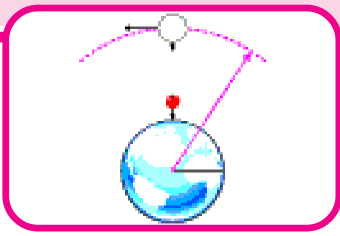
Chapter 7

GRAVITATION



We have learnt about uniform accelerated motion in the chapter 'motion'. In this chapter let us study about uniform circular motion which is an example of non-unifom accelerated motion.

We always observe that an object dropped from certain height falls towards the earth. We know that all planets move around the sun. We also know that the moon moves around the earth. In all these cases there must be some force acting on these objects to make them move around another object, instead of moving in a straight line.

- What is that force?
- Is the motion of the earth around the sun uniform motion?
- Is the motion of the moon around the earth uniform motion?

Newton explained the motion of moon by using the concept of uniform circular motion and then he developed the idea of gravitation between any two masses.

In this chapter you will learn about gravitation and centre of gravity.

Uniform circular motion

Activity-1

Observing the motion of an object moving in a circular path

Take an electric motor and fix a disc to the shaft of the electric motor. Place a small wooden block on the disc at the edge as shown in figure 1 (a). Switch on the motor. Find the time required to complete ten revolutions by the block and repeat the same two to three times. Begin counting of revolutions after few seconds of start of motor.

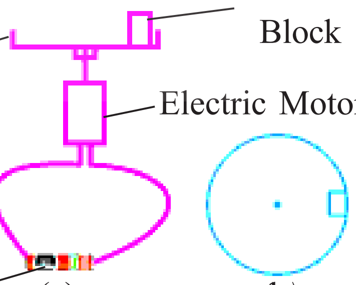


Fig-1 (a) motion of wooden block on a circular plate (b) top view of wooden block

- Is the time of revolution constant?
- Is the speed of the block constant?

- What is the shape of path?

The wooden block moves in a circular path with a constant speed. So this motion of wooden block is called uniform circular motion.

"**Uniform circular motion** is a motion of the body with a constant speed in circular path"

- Does the velocity of the body change in uniform circular motion? Why?
- Does the body in uniform circular motion have an acceleration? What is the direction of acceleration?

Activity-2

Drawing velocity vectors for a body in uniform circular motion

Recall the motion and path taken by the wooden block in the above activity. Draw the path of the wooden block and draw velocity vectors at successive time intervals as shown in the figure 2.

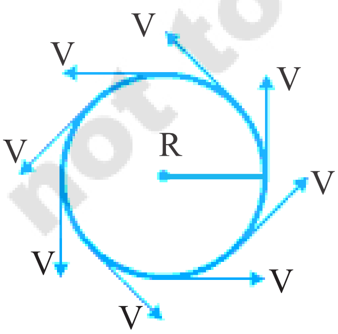


Fig-2: Velocity vectors at different points

Use figure 2 and transfer tails of each velocity vector to coincide at a single point as shown in figure 3(a) without changing their directions. Figure 3(a) represents the velocity vectors of figure 2 and the directed line joining two vectors represents change in velocity (ΔV).

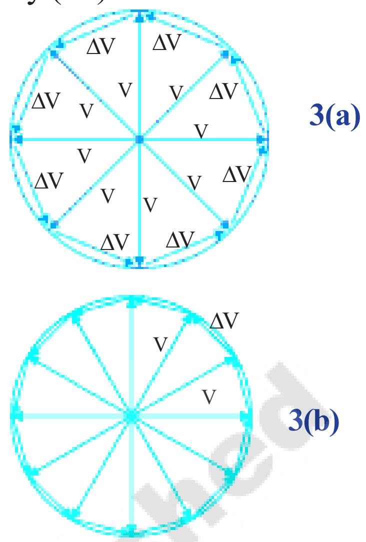


Fig-3(a) & (b): Transformed velocity vectors

Let a body move with a constant speed v in a circular path of radius 'R'. The velocity vector changes direction and appears to rotate. If a velocity vector is rotated through a small angle, the change in velocity (ΔV) will be represented by the base of the isosceles triangle as shown in figure 3(a).

Let us consider the change in velocity during the course of a complete revolution of a body; the sum of the magnitudes of the changes in velocity during a complete revolution will be equal to the sum of the sides of the depicted polygon. But the direction of velocity is changing continuously.

It is perfectly clear that the smaller we take vertex angles of the small triangles, the less will be our error. The smaller the sides of our polygon , the closer they cling to the circle of radius v as shown in figure 3(b) Consequently, the exact value of the sum of the magnitudes of the changes in velocity of the body during the course of revolution, will be equal to the circumference "$2\pi v$" of the circle.

We know that the magnitude of the acceleration is equal to the ratio of magnitude of change in velocity for one revolution and time period.

Let a_C be magnitude of acceleration of the body in uniform circular motion.

That is, $a_C = 2\pi v/T$

Where 'T' is time required to complete revolution.

We knew that $T = 2\pi R/v$

Substituting this expression in preceding formula, we get,

$$a_C = v^2/R$$

As the vertex angle of isosceles triangles decreases, the angle between the change in velocity and velocity vector approaches 90^0.

Therefore, the acceleration of a body in uniform circular motion is directed perpendicular to its velocity. But how are the velocity and acceleration directed relative to the path? Since the velocity is tangent to the path; the acceleration of the body is directed along the radius towards the centre of the circle.

The acceleration which can change only the direction of velocity of a body is called "**centripetal acceleration**".

Newton's second law says that net force on a moving body produces an acceleration in it which is directed along the net force.

So in uniform circular motion, a net force acts towards the centre. This net force is called "Centripetal force".

The net force which can change only the direction of the velocity of a body is called "**centripetal force**".

Let us find the value of centripetal force.

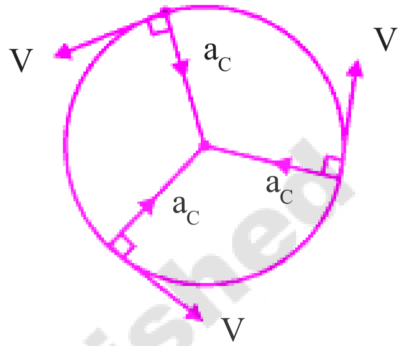


Fig-4

According to the Newton's second law of motion,

F_{net} = (mass) (acceleration)

$F_C = ma_C$

$F_C = mv^2/R$ (Since $a_C = v^2/R$)

Where R is the radius of circle.

In uniform circular motion, 'F_C' always directs towards the centre.

Note: Centripetal force is a net force directed towards the centre of the circle.

Think and discuss

- Can an object move along a curved path if no force acts on it?
- As a car speeds up when rounding a curve, does its centripetal acceleration increase? Use an equation to defend your answer.
- Calculate the tension in a string that whirls a 2 kg - toy in a horizontal circle of radius 2.5 m when it moves at 3m/s.

Universal law of gravitation

Once while Isaac Newton was sitting under a tree, an apple fell to the ground.

- Do you know what questions arose in his mind from this observation?
- Why did the apple fall to the ground?
- Why does the moon not fall to the ground?
- What makes the moon to move in a circular orbit around the earth?

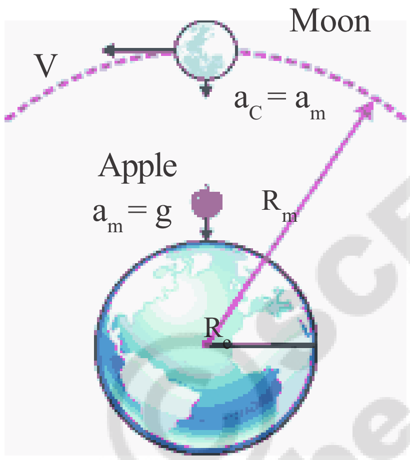


Fig-5: Comparing the motions of the moon and apple

Newton knew that the motion of moon around the earth is approximately uniform circular motion. So certain net force, which we call centripetal force, is required to maintain the uniform circular motion.

So he introduced the idea of force of attraction between the moon and earth. He proposed that earth attracts moon and termed it as gravitational force. This gravitational force acts as a centripetal force and makes the moon to revolve around the earth in uniform circular motion. Newton knew the following data.

The distance of the moon from center of the earth is 384 400 km = 3.844×10^{10} cm. The moon takes 27.3 days or 2.35×10^{6} s for a complete revolution around the earth.

- What is the speed of the moon?

You can calculate the speed of the moon using the equation,

$$v = 2\pi R/T$$

Thus the acceleration of the moon towards the centre of the earth

$$a_m = v^2/R = 4\pi^2 R/T^2$$

Substituting the values of R and T in above equation we can get

$$a_m = 0.27 \text{ cm}/s^2.$$

Galileo found that the acceleration of bodies acquired near the surface of earth is equal to $981 \text{cm}/s^2$. Thus acceleration of apple approximately is equal to $981 \text{cm}/s^2$.

He compared the both the acceleration of apple, a_e to the acceleration of the moon, a_m. We get, $a_e / a_m = 981/0.27 \cong 3640$.

Newton knew that the radius of Earth, R_e and the distance of the moon from the centre of the Earth, R_m are 6371 km and 3,84,400 km respectively. We get

$$R_m / R_e = 384400/6371 \cong 60.3$$

$$(R_m / R_e)^2 = (60.3)^2 \cong 3640$$

From above discussion it is clear that

$$a_e / a_m = (R_m / R_e)^2$$

So we get, Acceleration α 1/ (Distance)^2

$$a \, \alpha \, 1/R^2 \quad \text{-----} \ (1)$$

Force of attraction α 1/(Distance)^2

$$F \, \alpha \, 1/R^2 \quad \text{-----} \ (2)$$

Thus it became clear that the force of gravity decreases with increase in distance of the object from the center of the earth.

According to the Newton's third law force on the apple by the earth is equal to force on the earth by the apple. We get the force on the object by the earth by using second law of motion and equation-1.

From Newton's second law of motion $F = ma$, and from equation-1, $a \propto 1/R^2$

$\Rightarrow a = k/R^2$ (where k is proportionality constant)

Thus we get, $F = km/R^2$

Therefore the force on the apple by the earth $= Km/R^2$ ---- (3)

Where 'm' is the mass of apple and 'R' is the radius of the earth.

Force on the earth by the apple $= K'M/R^2$ ---- (4)

Where M is the mass of the earth.

The above forces are equal in magnitude only when the following condition is satisfied.

$K=GM$ and $K' = Gm$ ---- (5)

From equations (3) & (5) we have force on apple by the earth, $F = GMm/R^2$

We conclude that gravitational force between the masses is directly proportional to product of their masses.

Force of attraction $\propto$ $(mass)_1$ $(mass)_2$

Newton generalized the force of gravitation and said it acts on all bodies in the universe. The universal law of gravitation states that every body in the universe attracts other body with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. The direction of the force of attraction is along the line joining the centers of the two bodies.

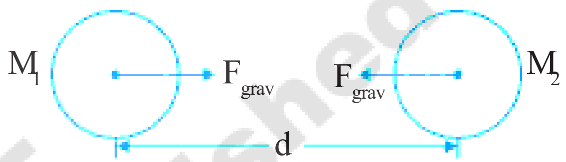


Fig-6

Let two bodies of masses M_1 and M_2 be separated by a distance of 'd'. Then the force of gravitation between them

$$F_{grav} \propto M_1 M_2/d^2$$

$$F_{grav} = G M_1 M_2/d^2$$

G is a proportionality constant, called universal gravitational constant and found by Henry Cavendish to be

$$G=6.67\times10^{-11}\ Nm^2Kg^{-2}$$

The value of G is equal to the magnitude of force between a pair of 1- kg masses that are 1 metre apart.

Note: This formula is applicable to spherical bodies. We use the above formula for all bodies on the earth though they are not spherical because, when compared to the earth, any object on earth is very small and it is assumed as a point object.

Think and discuss

- In figure 7, we see that the moon 'falls' around earth rather than straight into it. If the magnitude of velocity were zero, how would it move?

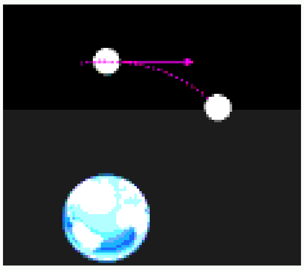


Fig-7

- According to the equation for gravitational force, what happens to the force between two bodies if the mass of one of the bodies doubled?
- If there is an attractive force between all objects, why do we not feel ourselves gravitating toward massive buildings in our vicinity?
- Is the force of gravity stronger on a piece of iron than on a piece of wood if both have the same mass?
- An apple falls because of the gravitational attraction of earth. What is the gravitational attraction of apple on the earth? Why?

Example 1

What is the time period of satellite near the earth surface neglect height of the orbit of satellite from the surface of ground?

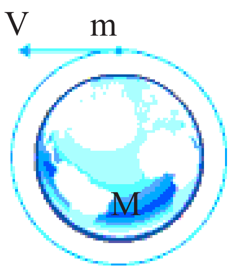


Fig-8

Solution

The force on the satellite due to earth is given by $F = G\,m\,M/R^2$

M-Mass of earth,

m-mass of satellite,

R-radius of earth.

Let v be the speed of the satellite $v = 2\pi R/T \Rightarrow T = 2\pi R/v$

Required centripetal force is provided to satellite by the gravitational force hence $F_C = m\,v^2/R$.

But $F_C = GMm/R^2$ according to Newton's law of gravitation.

i.e., $GMm/R^2 = m(2\pi R)^2/T^2R$

$\Rightarrow T^2 = 4\pi^2 R^3/GM$, as mass of the earth (M) and G are constants the value of T depends only on the radius of the earth.

$\Rightarrow T^2 \alpha R^3$

Substituting the values of M, R and G in above equation we get, T = 84.75 minutes.

Thus the satellite revolving around the earth in a circular path near to the earth's surface takes 1Hour and 24.7 minutes approximately to complete one revolution around earth.

Free fall

Activity-3

Acceleration is independent of masses

Place a small paper on a book. Release the book with the paper from certain height from the ground.

- What is your observation? Now

drop the book and paper separately, what happens?

A body is said to be free fall body when only one gravitational force acts on that body.

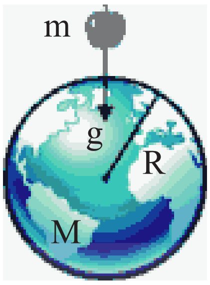


Fig-9

Let us drop a body of mass m near the earth's surface.

Let M be the mass of the earth and R be the radius of the earth.

Now the force of attraction on the mass is given by,

$F = GMm/R^2 \Rightarrow F/m = GM/R^2$

From Newton's second law, F/m is equal to acceleration. Here this acceleration is denoted by 'g'

Hence, $g = GM/R^2$

from above equation you can conclude that 'g' is the independent of the bodies mass.

If there were no air friction or resistance, all the bodies fall with same acceleration. This acceleration, produced due to gravitational force of the earth near the surface, is called free- fall acceleration.

Mass of the earth (M) = 6×10^{24} kg

Radius of earth (R) = 6.4×10^{6} km

Putting these values in the above equation.

We get $g = 9.8$ m/s^2 (approximately)

In general, this value of acceleration due to gravity changes due to change in distances of objects from the center of the earth.

Since free - fall acceleration is constant near the ground, the equations of uniform accelerated motion can be used for the case of free-fall body.

$v = u + at$,

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

$v^2 - u^2 = 2as$.

While solving problems related to Free fall objects we use 'g' instead of 'a' in above equations.

When we use these equations, you must follow the sign convention (It is discussed in the chapter "motion")

Activity-4

What is the direction of 'g'

Throw a stone vertically up. Measure the time required for it to come back to earth's surface with stop clock.

- What happens to speed when it moves up and down?
- What is the direction of acceleration?

When a stone moves up, the speed dereases. When a stone moves down, the speed increases. So the free-fall acceleration is vertically downwards. No matter how you throw objects, the " g " is directed vertically down as shown in figure10.

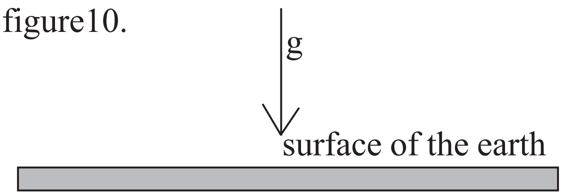


Fig-10

Think and discuss

- Give an example for the motion of an object of zero speed and with non zero acceleration?
- Two stones are thrown into air with speeds 20 m/s, 40m/s respectively? What are accelerations possessed by the objects?

Example 2

A body is projected vertically up. What is the distance covered in its last second of upward motion? ($g = 10\ m/s^2$)

Solution

The distance covered by the object in its last second of its upward motion is equal to the distance covered in the first second of its downward motion.

Hence $s = \frac{1}{2}gt^2 = \frac{1}{2} \times 10 \times 1 = 5\ m$

Example 3

Two bodies fall freely from different heights and reach the ground simultaneously. The time of descent for the first body is $t_1 = 2s$ and for the second $t_2 = 1s$. At what height was the first body situated when the other began to fall? ($g = 10\ m/s^2$)

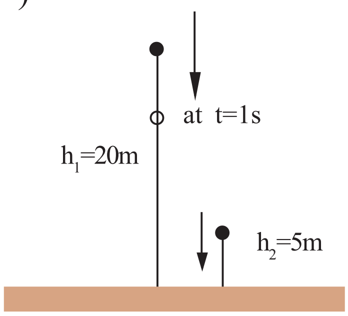


Fig-11

Solution

The second body takes 1 second to reach ground. So, we need to find the distance traveled by the first body in its first second and in two seconds.

The distance covered by first body in 2s,

$h_1 = \frac{1}{2}\ gt^2 = \frac{1}{2} \times 10 \times 2^2 = 20m.$

The distance covered in 1s, $h_2 = 5\ m$.

The height of the first body when the other begin to fall $h = 20 - 5 = 15m$.

Example 4

A stone is thrown vertically up from the tower of height 25m with a speed of 20 m/s. What time does it take to reach the ground? ($g = 10\ m/s^2$)

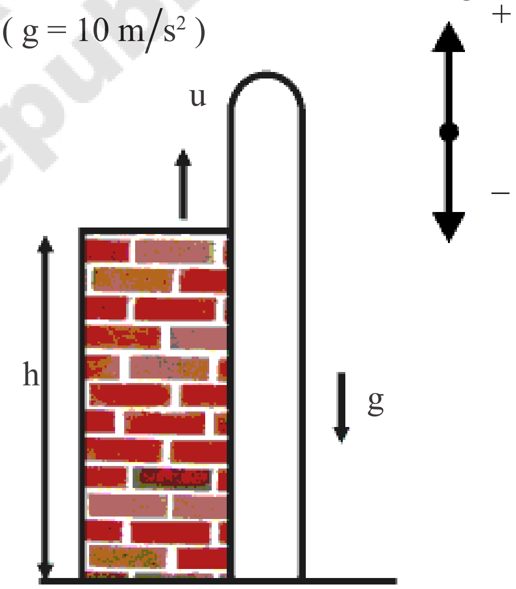


Fig-12

Solution

Sign convention must be used to solve this problem. It is shown in figure.

We consider the upward direction as positive and downward direction as negative with respect to a point of reference. In the above example the point of projection is considered as the point of reference.

Then, $u = 20\ m/s$

$a = g = -10\ m/s^2$

$s = h = -25\ m$

From equation of motion $s = ut + \frac{1}{2}at^2$

$-25 = 20t - \frac{1}{2} \times 10 \times t^2$

$-25 = 20t - 5t^2$

$-5 = 4t - t^2$

$\Rightarrow t^2 - 4t - 5 = 0$

Solving this equation,

We get, $(t - 5)(t + 1) = 0$

$t = 5$ or -1

$t = 5s$

Example 5

Find the time taken, by the body projected vertically up with a speed of u, to return back to the ground.

Solution

Let us take the equation $S = ut + \frac{1}{2}at^2$

For entire motion $S = 0$

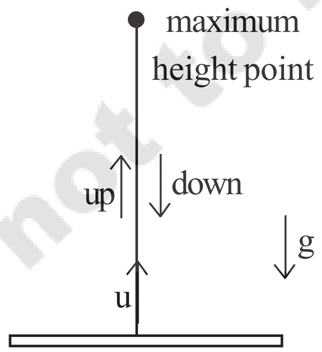


Fig-13

$a = -g$

$u = u$

$O = ut - \frac{1}{2}gt^2$

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

$t = 2u/g$

Weight

Weight of a body is the force of attraction on the body due to earth.

So, from Newton's second law of motion.

$F_{net} = ma$

We get,

$W = mg$

It is measured in newtons

1 kg body weighs 9.8 N

2 kg body weighs 19.6 N

10kg body weighs 98 N

Activity-5

Can we measure the weight of free-fall body

Let us find,

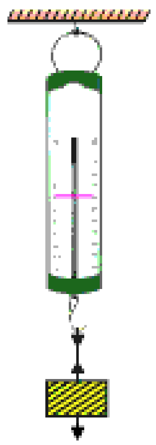


Fig-14 (a)

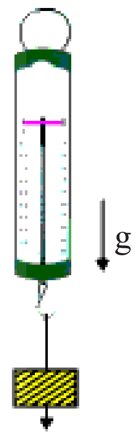


Fig-14 (b)

Take a spring balance and suspend it to the ceiling and put some weight to it. Note the reading of the spring balance. Now drop the spring balance with load from certain height to fall freely. Carefully observe the change in the position of indicator on the spring balance scale while it is in free-fall.

- What changes do you notice in the readings of spring balance in above two instances?
- Are they same? If not why?

Some of you might have the experience of diving into a swimming pool from certain height.

- How do you feel during the free-fall of your body from the height?

Activity-6

Observing the changes during the free-fall of a body

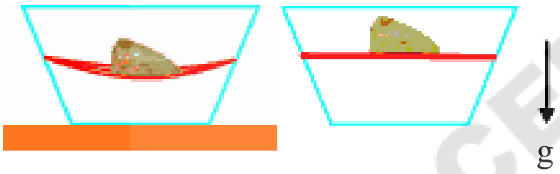


Fig-15 (a) *Fig-15 (b)*

Take a transparent tray and make holes on opposite sides. Take two or three rubber bands and tie them tightly, close to each other between the holes. Now place a stone on the bands as shown in the figures 15(a) and 15(b).

- Do the bands bend? Now drop the tray with stone. Now what happens?

We get the following results in free fall.

In spring - mass activity. The reading becomes zero. In jumping, the man feels weightlessness. In the activity-6, the bands are straight. No stretch occurs in the rubber bands.

We treated the weight of an object as the force due to gravity upon it. When in equilibrium on a firm surface, weight is evidenced by a support force or when in suspension, by a supporting tension. In either case with no acceleration, weight equals mg. A support force can occur without regard to gravity. So broader definition of the weight of something is the force it exerts against a supporting floor.

When the body falls freely then it experiences weightlessness. Even in this weightless condition, there is still a gravitational force acting on the body, causing downward acceleration. But gravity now is not felt as weight because there is no support force.

Think and discuss

- When is your weight equal to mg?
- Give example of when your weight is zero?

Centre of gravity

Activity-7

Balancing of spoon and fork

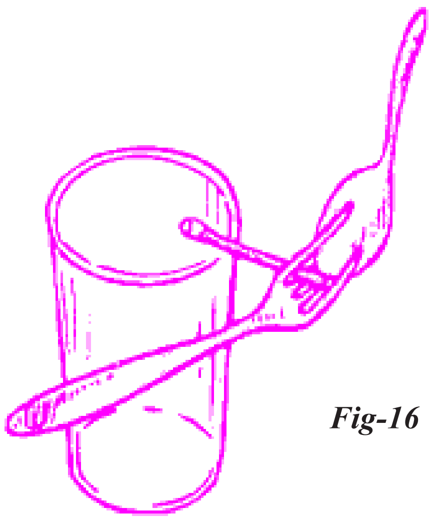


Fig-16

Fasten a fork, spoon, and wooden match stick together as shown. The combination will balance nicely - on the edge of the glass. Why?

Acivity-8

Can you get up without bending

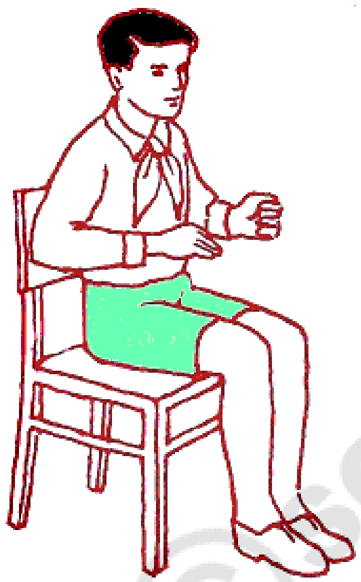


Fig-17

Sit in a chair comfortably as shown in fig-17. Try to get up from the chair without bending your body or legs.

- Are we able to do so? If not why?

Activity-9

Balancing a ladder

Try to balance ladder on your shoulder?

When does it happen?

We need to introduce the idea of "Centre of gravity" to understand the above activities.

The center of gravity is simply the average position of weight distribution. The point where total weight appears to act is called **centre of gravity**.

Activity-10

Locating centre of gravity

Take a meter scale. Suspend it from various points. What do you notice? Suspend it from its mid point. What happens?

The center of gravity of a uniform object, such as meter stick, is at its midpoint. The stick behaves as if its entire weight was concentrated at that point. The support given to that single point gives support to the entire stick. Balancing an object provides a simple method of locating its centre of gravity. The many small arrows represent the pull of gravity all along the meter stick. All of these can be combined into resultant force acting through the centre of gravity.

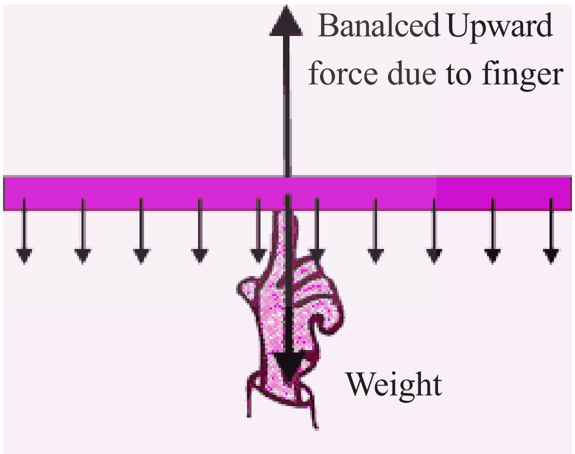


Fig-18

The entire weight of the stick may be thought of as acting at this single point. Hence we can balance the stick by applying a single upward force in a direction that passes through this point.

- How to find the center of gravity of an object?

The center of gravity of any freely suspended object lies directly beneath the point of suspension.

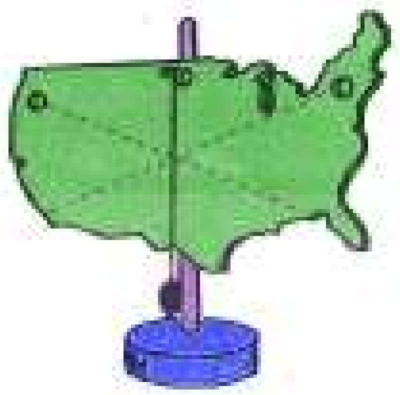


Fig-19

If a vertical line is drawn through the point of suspension, the center of gravity lies somewhere along that line. To determine exactly where it lies along the line, we have only to suspend the object from the some other point and draw a second vertical line through that point of suspension. The center of gravity lies where the two lines intersect.

Activity-11

Identifying the center of gravity of a ring

Find the centre of gravity of ring using the method explained in the above example.

- Where does the center of gravity of a ring lie?
- Does the center of gravity of a body exist outside the body?
- Does center of gravity of an object exist at a point where there is no mass of the object?

Stability

The location of the centre of gravity is important for stability. If we draw a line straight down from the centre of gravity of an object of any shape and it falls inside the base of the object, then the object will stable.

If the line through the center of gravity falls outside the base then the object will be unstable.

Activity-12

Shift of the center of gravity and its effects

When you stand erect, where is your centre of gravity?

Fig-20 (a)

Fig-20 (b)

Try to touch your toes as shown in figure 20 (a). Try this gain when standing against a wall as shown in figure 20 (b).

- Are you able to touch your toes in second case as shown in fig-20(b)? If not why?
- What difference do you notice in the center of gravity of your body in the above two positions?

Think and discuss

- Where does the center gravity of a sphere and triangular lamina lie?
- Can an object have more than one centre of gravity?
- Why doesn't the leaning tower of Pisa topple over?
- Why must you bend forward when carrying a heavy load on your back?

Key words

Uniform circular motion, centripetal acceleration centripetal force, centre of gravity, law of gravitation, weight, weightlessness, stability, free fall.

What we have learnt

- Motion of body with constant speed in a circular path is called uniform circular motion .
- The acceleration which causes changes only in direction of the velocity of a body is called centripetal acceleration and it is always directed towards the center of the circle.
- The net force required to keep a body in uniform circular motion is called "Centripetal force". $F_C = Mv^2 / R$.
- Every object in the universe attracts other bodies. The force of attraction between the bodies is directly proportional to the product of masses and inversely proportional to the square of the distance between them.
- All the bodies have the same acceleration ($9.8 m/s^2$) near the surface of the earth. But this acceleration slightly decreases as we move away from the surface of the earth.
- A body is said to be in free fall when only gravity acts on it. (its acceleration is 'g')
- Weight of an object is the force of gravity acting on it.

  $W = mg$

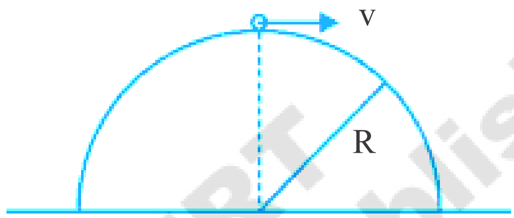
  During free fall condition, the body is in state of 'weightlessness'.
- The center of gravity is the point where total weight of the body acts.
- The body is in equilibrium when the weight vector goes through the base of the body.

Improve your learning

1. What path will the moon take when the gravitational interaction between the moon and earth disappears? (AS_2)

2. A car moves with constant speed of 10 m/s in a circular path of radius 10m. The mass of the car is 1000 kg. Who or what is providing the required centripetal force for the car? How much is it? (Ans:10^4N) (AS_1)

3. A small metal washer is placed on the top of a hemisphere of radius R. What minimum horizontal velocity should be imparted to the washer to detach it from the hemisphere at the initial point of motion? (See figure) (AS_1 , AS_7)



(Ans: $v = \sqrt{(gR)}$)

4. Explain why a long pole is more beneficial to the tight rope walker if the pole has slight bending. (AS_1 , AS_7)

5. Why is it easier to carry the same amount of water in two buckets, one in each hand rather than in a single bucket? (AS_7)

6. What is the speed of an apple dropped from a tree after 1.5 second? What distance will it cover during this time? Take $g=10m/s^2$ (AS_1) (Ans: 15m/s; 11.25m)

7. A body is projected with a speed of 40 m/s vertically up from the ground. What is the maximum height reached by the body? What is the entire time of motion? What is the velocity at 5 seconds after the projection? Take $g=10m/s^2$ (AS_1)

   (Ans: 80m; 8s; 10m/s down)

8. A boy is throwing balls into the air one by one in such a way that when the first ball thrown reaches maximum height he starts to throw the second ball. He repeats this activity. To what height do the balls rise if he throws twice in a second? (AS_1 AS_7)

   (Ans: 1/4m)

9. A man is standing against a wall such that his right shoulder and right leg are in contact with the surface of the wall along his height. Can he raise his left leg at this position without moving his body away from the wall? Why? Explain.(AS_7)

10. A ball is dropped from a height. If it takes 0.2s to cross the last 6m before hitting the ground, find the height from which it is dropped. Take g = 10m/ s^2 (AS_1) (Ans: 54.45m)
11. A ball is dropped from a balloon going up at a speed of 5 m/s. If the balloon was at a height 60 m. at the time of dropping the ball, how long will the ball take to reach the ground? (AS_1, AS_7) (Ans: 4s)
12. A ball is projected vertically up with a speed of 50 m/s. Find the maximum height, the time to reach the maximum height, and the speed at the maximum height (g=10 m/ s^2) (AS_1) (Ans: 125m; 5s; zero)
13. Two cars having masses m_1 and m_2 move in circles of radii r_1 and r_2 respectively. If they complete the circle in equal time. What is the ratio of their speeds and centripetal accelerations? (AS_1) (Ans: r_1/r_2, r_1/r_2)
14. Two spherical balls of mass 10 kg each are placed with their centers 10 cm apart. Find the gravitational force of attraction between them. (AS_1) (Ans: 10^4G)
15. Find the free-fall acceleration of an object on the surface of the moon, if the radius of the moon and its mass are 1740 km and 7.4 x 10^{22} kg respectively. Compare this value with free fall acceleration of a body on the surface of the earth. (AS_1) (Ans: approximately 1.63 m/s^2)
16. Can you think of two particles which do not exert gravitational force on each other? (AS_2)
17. An apple falls from a tree. An insect in the apple finds that the earth is falling towards it with an acceleration g. Who exerts the force needed to accelerate the earth with this acceleration? (AS_7)
18. A scooter weighing 150kg together with its rider moving at 36 km/hr is to take a turn of radius 30 m. What force on the scooter towards the center is needed to make the turn possible? Who or what provides this? (AS_1) (Ans: 500N)
19. The bob of a simple pendulum of length 1 m has mass 100g and a speed of 1.4 m/s at the lowest point in its path. Find the tension in the string at this moment. (AS_1) (Ans: 1.076N)
20. How can you find the centre of gravity of a India map made of steel? Explain.(AS_3)
21. Explain some situations where the center of gravity of man lies out side the body. (AS_1)
22. Where does the center of gravity of the atmosphere of the earth lie?(AS_2)
23. Where does the center of gravity lie, when a boy is doing sit-ups? Does weight vector pass through the base or move away from the base? Explain.(AS_7)