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

Ans. Weight, W = mass × acceleration due to gravity or $W = mg$

'g' on earth (g_e) = 6 × 'g' on moon (g_m).

Weight on earth, $W_e = mg_e = 10 \text{ kg} \times 9.8 \text{ ms}^{-2} = 98 \text{ N}$

Weight on moon, $W_m = \frac{1}{6} W_e = \frac{1}{6} \times 98 = 16.3 \text{ N}$.

13. **A ball is thrown vertically upwards with a velocity of 49 ms^{-1}. Calculate:**
(a) the maximum height to which it rises.
(b) the total time it takes to return to surface of earth.

Ans. Initial velocity, $u = 49 \text{ ms}^{-1}$

Final velocity, $v = 0$ (at the highest point)

$g = -9.8 \text{ ms}^{-2}$ (opposite to direction of motion)

(a) Height, $h = \frac{v^2 - u^2}{2g} = \frac{0 - (49)^2}{-2 \times 9.8} = \frac{49 \times 49}{19.6} = 122.5 \text{ m}$

(b) Time of ascend, $t = \frac{v - u}{g} = \frac{0 - 49}{-9.8} = 5 \text{ s}.$

Since, Time of ascend = Time of descend,

Total time = Time of ascend + Time of descend = 2 × 5 = 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.**

ns. Initial velocity, $u = 0$, height, $h = 19.6$ m and $g = 9.8 \text{ ms}^{-2}$

Final velocity, $v = \sqrt{u^2 + 2gh}$

$= \sqrt{0 + 2 \times 9.8 \times 19.6} = 19.6 \text{ ms}^{-1}$.

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

s. Initial velocity, $u = 40 \text{ ms}^{-1}$, $g = -10 \text{ ms}^{-2}$ (upward motion), Final velocity, $v = 0$

During upward motion, $g = -10 \text{ ms}^{-2}$

$$\text{Height, } h = \frac{v^2 - u^2}{2g} = \frac{0 - (40)^2}{2 \times (-10)} = 80 \text{ m}$$

Net displacement on returning back = zero

Total distance = 80 m + 80 m = 160 m

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

Mass of earth, $M_e = 6 \times 10^{24}$ kg, mass of sun $M_s = 2 \times 10^{30}$ kg and distance, $r = 1.5 \times 10^{11}$ m

Gravitational constant, $G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$

$$\text{Force, } F = \frac{GM_eM_s}{r^2}$$

$$= \frac{6.67 \times 10^{-11} \times 6 \times 10^{24} \times 2 \times 10^{30}}{(1.5 \times 10^{11})^2} = 3.56 \times 10^{22} \text{ N}$$

14. **Why is law of gravitation called a universal law?**

Ans. It is called a universal law as it is applicable to all bodies, whether big or small, whether celestial or terrestrial.

15. **If gravitational force exists between every two objects in the universe, why don't you and your friend sitting together experience it?**

Ans. Gravitational force is a weak force. It exists between all objects, but it is too weak to be experienced by small masses such as human beings.

16. **Why does moon exert lesser force of attraction on objects than earth?**

Ans. Weight of an object on moon is the force with which moon attracts it. Mass of moon is less than that of earth. Thus, it exerts lesser force of attraction on object than earth.

17. **How will the gravitational force of attraction between two objects change if their masses are doubled?**

Ans. If masses are doubled, force becomes four times as $F \propto m_1 m_2$.

18. **Distance between two objects is halved. How does the gravitational force between them change?**

Ans. When distance is halved, F becomes four times as $F \propto \frac{1}{r^2}$.

19. **What do you mean by free fall?**

Ans. When a body falls towards the centre of a celestial body under the influence of its gravity alone, then it is said to be in free fall.

20. **What is acceleration due to gravity?**

Ans. The acceleration experienced by an object during the course of its free fall is called acceleration due to gravity.

21. **Two objects of masses m_1 and m_2 are droped in vacuum from a height above the surface of earth (m_1 is greater than m_2). Which one will reach the ground first and why?** [CBSE 2014]

Ans. Both objects will reach the ground simultaneously because acceleration due to gravity is independent of mass of falling object.

22. **What does it mean to state that an object experiences equal acceleration during free fall?**

Ans. It means that acceleration experienced by an object during free fall is independent of its mass. It does not depend on size or mass of object.

23. **State the SI unit of (*i*) G (*ii*) g.**

Ans. (*i*) $Nm^2 kg^{-2}$ (*ii*) ms^{-2}

24. **How does the value of 'g' vary with mass of the object?**

Ans. The value of g is independent of mass of the object instead it depends on the mass of earth/celestial body.

25. **How is Newton's second law of motion related to universal law of gravitation?**

Ans. By Newton's second law of motion, $F = mg \quad \therefore \quad (a = g)$

By law of gravitation, $$F = \frac{GMm}{R^2}$$

or $$mg = \frac{GMm}{R^2} \quad \text{or} \quad g = \frac{Gm}{R^2}$$

26. **Does velocity of a body during free fall remain constant? Why/why not?**

Ans. The velocity of a body increases at every point of its motion during free fall as acceleration due to gravity acts on it.

4. **If gravitational force acts between all objects, why don't they move towards each other?**

Ans. The gravitational force is very weak, hence objects kept on a surface don't move towards each other.

5. **Give reasons for the following observations:**

an object dropped from a height falls towards the earth; all planets go round the sun.

Ans. When dropped from height, object falls towards the earth due to gravitational force of earth acting on object, while all planets go round the sun due to gravitational force of sun acting on them.

6. **Write the direction of acceleration due to gravity.**

Ans. Acceleration due to gravity is always directed towards the centre of the planet or celestial body on which it is measured.

7. **Define the universal gravitational constant (G).**

Ans. The gravitational force between two objects of unit mass each, separated by a unit distance, is equal to universal gravitational constant, i.e. when $m_1 = m_2 = 1$ kg and $r = 1$ m, then $F = G$.

8. **State Newton's law of gravitation.**

Ans. It states that the gravitational force exerted between any two objects of mass m_1 and m_2, whose centres are 'r' units apart, is

- directly proportional to product of masses, i.e. $F \propto m_1 m_2$
- inversely proportional to square of distance between their centres, i.e. $F \propto \frac{1}{r^2}$

i.e. $F = \frac{Gm_1m_2}{r^2}$

9. **What is the force of gravity between the earth and mass of 1 kg placed on its surface?**

Ans. Gravitational force, $F = \frac{Gm_1m_2}{r^2}$

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

Mass of object, $m_2 = 1$ kg

Distance between them, $r = 6 \times 10^6$ m

$G = 6.67 \times 10^{-11}$ Nm^2/kg^2.

$\therefore$ $F = \frac{6.67 \times 10^{-11} \times 6 \times 10^{24} \times 1}{(6 \times 10^6)^2} = 9.8$ N.

10. **State the value of G. Who obtained it for the first time?**

Ans. $G = 6.673 \times 10^{-11}$ Nm^2/kg^2. It was obtained by Henry Cavendish (1731-1810) with the help of a sensitive balance.

11. **The value of gravitational constant G on earth is 6.67×10^{-11} Nm^2/kg^2. What is its value on the surface of moon?** [CBSE 2013]

Ans. 'G' on moon = 6.67×10^{-11} Nm^2/kg^2 as it is a constant.

12. **Which force is responsible for motion of moon around the earth? What would happen of there was no such force?**

Ans. Motion of moon around the earth is due to centripetal force of earth. If there was no such force, the moon would pursue a uniform straight line motion.

13. **State the name and type of force which is responsible for the formation of tides in the sea.** [CBSE 2014]

Ans. Tides in the sea are caused due to gravitational pull of moon.

Very Short Answer Type Questions [1 Mark]

1. Briefly explain why Newton pondered over the existence of gravitation?

Ans. It is said an apple fell on Newton's head when he was sitting under a tree. He thought if earth attracts an apple, can it also attract the moon? Is the force same in both cases? This led to the study on gravitation.

2. What is the difference between gravity and gravitation? [CBSE 2010]

Ans. Gravitational pull of earth is called gravity.
Gravitation is the attractive force between any two objects in the universe.

3. State the significance of universal law of gravitation. [CBSE 2010]

Ans. Planetary motion around the sun, occurrence of tides etc. are phenomena which are possible due to law of gravitation.

27. **Write the equations of free fall.**

Ans. $v = u + gt$
$h = ut + \frac{1}{2}gt^2$
$v^2 = u^2 + 2gh$
} where symbols have usual meanings

28. **The value of g on the surface of the earth is 9.8 m/s^2. What will be its value on the surface of the moon?**

Ans. It will be 1/6th of 9.8 m/s^2 $= \frac{1}{6} \times 9.8 = 1.63$ m/s^2

29. **A ball is dropped from a tower of height 5 m. With what velocity does it strike the ground? [g = 10 m/s^2]**

Ans. $h = 5$ m, $u = 0$, $g = 10$ m/s^2.
$v^2 = u^2 + 2gh = 0 + 2 \times 10 \times 5 \Rightarrow v = 10$ m/s.

30. **A stone dropped from a tree takes 2 s to reach the ground. Find its velocity on striking the ground.**

Ans. $t = 2$ s, $u = 0$, $g = 9.8$ m/s^2
$v = u + gt = 0 + 9.8 \times 2 = 19.6$ m/s.

31. **Identify vector and scalar quantities: Weight, acceleration due to gravity, mass, gravitational constant.**

Ans. Vector: weight and acceleration due to gravity
Scalar: mass
Gravitational constant is neither a vector nor a scalar quantity. It is a constant.

32. **Mass of a book is 500 g on surface of the earth. What will be its mass at a height equal to radius of earth?**

Ans. $m = 0.5$ kg
At any height equal to radius of earth, it remains the same, i.e. 500 g as mass is constant everywhere.

33. **What is the relation between mass and weight of a body?** [CBSE 2014]

Ans. Weight = Mass × acceleration due to gravity.

34. **Define weight.**

Ans. The force of gravitation exerted upon an object by earth or any other celestial body called its weight.

35. **What is the weight of an object at centre of earth?** [CBSE 2013]

Ans. Zero because at centre of earth $g = 0$.

36. **Define 1 kg weight. Express it in newton.**

Ans. The force exerted by earth upon an object of mass 1 kg on its surface is called 1 kg weight.
In Newton, 1 kg wt = 1 kg × 9.8 m/s^2 = 9.8 N.

37. **State the SI unit of (*a*) mass (*b*) weight.**

Ans. (*a*) kilogram (*b*) newton

38. **Why does the weight of a body vary from poles to equator?** [CBSE 2010]

Ans. Weight of the body decreases from poles to equator.

39. **What will be the weight of an object on the earth whose mass is 10 kg? [g = 10 ms^{-2}]**

Ans. $m = 10$ kg, $g = 10$ m/s^2
$W = mg = 10 \times 10 = 100$ N.

40. **How does weight vary with the value of g?**

Ans. $W = mg$. Thus weight varies in direct proportion with g.