NCERT TEXTUAL EXERCISE (SOLVED)

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

Ans. Force of gravitation, $F = \frac{Gm_1m_2}{r^2}$.

When distance between the objects, i.e., r is reduced to half ($r/2$), force F would become 4 times.

2. 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. It is true that gravitational force acts on all objects in proportion to their masses. But a heavy object does not fall faster than a light object. This is because of the reason that $\text{acceleration} = \frac{\text{force}}{\text{mass}}$. As force $\propto$ mass, therefore, acceleration is constant for a body of any mass.

3. 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. $m = 1$ kg, $M = 6 \times 10^{24}$ kg, $R = 6.4 \times 10^6$ m, $G = 6.67 \times 10^{-11}$ N m^2/kg^2

As $$F = \frac{GMm}{R^2}$$

$$\Rightarrow \quad F = \frac{(6.67 \times 10^{-11}) \times 6 \times 10^{24} \times 1}{(6.4 \times 10^6)^2} = 9.8 \text{ N}$$

4. 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 attracts the moon with a force which is same as the force with which the Moon attracts the Earth. This is because as per Newton's third law of motion, forces of action and reaction are always equal and opposite. The force exerted by Earth on Moon is equal and opposite to the force exerted by the moon on Earth.

5. If the Moon attracts the Earth, why does the Earth not move towards the moon?

Ans. The force exerted by the Earth on Moon is used in changing the path of Moon from straight line to circular path. The Moon attracts the Earth with the same force. But the Earth is too heavy to move towards the Moon. Rather, we can show that distance moved by Earth towards the Moon is so small that it cannot be detected.

6. 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. As gravitational force between two objects, $F \propto \frac{m_1 m_2}{r^2}$, therefore,

(i) When mass of one object is doubled, the force becomes twice.

(ii) When distance between the object is doubled, force becomes (1/4) of its previous value. When distance between the objects is tripled, the force becomes (1/9) of its previous vlaue.

(iii) When masses of both objects are doubled, force becomes 4 times.

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

Ans. Universal law of gravitation is important as it accounts for motion of planets around the Sun; motion of Moon and other artificial satellites around the Earth, snowfall and rainfall on the Earth, flow of water in rivers and so many together phenomena.

8. What is the acceleration of free fall?

Ans. All objects moving towards the Earth on account of gravitational force of the Earth on them are said to be in free fall. This force produces a uniform acceleration in the objects. This is the acceleration of free fall, and is called acceleration due to gravity.

9. What do we call the gravitational force between the Earth and an object?

Ans. The gravitational force between the Earth and an object is called the Earth's gravity.

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.]

Ans. We have learnt that value of g is greater, at the poles than at the equator, i.e., $g_p > g_e$.

As weight of gold at poles, $W_p = mg_p$ andweight of gold at equator, $W_e = mg_e$. Therefore, $W_p > W_e$ or $W_e < W_p$.

i.e., weight of gold at the equator will be less than the weight of gold at the poles. Obviously, the friend at equator will not agree withthee weight of gold bought at poles.

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

Ans. A sheet of paper will fall slower than the one that is crumpled into a ball. This is because the air offers resistance due to friction to the motion of the falling objects. The resistance offered by air to the sheet of paper is more than the resistance offered by air to the paper ball because thee paper sheet has larger area.

12. Gravitational force on the surface of the Moon is only 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. Mass of object, $m = 10$ kg

Weight of the object on Earth, $W_e = mg_e = 10 \times 9.8 = 98$ N

Weight of the object on Moon, $W_m = mg_m = 10 \times \frac{9.8}{6} = 16.3$ N

13. 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. Here, $u = 49$ m/s;

Total time = time of ascent + time of descent = $t + t = 2t$

At maximum height; final velocity, $v = 0$

acceleration = – 9.8 m/s^2

From $v^2 - u^2 = 2\,gh$

$\Rightarrow \quad 0 - (49)^2 = 2\,(-9.8)\,h \quad$ or, $h = \frac{49 \times 49}{2 \times 9.8} = 122.5$ m

From $v = u + gt$

$\Rightarrow \quad 0 = 49 - 9.8\,t \;$ or, $t = \frac{49}{9.8} = 5$ s

Total time = $2t = 10$ s

14. 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. Here, $u = 0$, $h = 19.6\,m$, $g = 9.8$ m/s^2

From $v^2 - u^2 = 2\,gh$

$\Rightarrow \quad v^2 - 0 = 2 \times 9.8 \times 19.6$

$\Rightarrow \quad v = \sqrt{19.6 \times 19.6} = 19.6$ m/s

15. 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?

Ans. Here, u = 40 m/s, g = – 10 m/s^2, $v = 0$

From $v^2 - u^2 = 2gh$

$$\Rightarrow \quad 0-(40)^2 = 2(-10)h \quad \text{or,} \quad h = \frac{40\times 40}{20} = 80 \text{ m}$$

As final position of the stone coincides with its inital position, net ldisplacement = 0.

16. 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 × 10^{30} kg. The average distance between the two is 1.5 × 10^{11} m.

Ans. Here, $m_1 = 6 \times 10^{24}$ kg, $m_2 = 2 \times 10^{30}$ kg

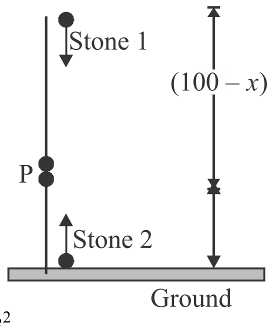
$r = 1.5 \times 10^{11}\, m$, G = 6.7 × 10^{-11} N m^2/kg^2

$$F = \frac{Gm_1m_2}{r^2} = \frac{6.7\times 10^{11}\times\left(6\times 10^{24}\right)\times\left(2\times 10^{30}\right)}{\left(1.5\times 10^{11}\right)^2} = 3.57\times 10^{22}\text{ N}$$

17. 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. Here, $h = 100$ m

Let the two stones meet after t seconds at a point P which is at a height x above the ground as shown in figure.



For stone 1 : $u = 0$, $h = (100 - x)$ m,

$a = g = 9.8$ m/s^2

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

$$(100 - x) = 0 + \frac{1}{2}\times 9.8t^2 = 4.9t^2 \quad ....(i)$$

For stone 2 : $u = 25$ m/s, $h = x$, $a = -g = -9.8$ m/s^2

From $s = ut + \frac{1}{2}at^2$, $x = 25t + \frac{1}{2}(-9.8)t^2 = 25t - 4.9t^2$ ....(ii)

Add eqns. (i) and (ii), $100 - x + x = 25t$

$\Rightarrow \quad t = \frac{100}{25} = 4$ s

From eqn.(i), $100 - x = 4.9 \times (4)^2 = 78.4$

$x = 100 - 78.4 = 21.6$ m

18. 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. (a) $v = 0$, $a = -g = -9.8$ m/s^2

From $v = u + at$

$\Rightarrow 0 = u - 9.8 \times 3$ or, $u = 29.4$ m/s

(b) From $v^2 - u^2 = 2as$

$\Rightarrow 0 - (29.4)^2 = 2 \times (-9.8)h$

or, $h = \frac{29.4 \times 290.4}{2 \times 9.8} = 440.1$ m

(c) At $t = 3$ s, ball is at maximum height. In the next 1 second (= 4 s – 3 s)

From $s = ut + \frac{1}{2}at^2$, $h = 0 + \frac{1}{2}9.8 \times (1)^2 = 4.9$ m (below the top)