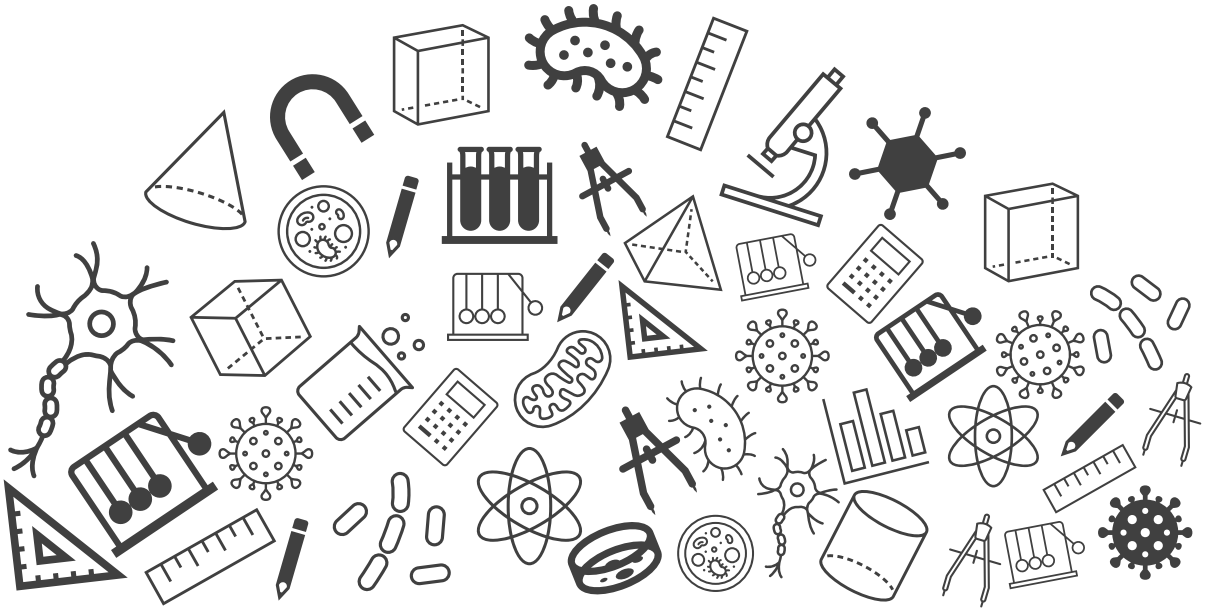
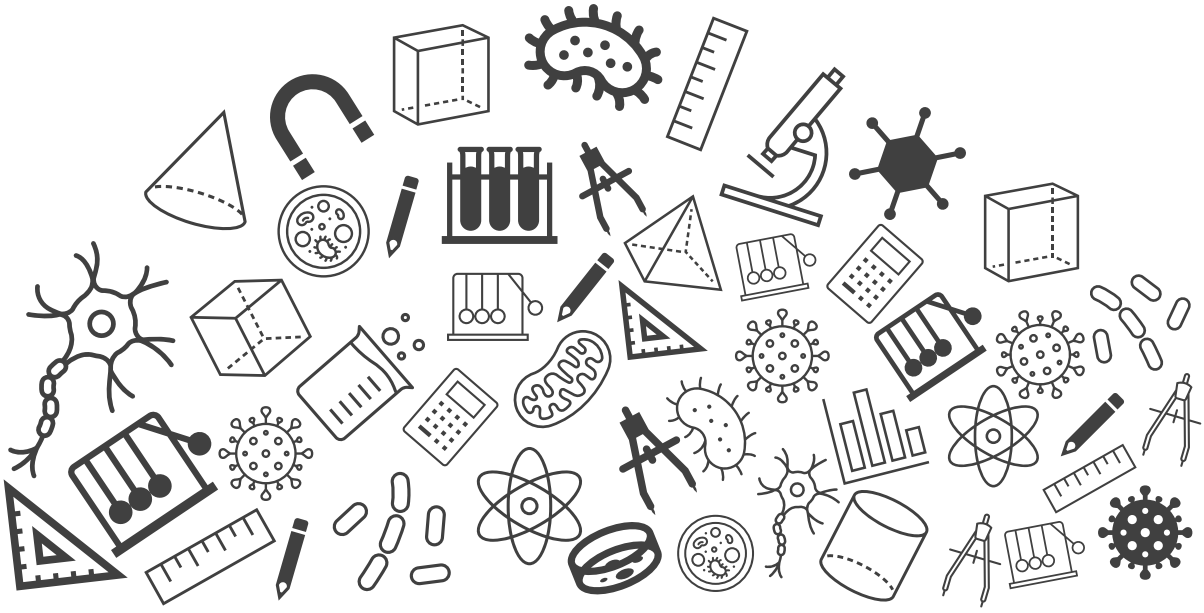
Grade 09
Science Chapter Notes



Gravitation



Gravitation

1. What is the acceleration of free fall?

   [1 mark]
   [NCERT Question]
   [Acceleration due to gravity]

   Solution:
   Acceleration of free fall is the acceleration produced when a body falls under the influence gravitational force of the earth alone. It is denoted by g and its value on the surface of the earth is $9.8\ ms^{-2}$. [1 mark]

2. 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?

   [2 marks]
   [NCERT Question]
   [Universal Law of Gravitation]

   Solution:
   According to the universal law of gravitation, two objects with masses attract each other with equal gravitational force, but in opposite directions.
   This force is given by
   $F = G\frac{Mm}{r^2}$

   [1 Mark]

   Hence, the earth attracts the moon with the same force with which the moon attracts the earth. This is also explained by Newton's Thrid Law of Motion.

   [1 Mark]

3. 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?

[3 marks]
[NCERT Question]
[Universal law of Gravitation]

Solution:
According to the universal law of gravitation, gravitational force acting between two objects of mass M and m separated by distance r is given by
$F = G\frac{M \times m}{r^2}$

(i) When mass of one of the objects, say m, is doubled then
$F' = G\frac{M \times 2m}{r^2} = 2F$
So when the mass of any one of the objects is doubled, the force is also doubled. [1 mark]

(ii) The force F is inversely proportional to the square of the distance between the objects. So if the distance between two objects is doubled then the gravitational force of attraction between them is reduced to one-fourth of the original value.
$F' = G\frac{M \times m}{(2r)^2} = F/4$

Similarly, if the distance between two objects is tripled, then the gravitational force of attraction becomes one-ninth the original value.
$F' = G\frac{M \times m}{(3r)^2} = F/9$ [1 mark]

(iii) The gravitational force F is directly proportional to the product of the masses. So if both the masses are doubled then the gravitational force of attraction becomes four times the original value.
$F' = G\frac{2M \times 2m}{r^2} = 4F$ [1 mark]

4. 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?
[4 Marks]
[NCERT; Exercises; Q.22]
[Float or sink]

Solution:
Density of the sealed packet $= \frac{\text{Mass of the packet}}{\text{Volume of the packet}} = \frac{500}{350} g\ cm^{-3}$
$= 1.428\ g\ cm^{-3}$
Density of water = $1\ g\ cm^{-3}$ [2 Marks]

Since the density of the substance is more than that of water, it will sink in water. [1 Mark]

The volume of water displaced by the packet is equal to the volume of the packet, i.e., $350 cm^3$.
So, mass of water displaced = Volume of water displaced $\times$ Density of water = 350 g [1 Mark]

5. 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

[5 marks]

[NCERT Questsion]

[Equations of Motion for Freefall]

Solution:

(a) Time of ascent is equal to the time of descent. The ball takes a total of 6 s for its upward and downward journey.

Hence, it has taken 3 s to attain the maximum height.

Final velocity of the ball at the maximum height, v = 0

Acceleration due to gravity, $g = -9.8\ ms^{-2}$

From the first equation of motion,

v = u + gt

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

$u = 9.8 \times 3 = 29.4\ ms^{-1}$

Hence, the ball was thrown upwards with a velocity of $29.4\ ms^{-1}$

[2 marks]

(b) Let the maximum height attained by the ball be h.

Initial velocity during the upward journey, $u = 29.4\ ms^{-1}$

Final velocity, v = 0

Acceleration due to gravity, $g = -9.8\ ms^{-2}$

From the second equation of motion,

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

$h = 29.4 \times 3 + \frac{1}{2} \times -9.8 \times (3)^2 = 44.1\ m$

[1.5 marks]

(c) Ball attains the maximum height after 3 s. After attaining this height, it will start falling downwards.

In this case,

Initial velocity, u = 0

Distance travelled by it during its downward journey in remaining 1 s is given by

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

Total height = 44.1 m

This means that the ball is 39.2 m (44.1 m - 4.9 m) above the ground after 4 seconds.

[1.5 marks]

6. Which force is responsible for the earth to revolve around the sun?
[1 Mark]

The gravitational force of attraction between the Sun and the Earth. Such a force, that makes an object move in a circle is known as centripetal force.
[1 Mark]

7. Why two stones do not come closer, even if there is gravitational force of attraction between them ?
[2 marks]
[Universal law of gravitation]

Solution:
If we calculate the acceleration because of the force of gravitation between two stones, we see that it is of the order of $10^{-12}\ m/s^2$. So, the effect is negligible.
(1 mark)
In addition, it is not enough to overcome friction. Therefore, they do not come closer.
(1 mark)

8. Calculate the force between two masses of 100 kg and 1000 kg separated by a distance of 10 m.
($G = 6.67 \times 10^{-11}\ N\ m^2\ kg^2$)
[2 Marks]

Solution:

According to Newton's law of gravitation, force of attraction between two bodies is:
$F = \frac{Gm_1m_2}{r^2}$

[1 Mark]

$$F = \frac{6.67 \times 10^{-11} \times 100 \times 1000}{10^2}$$
$$F = 6.67 \times 10^{-8}\ N$$

[1 Mark]

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

[3 Marks]

[NCERT; Exercises; Q.2]

Solution:

The gravitational force F acting on a body of mass m near the surface of earth is given by

$F = G\frac{M \times m}{R^2}$ [1 Mark]

where R = Radius of the earth

and M = Mass of the earth

=> Acceleration, $g = \frac{F}{m} = G\frac{M}{R^2}$ [1 Mark]

This value is constant (if we neglect air resistance) and does not depend upon the mass of an object. Hence, heavy objects do not fall faster than light objects. [1 Mark]

10. 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 newtons of a 10 kg object on the moon and on the Earth?

(3 Marks)

We know that,

Weight = Mass $\times$ Acceleration due to gravity

Acceleration due to gravity on earth = $9.8 m/s^2$

Therefore, weight of a 10 kg object on earth $= 10 \times 9.8 = 98\ N$

[1 Mark]

Weight of an object on the moon $= \frac{1}{6} \times$ Weight of the object on earth

$= \frac{1}{6} \times 98 = 16.3\ N$ [2 Marks]

11. Define pressure. Why is it difficult to hold a school bag having a strap made of a thin and strong string?
[3 marks]
[NCERT; In Text]
[Thrust and pressure]

Solution:

1. Pressure is an expression of force exerted on a surface per unit area.
[1 Mark]

2. 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 surface area on which the force acts. The smaller is the surface area; the larger will be the pressure on the surface. In the case of a thin strap, the contact surface area is very small. Hence, the pressure exerted on the shoulder is very large.
[2 Mark]

12. A block of wood is kept on a table top.The mass of wooden block is 5kg and it's dimensions are 40cm×20cm×10cm. Find the pressure exerted by the wooden block on the table top if it is made to lie of dimensions:
(a) 20 cm × 10 cm
(b) 40 cm × 20 cm
[3 marks]
[NCERT; In Text]
[Thrust and pressure]

Solution:
Mass of the wooden block = m= 5 kg
Dimensions = 40 cm × 20 cm × 10 cm
the weight of the wooden block applies a thrust on the table top.
Thrust = F = mg= 5 kg × 9.8 m/s²= 49 N

1) Area of a side = length × breadth
= 20 cm × 10 cm
= 200 cm²
= 0.02 m² [0.5 marks]

Pressure = thrust/ area
Pressure = 49 /0.02= 2450 N/m² [1 marks]

2) The same thrust in implied when it lies on the given dimension.
Area= length × breadth= 40 × 20= 800= 0.08 m²
[0.5 marks]
Pressure = 49/0.08= 612.5 [1 marks]

13. 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?
[3 Marks]

Solution:
Density of the substance $= \frac{\text{Mass of the substance}}{\text{Volume of the substance}} = \frac{50}{20} g\ cm^{-3}$
$= 2.5\ g\ cm^{-3}$
Density of water $= 1\ g\ cm^{-3}$ [2 Marks]

If the density of an object is more than the density of a liquid, then it sinks in the liquid, otherwise, it floats.
Here the density of the substance is more than the density of water, so it will sink in water. [1 Mark]

14. 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.

[5 Marks]

[Free fall]

Solution:

(i) According to the third equation of motion under gravity:

$v^2 - u^2 = 2\ gs$ [1 Mark]

Where,

u = Initial velocity of the ball

v = Final velocity of the ball

s = Height achieved by the ball

g = Acceleration due to gravity

At maximum height, final velocity of the ball is zero, i.e., v = 0, u = 49 m/s

During upward motion, $g = -9.8\ ms^{-2}$

Let h be the maximum height attained by the ball.

Hence,

$0 - 49^2 = 2 \times -9.8 \times h$ [1 Mark]

$h = \frac{49 \times 49}{2 \times 9.8} = 122.5\ m$ [1 Mark]

(ii) Let t be the time taken by the ball to reach the height 122.5 m, then according to the first equation of motion:

v = u + gt

We get,

$0 = 49 + t \times (-9.8)$ [1 Mark]

$9.8t = 49$

$t = \frac{49}{9.8} = 5s$

But,

Time of ascent = Time of descent

Therefore, total time taken by the ball to return = 5 s + 5 s = 10 s

[1 Mark]

15. An object is put one by one in three liquids having different densities. The object floats with $\frac{1}{9}$, $\frac{2}{11}$ and $\frac{3}{7}$ parts of their volumes outside the liquidsurface 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) $d_1 < d_2 < d_3$
[2 Marks]
[Relative density]

(d) $d_1 < d_2 < d_3$

In a liquid of higher density more part of the object remains outside the liquid. The order of densities in the increasing order is $d_1 < d_2 < d_3$.
[2 Marks]