its S.I. unit is Newton.

Q2. Why is the weight of an object on the Moon $\frac{1}{6}$th of its weight on the earth ?

Ans. Acceleration due to gravity (g_m) on Moon is $\frac{1}{6}$th of the acceleration due to gravity (g_e) on earth. i.e.,

$$g_m = \frac{1}{6} g_e$$

or $\quad mg_m = \frac{1}{6} mg_e \quad$ where, m = mass of object

or $\quad W_m = \frac{1}{6} W_e \quad$ [weight = mg]

Since, g_m is $\frac{1}{6}$th of g_e, thus, weight of an object on the Moon is also $\frac{1}{6}$th of the weight of the object on earth.

Questions and Solutions | Page NO. 109 - NCERT Books

Q1. Why is it difficult to hold a school bag having a strap made of a thin and strong string ?

Ans. It is difficult to hold a school bag having a thin strap because the pressure on the shoulders is quite large. This is because the pressure is inversely proportional to the area on which the force acts. The smaller is the area, the larger will be the pressure on the surface. In the case of a thin strap, the contact area is very small. Hence, the pressure exerted on the shoulder is very large.

Q2. What do you mean by buoyancy ?

Ans. The tendency for an immersed body to be lifted up in a fluid, due to an upward force that acts opposite to the action of gravity is called **buoyancy**.

Q3. Why does an object float or sink when placed on the surface of water ?

Ans. If the density of an object is more than the density of the liquid, then it sinks in the liquid. This is because the buoyant force acting on the object is less than the weight of the object. If the density of the object is less than or equal to the density of the liquid, then it floats on the surface of the liquid. This is because the buoyant force acting on the object is equal to the weight of the object.

Questions and Solutions | Page NO. 110 - NCERT Books

Q1. You find your mass to be 42 kg on a weighing machine. Is your mass more or less than 42 kg ?

Ans. When you weigh your body, an upward buoyant force acts on your body due to the air (a fluid) present around you. As a result, the body gets pushed slightly upwards, causing the weighing machine to show a reading slightly less than the actual value.

Q2. You have a bag of cotton and an iron bar, each indicating a mass of 100 kg when measured on a weighing machine. In reality, one is heavier than other. Can you say which one is heavier and why ?

Ans. A weighing machine measures the apparent weight of an object. We know that apparent weight (W_a) is equal to true weight (W_t) minus buoyant force (F_B) i.e.,

$W_a = W_t - F_B$

or $W_t = W_a + F_B$

Now, buoyant force on the cotton due to the air present around it is large as compared to the buoyant force on the iron. This is because the volume of cotton is very large as compared to the volume of iron. As a result, the true weight of cotton must be greater than the true weight of iron. Thus, the given cotton sample is heavier than the given iron sample.

EXERCISES

Q1. How does the force of gravitation between two objects change when the distance between them is reduced to half ?

Ans. When all other variables remain constant, the force of gravitation is inversely proportional to the square of distance between the two objects.

$$F \propto \frac{1}{r^2} \Rightarrow \frac{F'}{F} = \frac{r^2}{\left(\frac{r}{2}\right)^2} = \frac{4r^2}{r^2} = 4$$

$\therefore$ The force of gravitation increases 4 times.

Q2. Gravitational force acts on all objects in proportion to their masses. Why then, a heavy object does not fall faster than a light object ?

Ans. A freely falling object of any mass falls under the action of gravity given by

$g = \frac{GM}{r^2}$, where 'G' is constant of gravitation,

M is mass of earth, r is the distance between the object and the centre of earth.
Thus, the acceleration due to gravity is independent of the mass of the objects.
$\therefore$ All objects fall with the same acceleration towards the earth.

Q3. What is the magnitude of the gravitational force between the earth and a 1 kg object on its surface ? (Mass of the earth is 6×10^{24} kg and radius of the earth is 6.4×10^6 m.)

Ans. $F_g = \frac{G \times M \times m}{R^2}$

Where, M = mass of the earth ; m = mass of object; R = radius of earth.

$$F_g = \frac{6.67 \times 10^{-11} \times (6 \times 10^{24}) \times (1)}{(6.4 \times 10^6)^2}$$

$= 9.770 \text{ N} \approx 9.8 \text{ N}$

Q4. The earth and the Moon are attracted to each other by gravitational force. Is the force with which the earth attracts the Moon greater, smaller or the same as the force with which the Moon attracts the earth ? Why ?

Ans. The earth attracts the Moon with the same force with which the Moon attracts the earth because, the gravitational forces between any two bodies are equal and opposite (Newton's third law).

Q5. If the Moon attracts the earth, why does the earth not move towards the Moon ?

Ans. The earth does not move towards the Moon because the force exerted by the earth or the Moon on each other is insufficient to move the earth, on account of its huge mass.

Q6. What happens to the force between two objects, if
(i) the mass of one object is doubled ?
(ii) the distance between the objects is doubled and tripled ?
(iii) the masses of both objects are doubled ?

Ans. (i) The force of gravitation doubles.
(ii) The force of gravitation decreases 4 times if the distance between the objects is doubled, and if the distance between the objects is tripled then the force of gravitation decreases 9 times.
(iii) The force of gravitation increases 4 times.

Q7. What is the importance of universal law of gravitation ?

Ans. Importance of universal law of gravitation is as follows :
(i) It is the gravitational force between the Sun and the earth, which makes the earth move around the Sun.
(ii) The tides formed in sea are because of gravitational pull exerted by the Sun and the Moon on the surface of water.
(iii) It is the gravitational pull of earth, which keeps us and other bodies firmly on the ground.
(iv) It is the gravitational pull of the earth, which holds our atmosphere in place.

Q8. What is the acceleration of free fall ?

Ans. The acceleration of free fall for object moving near the surface of earth is $9.81\ ms^{-2}$.

Q9. What do we call the gravitational force between the earth and an object ?

Ans. It is called force of gravity.

Q10. Amit buys few grams of gold at the poles as per the instruction of one of his friends. He hands over the same when he meets him at the equator. Will the friend agree with the weight of gold bought ? If not, why? [Hint : The value of g is greater at the poles than at the equator]

Ans. Weight of an object = mg, where 'm' is mass of the object.
'g' at equator is less than the 'g' at poles.
Thus, weight at equator will be less than that on poles.
So, his friend will not agree with weight of the gold at the poles when measured at equator.

Q11. Why will a sheet of paper fall slower than one that is crumpled into a ball ?

Ans. Sheet crumpled into a ball has small surface area as compared to the similar unfolded sheet. Therefore, unfolded sheet will experience more resistance due to air as compared to the sheet crumpled into a ball, inspite of same force of gravity acting upon them. It is larger resistance of air which slows down the unfolded sheet, and therefore it falls slower as compared to sheet crumpled into a ball.

Q12. Gravitational force on the surface of the Moon is only $\frac{1}{6}$ as strong as gravitational force on the earth. What is the weight in newton of a 10 kg object on the Moon and on the earth ?

Ans. Mass of object (m) = 10 kg

Acceleration due to gravity on earth

$(g_e) = 9.81\ ms^{-2}$.

Acceleration due to gravity on Moon

$(g_m) = \frac{9.81}{6}\ ms^{-2}$.

Weight of the object on the earth

$= mg_e = 10 \times 9.81 = 98.1$ N

Weight of the object on the Moon

$= mg_m = 10 \times \frac{9.81}{6} = 16.35$ N

Q13. A ball is thrown vertically upwards with a velocity of 49 ms^{-1}. Calculate

(i) The maximum height to which it rises.

(ii) The total time it takes to return to the surface of the earth.

Ans. (i) Initial velocity of the ball,u = 49 ms^{-1}

Final velocity of the ball, v = 0

Acceleration due to gravity g = –9.8 ms^{-2}

[In upward direction, g is taken –ve]

Height attained by the ball, s = ?

Time for rising up, t = ?

We know, $v^2 - u^2 = 2gs$

$(0)^2 - (49)^2 = 2 \times (-9.8) \times s$

$s = \dfrac{-49 \times 49}{-2 \times 9.8} = 122.5\,m$

Aliter : Maximum height achieved is given by,

$H = \dfrac{u^2}{2g} = \dfrac{(49)^2}{2 \times 9.8} = \dfrac{49 \times 49}{2 \times 9.8} = 122.5\,m$

(ii) We know $v = u + gt$

$0 = 49 - 9.8 \times t$

$\Rightarrow t = \dfrac{49}{9.8}$

$\Rightarrow t = 5\,s$

Now, time for upward journey of the ball = the time for downward journey of the ball.

$\therefore$ Total time taken by the ball to return to the surface of earth $= 2 \times t = 2 \times 5 = 10$ s

[**Aliter:** Total time of journey, $T = \dfrac{2u}{g} = \dfrac{2 \times 49}{9.8} = 10\,s$]

Q14. A stone is released from the top of a tower of height 19.6 m. Calculate its final velocity just before touching the ground.

Ans. Initial velocity of stone, u = 0 ; final velocity of stone,

$v = ?$

height, h = 19.6 m ; acceleration due to gravity,

$g = +9.8\ ms^{-2}$

We know, $v^2 = u^2 + 2gh$

$v^2 = (0)^2 + 2 \times 9.8 \times 19.6$ or $v^2 = 19.6 \times 19.6$

$v = \sqrt{19.6 \times 19.6} = 19.6\ ms^{-1}$.

Q15. A stone is thrown vertically upward with an initial velocity of 40 ms^{-1}. Taking $g = 10\ ms^{-2}$, find the maximum height reached by the stone. What is the net displacement and the total distance covered by the stone ?

Ans. Initial velocity of stone

$u = 40\ ms^{-1}$;

final velocity of stone

v = 0 ;

acceleration due to gravity

$g = -10\ ms^{-2}$;

[For upward direction g is taken –ve] ;

height attained by stone (h) = ?

We, know, $v^2 - u^2 = 2gh$ or $(0)^2 - (40)^2 = 2 \times (-10) \times h$

or $h = \dfrac{-1600}{-20} = 80$ m

$\therefore$ Maximum height attained by stone = 80 m

Net displacement of stone = 0

(because the stone returns to the same point)

Total distance covered by the stone = 2 × height attained = 2 × 80 = 160 m

Q16. Calculate the force of gravitation between the earth and the Sun, given that the mass of the earth $= 6 \times 10^{24}$ kg and of the Sun $= 2 \times 10^{30}$ kg. The average distance between the two is 1.5×10^{11} m.

Ans. Given mass of earth, $M_e = 6 \times 10^{24}$ kg ; mass of Sun, $M_s = 2 \times 10^{30}$ kg ; distance between them, $r = 1.5 \times 10^{11}$ m.

Now, force of gravitation between them,

$$F_g = \frac{GM_eM_s}{r^2}$$

$$= \frac{6.67 \times 10^{-11} \times 6 \times 10^{24} \times 2 \times 10^{30}}{1.5 \times 10^{11} \times 1.5 \times 10^{11}}$$

$$= 35.57 \times 10^{21}\ N$$

Q17. A stone is allowed to fall from the top of a tower 100 m high and at the same time another stone is projected vertically upwards from the ground with a velocity of $25\ ms^{-1}$. Calculate when and where the two stones will meet. (Take $g = 10\ m/s^2$)

Ans. For stone moving downward, acceleration due to gravity, g = 10 ms^{-2}

initial velocity (u) = 0 ; distance, s = 100 – x ;

time, t = ?

$s = ut + \frac{1}{2}gt^2$,or $(100 - x) = 0 \times t + \frac{1}{2} \times 10\ t^2$

$\Rightarrow 100 - x = 5t^2$ ... (1)

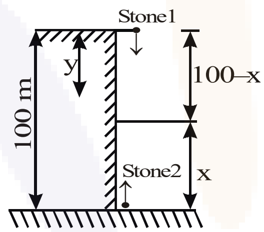
For the stone moving vertically upwards,

initial velocity, u = 25 ms^{-1} ; time (t) = ? ; acceleration due to gravity, g = –10 ms^{-1}

[In upward direction, g is taken –ve]

Distance, s = x

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



or $x = 25 \times t + \frac{1}{2} \times (-10\ t^2)$

$\Rightarrow x = 25t - 5t^2$ ... (2)

Substituting the value of x from (2) in (1) we get,

$100 - (25t - 5t^2) = 5t^2$

$100 - 25t + 5t^2 = 5t^2$

25 t = 100 or t = 4 s

Put the value of t in (1),

(1) $\Rightarrow 100 - x = 5(4)^2$

$\Rightarrow 100 - x = 80$ or x = 20 m

$\therefore$ The stones will meet at a height of 20 m from ground after 4 s.

Q18. A ball thrown up vertically returns to the thrower after 6 s. Find.

(a) the velocity with which it was thrown up

(b) the maximum height it reaches, and

(c) its position after 4 s (take g = 10 m/s^2)

Ans. (a) The ball returns to the thrower in 6 s, thus,

the time for its upward journey = 6 ÷ 2 = 3 s

For the upward motion of ball,

initial velocity u = ? ; final velocity v = 0

($\because$ Ball comes to rest)

Time, t = 3 s

Acceleration due to gravity, $g = -10\ ms^{-2}$

[In upward direction, g is taken –ve]

$v = u + gt$

or $0 = u - 10 \times 3$, or $-u = -30$

or $u = 30\ ms^{-1}$

$\therefore$ Initial velocity of ball is $30\ ms^{-1}$

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

$s = 30 \times 3 - \frac{1}{2} \times 10 \times (3)^2$

or $s = 90 - 45 = 45$ m

$\therefore$ Maximum height reached by ball is 45 m.

(c) For the downward motion of ball,

initial velocity, u = 0 ;

time for downward fall, t = 4 – 3 = 1 s ;

acceleration due to gravity, $g = 10\ ms^{-2}$;

distance covered in downward direction, s = ?

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

$s = 0 \times (1) + \frac{1}{2} \times 10 \times (1)^2$

$\Rightarrow$ $s = 0 + 5$

$\Rightarrow$ $s = 5$ m

$\therefore$ Position of ball after 4 s from ground

= 45 – 5 = 40 m.

Q19. In what direction does the buoyant force on an object immersed in a liquid act ?

Ans. An object immersed in a liquid experiences a buoyant force in upward direction.

Q20. Why does a block of plastic released under water come up to the surface of water ?

Ans. Density of plastic block is less than the density of water. Thus, when it floats, it is partially immersed in water such that its weight gets balanced with the buoyant force acting on it. When it is put completely in water, buoyant force on it becomes more than its weight. Thus, when it is released, it comes up to the surface of the water due to a net upward force acting on it.

Q21. The volume of 50 g of a substance is 20 cm^3. If the density of water is 1 g cm^{-3}, will the substance float or sink in water ?

Ans. Given, mass of substance, m = 50 g ;

volume, V = 20 cm^3 ; density, ρ = ?

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{50}{20} = 2.5 \text{ g cm}^{-3}$$

The density of the substance is more than the density of water (1 g cm^{-3}). Hence, the substance will sink in water.

Q22. The volume of a 500 g sealed packet is 350 cm^3. Will the packet float or sink in water if the density of water is 1 g cm^{-3} ? What will be the mass of the water displaced by this packet ?

Ans. Given, mass of sealed packet, m = 500 g ;

volume, V = 350 cm^3 ; density, ρ = ? ;

density of water, ρ_w = 1 g cm^{-3}

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{500}{350} = 1.428 \text{ g cm}^{-3}$$

The density of the packet is more than the density of water (1 g cm^{-3}). Hence, the packet will sink in water. Thus, the volume of sealed packet (V) is equal to the volume of water displaced (V_w) as the packet is completely immersed in water.

i.e. $V_w = V = 350 \text{ cm}^3$

Now, mass of water displaced, $m_w = \rho_w \times V_w$

or $m_w = 1 \times 350 = \mathbf{350\ g}$

Thus, the mass of water displaced by the packet is 350 g.