Gravitation

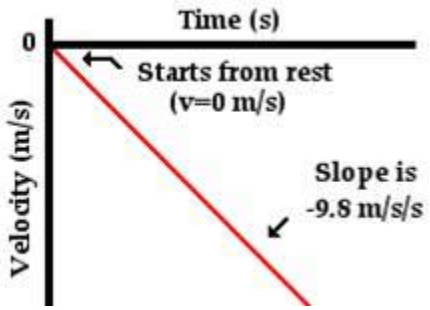
Assess Yourself

Q. 1. Draw a velocity-time graph to represent the motion of a freely falling body towards the surface of the earth.

Answer: i. During the free-fall motion of a body, the gravity is the only force acting upon the object.

ii. The motion of a free falling body is non-uniform because it experiences an acceleration of 9.81 ms^{-2} under the influence of gravity.

Hence its motion is uniformly accelerated.



Q. 2. State the value of universal gravitational constant. What was its value back in 1947?

Answer: The value of the universal gravitational constant in 1947 was the same as that of now.$G=6.673\times10^{-11}$ N m^2 kg^{-2}

Q. 3. State true/false. If false, correct the statement: "Earth exerts a greater force of attraction on apple than apple exerts on the earth."

Answer: False

Earth exerts the force of attraction on apple equal to the force apple exerts on the earth.

Q. 4. Why moon does not have an atmosphere?

Answer: The moon's gravity is 1/6th of the gravity on earth. It is not strong enough to hold the atmosphere on its surface from going back to space.

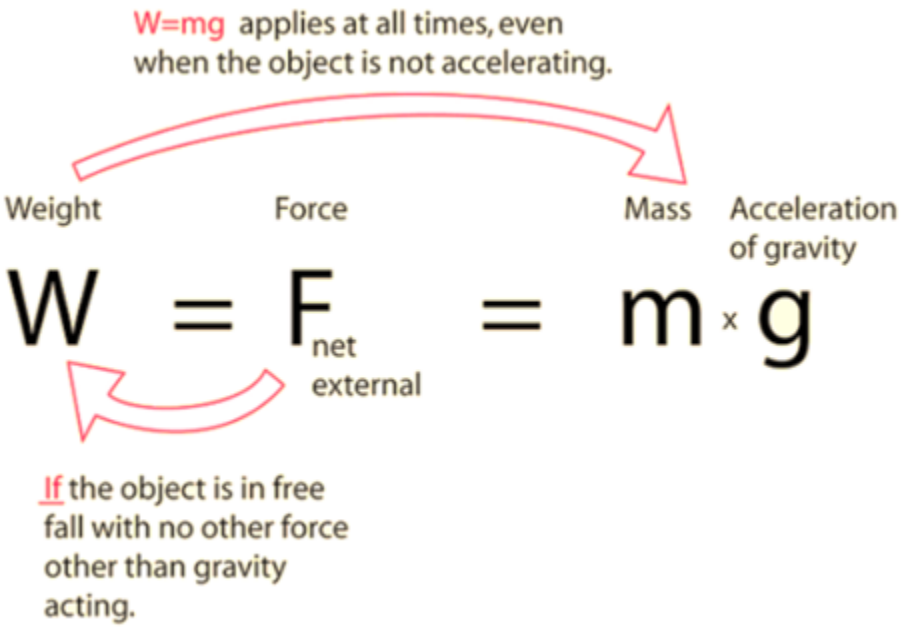
Q. 5. What is the gravitational force between earth and an object called?

Answer: Weight

Weight and it is equal to the product of mass(m) and acceleration due to gravity(g).

W = m×g

More explanation is given in this diagram.

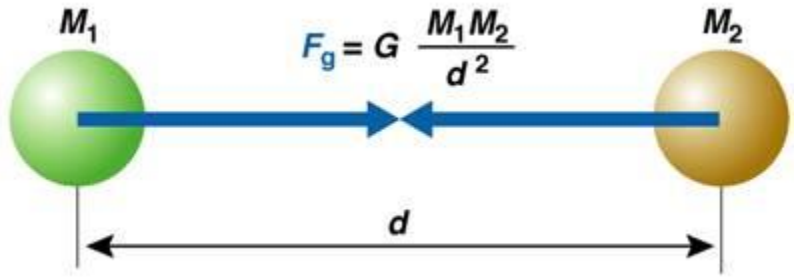


Q. 6. (a) State Newton's law of gravitation.

(b) Why is it called universal law?

Answer: (a) According to Newton's law of gravitation :(i) the force between two objects is directly proportional to the product of their masses and, (ii) the force between two objects is inversely proportional to the square of the distance between them.

Suppose two objects of masses M_1 and M_2 are kept at a distance "d", then the force between the two object is given as:



(b) The Newton's law of gravitation is applicable to all types of bodies- big or small, terrestrial or celestial. So, it is called the universal law.

Q. 7. Two electrons, each having mass 9.1 × 10^{-31} kg, are separated by a distance 10 Å. Calculate the gravitational force between them.

Answer: Given, mass of electron (m_e) = 9.1 × 10-31 kg

Distance between them(r) = 10 Å=10 × 10^{-10} m

G=6.673 × 10^{-11} N m^2 kg^{-2}

The gravitational force between them (Fg) is given by,

$$F_g = G \times \frac{(m_e)(m_e)}{r^2}$$

$$F_g = 6.67 \times 10^{-11} \times \frac{(9.1 \times 10^{-31})^2}{(10 \times 10^{-10})^2} = 5.52 \times 10^{-53}\ N$$

Q. 8.A. A person weighs 600 N earth. Find his mass (g = 10 ms-2).

Answer: Given, weight on earth (W) = 600 Ng= 10 ms^{-2}

Let the mass on earth be m. As we know, Weight = mass × acceleration due to gravity at

$$\text{placeW=mg} \Rightarrow m = \frac{W}{g} = \frac{600}{10} = 60\ kg$$

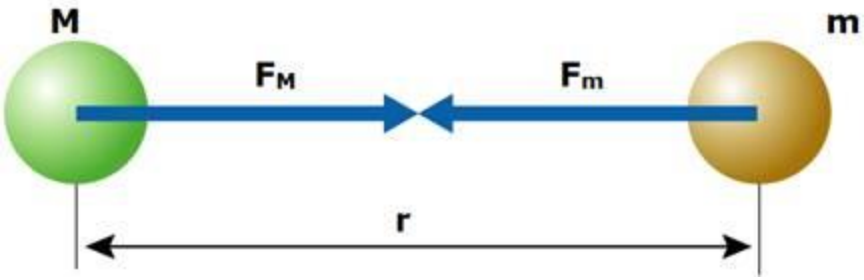
Q. 8.B. If he weighs 100 N on the moon, what is the acceleration due to gravity on the moon?

Answer: Given, Weight on the moon (W') = 100 NMass (m)=60 kgLet the acceleration due to gravity on the moon be g'. Weight = mass x acceleration due to gravity at that place $\Rightarrow W' = m \times g'$

$$\Rightarrow g' = \frac{W'}{m} = \frac{100}{60} = 1.67\ ms^{-2}$$

Q. 9. Mathematically prove that acceleration due to the gravity of a body is independent of its mass.

Answer: From second law of motion, the force on a body is the product of its mass and acceleration. Let the mass of body be m.



The acceleration of falling objects due to the gravitational force of earth is equal to the acceleration due to gravity(g).Thus, force(F) on the falling objects is given by ,F = mgThis force is equal to the gravitational force between the body and earth.

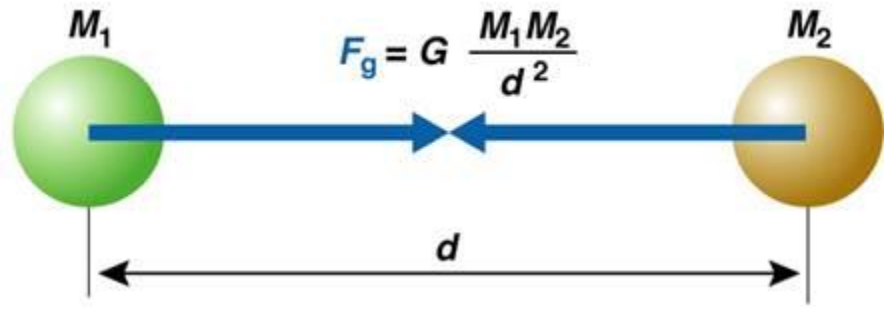
$\Rightarrow F = G\frac{Mm}{r^2}$ Where, G=Universal Gravitational constant

M=mass of earth m=mass of body r=distance between the body and the centre of earth

the as both forces are equal, $\Rightarrow g = G\frac{M}{r^2}$ which is independent of mass (m) of body.

Q. 10. Why is a gravitational force between you and your friend too weak to be experienced, but that between earth and sun is extremely large, through they are separated by large distance?

Answer: From Newton's law of gravitation, the gravitational force between two bodies is directly proportional to the product of their masses.

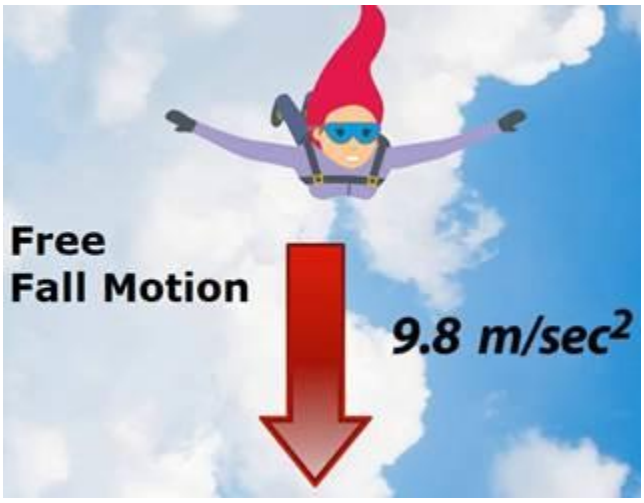


As the masses of earth and sun are very large as compared to the mass of me and my friend, the gravitational force between them is much greater than between me and my friend.

Q. 11. Distinguish between mass and weight of a body. When does a body experience weightlessness?

Answer: The mass of a body is a measure of its inertia. It is independent of the acceleration due to gravity at a place. The weight of a body is the force with which it is attracted to the earth. It is directly proportional to the acceleration due to gravity. Thus,

we feel heavier on earth than the moon. We experience weightlessness during free fall because we have no support to feel our



Q. 12. (a) A book has a mass 400 g. Find its weight when taken from the surface to a height equal to the radius of the earth.

(b) Define weight.

Answer: (a) Given, mass of book (m)=400 g=0.4 kgLet the radius of the earth be R. height of book = Rthe distance of book from the centre of the earth(d)=radius of earth + height of book=R+R=2RThe acceleration due to gravity at the surface of the earth(g) is given by, $g = G\frac{M}{d^2}$ The acceleration due to gravity at such height(g') is given by,

$$g' = G\frac{M}{d^2} = G\frac{M}{(2R)^2} = \frac{GM}{4R^2}$$

$$g' = \frac{g}{4} = \frac{9.8}{4} = 2.45\ ms^{-2}$$ Weight (W') = mg'=0.4×2.45=0.98 N

(b) Weight is the force with which a body is attracted towards the center of the earth. It is directly proportional to the acceleration due to gravity. It is given by, Weight=mass × acceleration due to gravity.

Q. 13. A car falls off a ledge and drops to the ground in 0.5 seconds.

Let g = 10 ms^{-2}, then

(a) What is its speed on striking the ground?

(b) What is its average speed during 0.5 second?

(c) How high is the ledge from the ground?

Answer: Given, time taken=0.5 second g=10 ms^{-2}

As the car is under free fall, the initial speed is zero. U = 0(a) Under free fall, u = 0, a = gv = u + a × tv = 0 + 10 × 0.5v = 5 ms^{-1}

(b) $\text{Average speed} = \frac{u+v}{2} = \frac{0+5}{2} = 2.5\ ms^{-1}$

(c) From Newton's equation of motion, As u=0,

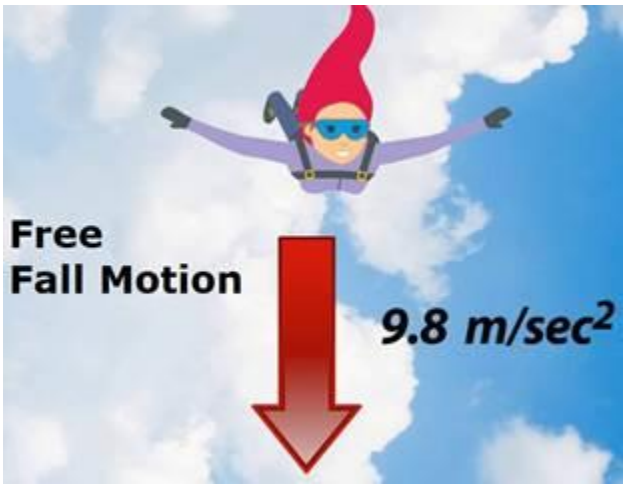
$$h = ut + \frac{1}{2}gt^2$$

Where h is the height, t is the time of free fall, g is the acceleration due to gravity. Putting the values in the above equation, we get

$$h = \frac{1}{2} \times 10 \times (0.5)^2 = 5 \times 0.25 = 1.25\ m$$

Q. 14.A. Define free fall.

Answer: Whenever an object falls under the effect of gravitational force towards the earth, it is said to be under free fall.



The direction of motion of the object does not change during free fall. But due to the acceleration due to gravity, the velocity of object changes.

Q. 14.B. State the equations of free fall.

Answer: The equations of motion are:v = u + at $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$

Under free fall, u = 0, a = acceleration due to gravity = g, s = height of fall = hThus under free fall, the equations become = gt $h = \frac{1}{2}gt^2$ $v^2=2gh$

Q. 14.C. Find the velocity with which a ball is thrown up if it reaches the maximum height in 5s. Also find its maximum height.

Answer: Given, time taken to reach top(t)=5sAs the object is thrown up, final velocity is zero. (v=0)The acceleration due to gravity will be negative as the direction of motion is opposite to the direction of gravity. Using equation of motion, v = u + gt ⇒ u = v - gt

Putting the values, u = 0 - (-10)(5) ⇒ u = 50 ms^{-1}

Q. 15. Raju goes to the vegetable vendor in the market. He notices that the needle of the balance is not in the centre of the balance. He takes the stuff, gets its mass checked in an electric balance and gets back to the vendor asking him to change the balance.

(a) How would you treat the vendor if you were in Raju's place?
(b) Which values of Raju are noteworthy?
(c) Why is it important to check the weight of substance before buying it?

Answer: (a) I would do the same Raju has done. I would ask the vendor to change the balance and check if it is done by mistake. If the vendor does not agree, I shall complain about him to the concerned authorities. **(b)** Raju shows values like observant, scientific temper. **(c)** The weight of balance should be checked before buying a substance to ensure if we are not paying more for a lesser quantity.