Chapter-9

Gravitation

EXERCISE-9.1
1 mark

1. State the universal law of gravitation.

Ans. According to Newton's universal law of gravitation:
Every mass in this universe attracts every other mass with a force which is directly proportional to the product of two masses and inversely proportional to the square of the distance between them.

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

Ans. The formula to find the magnitude of the gravitational force between the earth and an object on the surface of the earth is given below:

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

F = magnitude of gravitational force

G = Universal gravitation constant

M = mass of earth

m = mass of object

d = distance of object from the centre of earth

3. What do you mean by free fall?

Ans. It is the object falling towards earth under the influence of attraction force of earth or gravity.

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

Ans. During free fall any object that has mass experiences force towards centre of earth and hence an acceleration works as well. "acceleration experienced by an object in its free fall is called acceleration due to gravity." It is denoted by g.

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

Ans.

Mass of object	Weight of object
i) Mass is defined as quantity of matter contained in an object. ii) It is denoted by 'm'. iii) F = m x a iv) It remains constant at any place of the universe.	i) Weight is the force with which an object is attracted towards the earth's centre. ii) It is denoted by 'W'. iii) W = m x g iv) It is different at different places.

EXERCISE-9.2
2 mark

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

Ans. since we know

$W = m \times g$

Mass of object remains the same whether on earth or moon but the value of acceleration on moon is $1/6^{th}$ of the value of acceleration on earth. Because of this weight of an object on moon is 1/6th its weight on the earth.

2. 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 strap made of a thin and strong string because a bag of that kind will make its weight fall over a small area of the shoulder and produce a greater pressure that makes holding the bag difficult and painful.

3. What do you mean by buoyancy?

Ans. It is the upward force experienced by an object when it is immersed into a fluid.

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

Ans. As an object comes in contact with the surface of a fluid it experiences two types of forces: gravitational force or gravity that pulls the object in downward direction and the second force is the force of buoyancy that pushes the object in upward direction.
It is these two forces that are responsible for an object to float or sink

i.e. if gravity >buoyancy then object sinks

if gravity <buoyancy then object floats

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

Ans. Mass will be slightly more than 42 kg.

6. 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. The bag of cotton is heavier since volume of cotton bag is greater than iron bar, so the upthrust is larger in case of cotton hence real mass of cotton bag is more and it is heavier.

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

Ans. The force of gravitation between two objects is inversely proportional to the square of the distance between them therefore the gravity will become four times if distance between them is reduced to half.

EXERCISE-9.3
4 mark

1. 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. In free fall of objects the acceleration in velocity due to gravity is independent of mass of those objects hence a heavy object does not fall faster than a light object.

2. What is the magnitude of the gravitational force between the earth and a 1 kg object on its surface? Mass of the earth is $6\times1024\ \text{kg}$ and radius of the earth is $6.4\times106\ \text{m}$.

Ans. $F = G\frac{Mm}{d^2}$

$$= \frac{6.6\times10^{-11}\times6\times10^{24}\times1}{\left(6.4\times10^{6}\right)^2}$$

$$= \frac{6.7\times6\times10}{\left(6.4\times6.4\right)}$$

= 9.81 N

3. 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?

Ans. The earth and the moon are attracted to each other by same gravitational force because for both of them formula to calculate force of attraction is the same

$$F = G\frac{Me\times Mm}{d^2}$$

d is also same for both.

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

Ans. Earth does not move towards moon because mass of moon is very small as compared to that of earth.

5. 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 between two objects will be doubled.

ii the force between two objects will become $1/4^{th}$ and $1/9^{th}$ of the present force.

iii the force between two objects will become four times the present force.

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

Ans. The universal law of gravitation is important due to the following:

i this law explains well the force that binds us to earth.

ii this law describes the motion of planets around the sun.

iii this law justifies the tide formation on earth due to moon and sun.

iv this law gives reason for movement of moon around earth.

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

Ans. Weight

10. 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.]

EXERCISE-9.4
Frequently Asked Questions

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

Ans. A greater surface area offers greater resistance and buoyancy same is true in the case of a sheet of paper that has larger surface area as compared to paper crumpled into a ball. So sheet of paper falls slower.

2. Gravitational force on the surface of the moon is only 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?

Ans. value of gravity on earth $= 9.8\, m/s^2$

value of gravity on moon = 1/6th of earth = 9.8/6 $= 1.63\, m/s^2$

weight of object on moon $= m \times 1.63 = 10 \times 1.63$ = 16.3 N

weight of object on earth $= m \times 9.8 = 10 \times 9.8$ = 98 N

3. 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.

Ans. i v = u + gt

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

9.8t = 49

t = 49/9.8 = 5 s

$h = ut + \frac{1}{2}gt^2 = 49 \times 5 + \frac{1}{2} \times 9.8 \times 25$ = 245 – 122.5 = 122.5

ii total time taken to return = 5 + 5 = 10 s

4. A stone is released from the top of a tower of height 19.6 m. Calculate its final velocity.

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

19.6 $= 0 \times t \times \frac{1}{2} \times 9.8 \times t^2$

4.9 $t^2 = 19.6$

$t^2 = 19.6/4.9 = 4$

t = 2

since v= u + at $= 0 + 9.8 \times 2 = 19.6$ m/s

5. A stone is thrown vertically upward with an initial velocity of 40 m/s. Taking $g = 10\ \mathrm{m/s^2}$, 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 m/s
at maximum height stone will be at rest so v= 0

v = u + gt

$0 = 40 + (-10) \times t$

10t = 40

t = 40/10 = 4 s

distance covered /maximum height

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

$= 40\times 4 + \frac{1}{2}\times(-10)\times 4\times 4$ = 160 – 80 = 80 m

net displacement of stone = 0thrown upwards then falls back to same place

total distance covered by the stone = 80 + 80 = 160 m

6. Calculate the force of gravitation between the earth and the Sun, given that the mass of the $\text{earth} = 6 \times 1024\ \text{kg}$ and of the $\text{Sun} = 2 \times 1030\ \text{kg}$. The average distance between the two is $1.5 \times 1011\ \text{m}$.

Ans. $F = G\frac{Mm}{d^2}$

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

$$= 35.73\times 10^{21} N$$

7. 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.

Ans. Suppose both the stones will meet after t seconds.

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

$= 0\times t + \frac{1}{2}\times 10\times t^2$

$= 5t^2$

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

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

$= 25t - 5t^2$

h + h′ = 100 m

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

25t = 100

t = 4 s

$h = 5t^2 = 5 \times 4 \times 4$ = 80 m

Therefore, the two stones will meet after 4 seconds when the falling stone would have covered a height of 80 m.

8. 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.
Ans. atime taken by ball to reach maximum heightt = 6/2 = 3 s
v = u + gt

$0 = u + (-9.8) \times 3$

u = 29.4 m/s the velocity with which it was thrown up

b the maximum height it reaches: therefore $h = ut + \frac{1}{2}gt^2$
$= 29.4 \times 3 + \frac{1}{2} \times (-9.8) \times 3^2$

= 88.2 – 44.1

= 44.1 m

c its position after 4 s will be:
Since in first 3 s it will reach the maximum height and in next 1 s it will start a free fall so, u = 0, t =1

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

$= 0 \times t + \frac{1}{2} \times 9.8 \times 1$ = 4.9 m

therefore, after 4s the position of ball = 44.1 – 4.9 = 39.2 m