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Chapter – 10 Gravitation

Class 9 Science NCERT Textbook – Page 134

Q1. State the universal law of gravitation.

Answer: According to the universal law of gravitation every object attracts another object with a force known as gravitational force. The force between two objects is directly proportional to the product of masses and inversely proportional to the square of the distance between them.

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

Answer: Mass of earth = M.

Mass of the object = m.

Radius of the earth = R.

Gravitational Force,

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

Class 9 Science NCERT Textbook – Page 136

Q1. What do you mean by free fall?

Answer: Free fall is the motion of an object where force is gravity on it. A skydiver move towards earth by gravity, but air resistance is a force opposing downward movement**.**

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

Answer: The acceleration due to gravity is the rate of increase of velocity per unit time and its value is 980.665 centimetres per second per second**.**

Class 9 Science NCERT Textbook – Page 138

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

Answer: The mass of an object is its inertial property, or the amount of matter. The weight of an object is the force applied by gravity. The gravity on the earth on an object is 9.8 m/s2.

Q2. Why is the weight of an object on the moon 1/6th its weight on the earth?

Answer: The mass of moon is 1/100 times and its radius 1/4 times of earth. So, the gravitational force on the moon is one sixth of earth and the weight of an object on the moon is 1/6th of earth**.**

Class 9 Science NCERT Textbook – Page 141

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

Answer: It is difficult to hold a school bag with thin strap as the pressure on the shoulders is more and is inversely proportional to the surface area on which the force acts.

Q2. What do you mean by buoyancy?

Answer: Buoyancy is force or upthrust. It is an upward force which is due to a fluid. So, the objects lighter than the water floats on it.

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

Answer: When the object has density less than $1g\ cm^{-1}$, it floats on the surface of water, as it displaces equal amount of water to its weight. Buoyant force is less than its weight, so it sinks.

Class 9 Science NCERT Textbook – Page 142

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

Answer: The weighing machine measure less than the actual mass. An actual mass is more than 42 kg.

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?

Answer: The density of cotton bag is less than the iron bar, as the volume of cotton bag is more than iron bar and the cotton bag has more up thrust due to the presence of air. So, weight of cotton bag is more than the weight of iron bar**.**

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Class 9 Science NCERT Textbook – Page 143, 144 and 145 (Exercise)

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

Answer:

The force of gravitation between two objects is inversely proportional to the square of distance between them.

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

When the distance between two objects is half, then the force is four 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?

Answer:

Force = mass × acceleration

Gravitational force is in proportion to their masses (Force ∝ mass).

When the acceleration due to gravity is constant for a heavy object, its acceleration is also constant, so light or heavy objects falls at the same speed.

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 $6 \times 10^{24}\ kg$ and radius of the earth is 6.4×10^{6} m).

Answer:

The gravitational force, $F = G \times \frac{m_1 \times m_2}{r^2}$

Gravitational constant, $G = 6.7 \times 10^{-11}\ Nm^2/kg^2$

Mass of earth, $m_1 = 6 \times 10^{24}\ kg$

Mass of object, $m_2 = 1\ kg$

Distance (r)$of\ earth\ and\ object = Radius\ of\ earth$

$$= 6.4 \times 10^{6}\ m$$

$$F = \frac{6.7 \times 10^{-11} \times 6 \times 10^{24} \times 1}{(6.4 \times 10^{6})^2}$$

$$F = 9.8\ N$$

So, the gravitational force between the earth and one. kg object is 9.8 Newtons.

Q4. The earth and the moon are attracted to each other by gravitational force. Does the earth attract the moon with a force that is greater or smaller or the same as the force with which the moon attracts the earth? Why?

Answer:

The moon attracts the earth with a force. So, according to the Newton's law of motion, the forces of action and reaction is equal and opposite. When earth attracts moon with gravitational force, then the moon attracts the earth with an equal and opposite gravitational force.

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

Answer:

According to the Newton's second law of motion, the acceleration of body is inversely proportional to the mass of the body,

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

Due to large mass of earth, the acceleration of the earth is so small that movement of earth towards the moon is not visible.

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 (a) doubled, and (b) tripled?
iii) The masses of both are doubled?

Answer:

i) The gravitational force of two objects is directly proportional to the product of their masses. If the mass of one object is doubled, then the force is also doubled.

ii) The gravitational force between two objects is inversely proportional to the square of distance between them.

a) If the distance between the objects is doubled, the force is one-fourth.
b) If the distance between the objects is tripled, the force is one-ninth.

iii) If the masses of two objects are doubled, the force is four times.

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

Answer:

The Universal law of gravitational explains the motion of planets around the sun; the motion of moon around the earth, the motion of artificial satellites around the earth, and the phenomenon of rainfall, snowfall and flow of water in rivers on the earth.

Q8. What is the acceleration of free fall?

Answer:

The free fall is when the falling object from a height towards the earth is due to gravitational force of earth.

The uniform acceleration is due to gravitational force on the freely falling object and its speed goes on increasing. This is acceleration due to gravity and the value is 9.8 m/s^2.

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

Answer:

The gravitational force between the earth and an object is called 'gravity of earth'.

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?

Answer:

No, his friend at the equator will not agree with the weight of gold bought at poles.

Weight, $W = m \times g$

As the value of g is greater at the poles, so the weight of gold is greater at the poles. At equator the same mass of gold has weight less because as value of g is less at the equator. So, mass of gold at the poles has less weight than at the equator.

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

Answer:

A sheet of paper has a large area so when it is dropped from a height, it will experience more resistance from air, its speed decreases and it fall with slow rate.

A crumpled paper into a ball has a smaller area so when this ball is dropped from a height, it experiences less resistance of air, its speed will increase and it falls fast.

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

Answer:

The acceleration due to gravity on earth $= 9.8\ m/s^2$.

the acceleration due to gravity on moon is $\frac{1}{6}^{\text{th}}$ i.e., $9.8 \times \frac{1}{6}\ m/s^2$.

i) the weight on the moon:

Mass of object, $m = 10\ kg$
Acceleration due to gravity on moon, $g = 9.8\ \times \frac{1}{6}\ m/s^2$
Weight of object on moon, $W = m\ \times g$

$$= 10 \times 9.8\ \times \frac{1}{6}$$
$$= 16.3\ N$$

ii) the weight on the earth:

Mass of object, $m = 10\ kg$
Acceleration due to gravity on earth, $g = 9.8\ m/s^2$
Weight of object on earth, $W = m\ \times g$

$$= 10\ \times 9.8$$
$$= 98\ N$$

Q13. A ball is thrown vertically upwards with a velocity of 49 m/s. Calculate:

i) The maximum height to which it rises.
ii) The total time it takes to return to the surface of the earth.

Answer:

i) The acceleration due to gravity is negative because the ball goes up against the gravity.

Initial velocity of ball, $u = 49\ m/s$
Final velocity, $v = 0$
Acceleration due to gravity, $g = -9.8 m/s^2$
Height, $h = ?$

$$v^2 = u^2 + 2gh$$
$$(0)^2 = (49)^2 + 2 \times (-9.8) \times h$$
$$0 = 2401 - 19.6\,h$$
$$19.6\,h = 2401$$

$$h = \frac{2401}{19.6}$$

$$h = 122.5\,m$$

So, the maximum height of the ball is 122.5 metres.

ii) The time taken by the ball :

$$v = u + gt$$

Final velocity, $v = 0$

Initial velocity, $u = 49\,m/s$

Acceleration due to gravity, $g = -9.8\,m/s^2$

Time taken, $t = ?$

$$0 = 49 + (-9.8) \times t$$

$$0 = 49 - 9.8\,t$$
$$9.8\,t = 49$$

$$t = \frac{49}{9.8}$$

$$t = 5\,sec$$

So, the ball takes 5 seconds to reach the highest point upward. The ball takes a total time of 5 + 5 = 10 seconds to return back to the earth.

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.

Answer:

Initial velocity, $u = 0$

Final velocity, $v = ?$

Acceleration due to gravity, $g = 9.8\,m/s^2$

Height, h 19.6 m

$$v^2 = u^2 + 2gh$$
$$v^2 = (0)^2 + 2 \times 9.8 \times 19.6$$
$$v^2 = 19.6 \times 19.6$$
$$v^2 = (19.6)^2$$
$$v = 19.6\ m/s$$

So, the velocity of stone before hitting the ground is 19.6 metres/ second.

Q15. A stone is thrown vertically upward with an initial velocity of 40 m/s. Taking $g = 10\ m/s^2$, find the maximum height reached by the stone. What is the net displacement and the total distance covered by the stone when it falls back o the ground?

Answer:

i) Initial velocity, $u = 40\ m/s$
Final velocity, $v = 0$
Acceleration due to gravity, $g = -10\ m/s^2$
Height, $h = ?$

$$v^2 = u^2 + 2gh$$
$$(0)^2 = (40)^2 + 2 \times (-10) \times h$$
$$0 = 1600 - 20\ h$$
$$20\ h = 1600$$
$$h = \frac{1600}{20}$$
$$h = 80\ m$$

So, the maximum height covered by the stone is 80 meters

ii) The stone is thrown up and after reaching the maximum height, come back to the ground. The final position of stone coincides with its initial position and the net displacement of the stone is 'zero' (0).

iii) The distance covered by the stone to reach the maximum height is 80 metres. So, the total distance covered by the stone is 160 metres.

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

Answer:

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

Gravitational constant, G $= 6.7 \times 10^{-11}\ Nm^2\ kg^{-2}$

Mass of the earth, $m_1 = 6 \times 10^{24}\ kg$

Mass of the sun, $m_2 = 2 \times 10^{30}\ kg$

Distance between the earth and sun, $r = 1.5 \times 10^{11}\ m$

$$F = \frac{6.7 \times 10^{-11} \times 6 \times 10^{24} \times 2 \times 10^{30}}{(1.5 \times 10^{11})^2}$$

$$F = 3.57 \times 10^{22}\ N$$

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 m/s. Calculate when and where the two stones will meet.

Answer:

Suppose the two stones meet at a point P at a height x above the ground, so that the distance of point P from the top of the tower is 100 – x.

i) Height, $h = (100 - x)\ m$

Initial velocity, $u = 0$

Time, $t = ?$

Acceleration due to gravity, $g = 9.8\ m/s^2$

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

$$100 - x = 0 \times t + \frac{1}{2} \times 9.8 \times t^2$$

$$100 - x = 4.9\ t^2 \qquad \text{- - - - - - - - (1)}$$

ii) Height, $h = x$ m

Initial velocity, $u = 25\ m/s$

Time, $t = ?$

Acceleration due to gravity, $g = -9.8\ m/s^2$

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

$$x = 25 \times t + \frac{1}{2} \times (-9.8) \times t^2$$

$$x = 25\ t - 4.9\ t^2 \quad \text{- - - - - - - - -(2)}$$

Adding eq. (1) and (2)

$$100 - x + x = 4.9\, t^2 + 25\, t - 4.9\, t^2$$
$$100 = 25\, t$$

$$t = \frac{100}{25}$$

$$t = 4\ sec$$

So, the two stones meet after a time of 4 seconds.

From equation (1): $100 - x = 4.9\, t^2$

Substituting $t = 4$ in this equation:

$$100 - x = 4.9 \times (4)^2$$
$$100 - x = 4.9 \times 16$$
$$100 - x = 78.4$$
$$100 - 78.4 = x$$
$$21.6\, m = x$$
$$x = 21.6\, m$$

So, two stones meet at a height of 21.6 metres from the ground.

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

i) The velocity with which it was thrown up.
ii) The maximum height it reaches,
iii) Its position after 4 sec.

Answer:

The ball is thrown upward and return back to the thrower in 6 sec i.e., the ball take half of his time, that is 3 sec, and the remaining 3 sec to fall down from the maximum height and return to the thrower.

a) the velocity with which ball was thrown up.

Final velocity, $v = 0$
Initial velocity, $u = ?$
Acceleration due to gravity, $g = -9.8\ m/s^2$
Time taken to reach the top, $t = 3\ sec$

$$v = u + gt$$
$$0 = u + (-9.8) \times 3$$
$$0 = u - 29.4$$
$$u = 29.4\ m/s$$

So, the velocity with which the ball was thrown up is 29.4 metres / second.

b) the maximum height reached:

$$v^2 = u^2 + 2gh$$
$$(0)^2 = (29.4)^2 + 2 \times (-9.8) \times h$$
$$0 = 864 - 19.6\ h$$
$$19.6\ h = 864.36$$

$$h = \frac{864.36}{19.6}$$

$$h = 44.1\ m$$

So, the maximum height reached by the ball is 44.1 metres.

c) position of ball after 4 sec:

the height by which the freely falling ball comes down in 1 sec.

$$h = ut + \frac{1}{2}\ gt^2$$
$$h = 0 \times 1 + \tfrac{1}{2} \times 9.8 \times (1)^2$$
$$h = 0 + 4.9 \times 1$$

$$h = 4.9\ m$$

So, the position of the ball after 4 sec is 4.9 metres.

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

Answer:

The buoyant force on an object dipped in a liquid move in upward direction.

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

Answer:

A block of plastic released under water comes up to the surface of water because the buoyant force due to water is greater than its weight of plastic block.

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?

Answer:

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

Mass of substance = 50 g

Volume of substance = 20 cm^3

$$Density\ of\ substance = \frac{50\ g}{20\ cm^3}$$

$$= 2.5\ g\ cm^3$$

The density of substance 2.5 gcm^3 is more than the density of water 1 g cm^{-3} so, 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 water displaced by this packet?

Answer:

Mass of packet = 500 g

Volume of packet = 350 cm^3

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

$$= \frac{500\ g}{350\ cm^3}$$

$$= 1.42\ g\ cm^{-3}$$

The packet will sink as the density of packet is more than that of water. The volume of packet is 350 cm^3 so it displace 350 cm^3 of water. The packet which sinks in water displace equal volume of water

The mass of 350 cm^3 of water.

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

$$1\ g\ cm^{-3} = \frac{Mass\ of\ water}{350\ cm^3}$$

Mass of water = 1 g cm^3 × 350 cm^3

$$= 350\ g$$

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