Unit 2 Force and Motion

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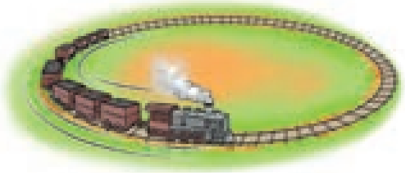
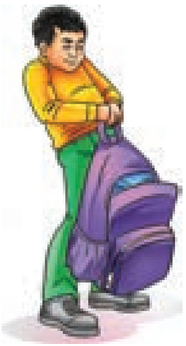



Learning Objectives

- ❖ To identify that push or pull or both are involved when there is a motion.
- ❖ To understand that some forces are contact forces and some are non-contact forces.
- ❖ To know that when a force is applied, it can make things move, change the direction or change its shape and size.
- ❖ To distinguish between rest and motion and understand that they are relative.
- ❖ To infer motion is caused by application of force.
- ❖ To classify different types of motion.
- ❖ To deduce the definition of speed.
- ❖ To understand and use the unit of speed.
- ❖ To distinguish uniform and non-uniform motion.
- ❖ To compute time, distance and speed.

Introduction

We have studied in our earlier classes that push or pull results in some motion of the object. When we open the door or kick a football or lift our school bag, motion is involved and there is some push or pull.



2.1 Motion and Rest

What is rest? What is motion?

Suppose there is a book on your table right in the middle. Is the book moving? You will say it is not moving; it is at rest. If you push the book to one side of the table to clear the space for keeping your notebook, then you will say the book is moving. When the book was at the same place with respect to the table, it was at rest; but when it was pushed from one place on the table to another place, it was moving.

Activity 1

Can you identify whether it is push or pull that results in motion in the following cases?

Push / Pull

Push / Pull

Push / Pull

Push / Pull

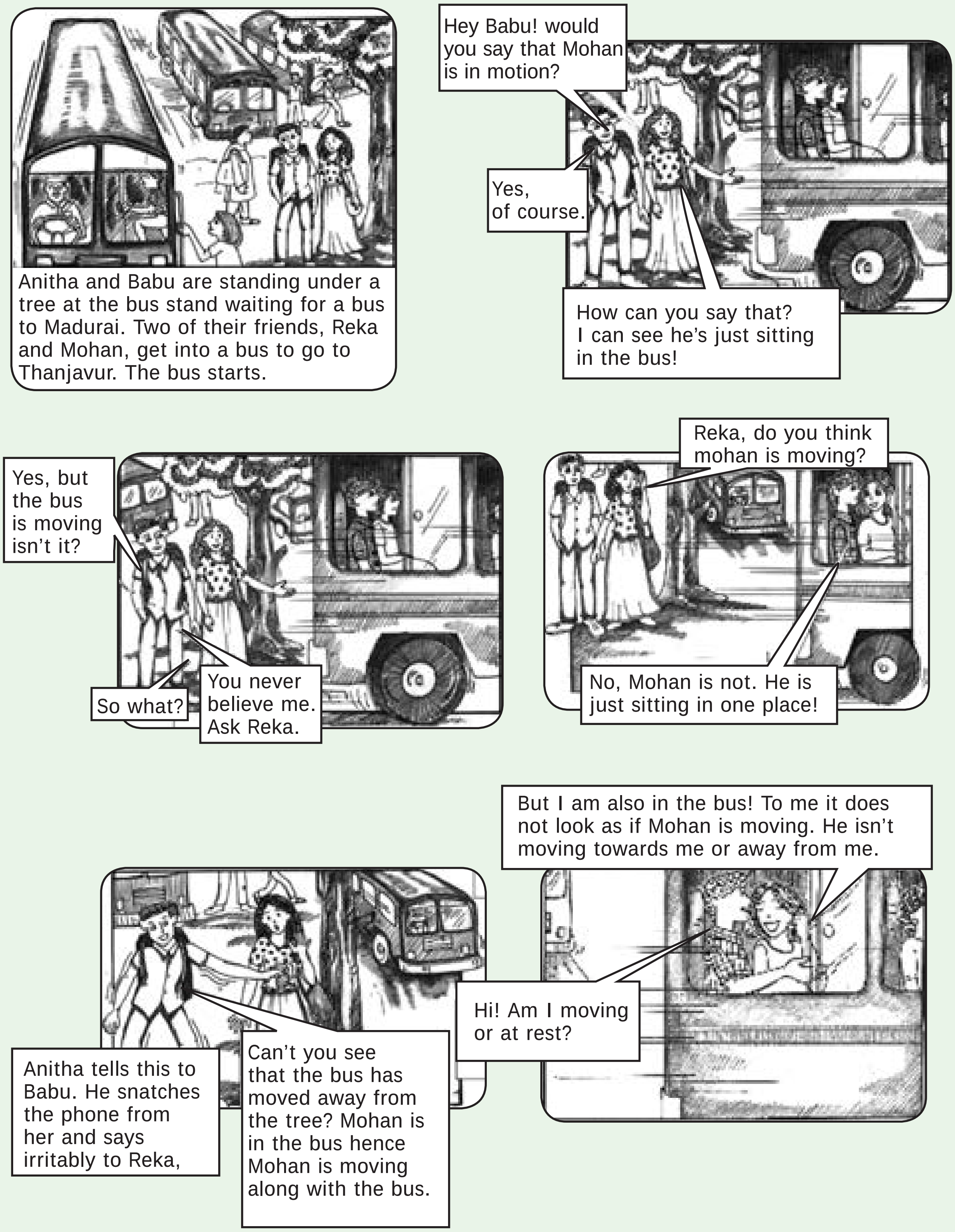
Push / Pull

Push / Pull

When there is a change in the position of an object with respect to time, then it is called motion. If it remains stationary it is called rest.

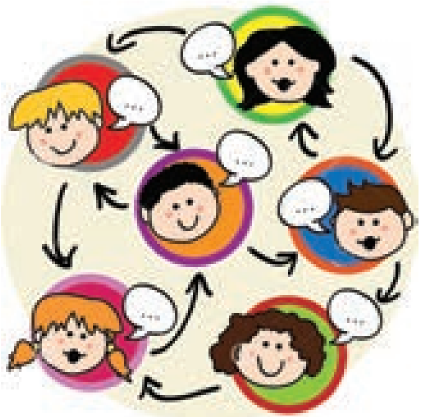
Is Mohan in motion?

Observe the following pictures and say whether Mohan is in motion or at rest



Discuss: Who is correct? Is Mohan really in motion?

We can clearly say that both Reka and Babu are correct. From the point of view of Babu, Mohan along with the bus is in motion; but for Reka who is sitting beside him, he is at one place; therefore stationary. So, according to Babu, Mohan is in motion; Mohan is at rest from Reka's observation. Can you think any other examples?



Answer by observing the situation in the picture

Event 1: The man in the boat is **moving** with respect to the bank of river. He is at **rest** with respect to the boat.

Event 2:

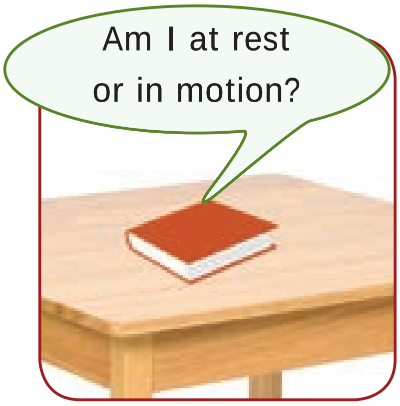
The girl on the swing is __________ with respect to the seat of the swing.

She is ________ with respect to the garden.

Event 3: Nisha is going to her grandmother's house by bicycle. Sitting on the bicycle, Nisha is ______________ with respect to the road.

She is _____________ with respect to the bicycle.

Take the case of a book on a table at rest. Is it really without any motion? We know that Earth is rotating on its axis; therefore the table along with the book must be rotating. Is it not? We are also moving along with the earth. Therefore, from the point of view of the ground on which we stand, the book is at 'rest'. Similarly, while travelling in a bus, we feel that the poles and trees seem to move backwards, and the things inside the bus are stationary.



An object may appear to be stationary for one observer and appear to be moving for another. An object is at rest in relation to a certain set of objects and moving in relation to another set of objects. **This implies that rest and motion are relative.**

Activity 2

Moon or Cloud?

Observe the moon on a windy night with a fair bit of cloud cover in the sky. As the cloud passes in front of the moon you sometimes think it is the moon which is moving behind the cloud. What would you think if you were to observe a tree at the same time?

Aryabatta, an ancient Indian astronomer, said, "As the banks of the river appear to move back to a person in a boat floating gently in a river, the night sky studded with stars appear to move from the east to the west and so the Earth rotates from the west to the east."

How things move?

When we kick a ball it moves. When we push the book on the table, it moves. When a bullock pulls, the cart moves. Motion occurs when an object is pulled or pushed by an agency.

In our daily life, we pull out water from the well using bucket. Animals pull a bullock cart. It is a person or animal, that is an animate agency that does the pushing or pulling.

Sometimes we see a tall grass in the meadow dancing in the wind or a piece of wood moving down a stream. What pushes or pulls them? We know that blowing wind and flowing water is the cause. Sometimes the push or pull can be due to the inanimate agency.

Forces are push or pull by an animate or inanimate agency.

Contact, Non-contact Forces

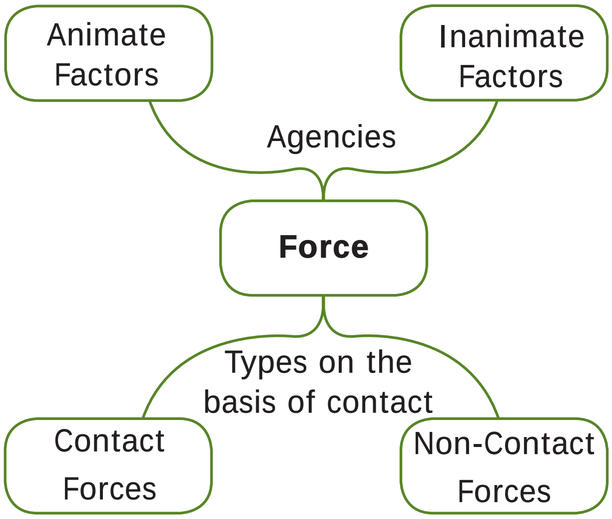
Forces can be classified into two major types; contact and non-contact forces.

Wind making a flag flutter, a bullock pulling a cart are contact forces. Magnetism, gravity are some examples of non-contact forces.

In all the above cases, the force is executed by touching the body. So, this type of forces are called contact forces.

Mysteriously, ripen coconut falls to the ground. What pulls it to the ground? We would have heard about 'force of gravity' of Earth. Gravity pulls the ripen coconut from the tree to the ground.

When we bring a magnet near a small iron nail, the nail jumps into the air and sticks with the magnet. Observe that the magnet and the nail did not touch each other. Still, there was a pulling force that made the nail to jump towards the magnet. In these two examples, the force is applied without touching the object. Such forces are known as non-contact forces.

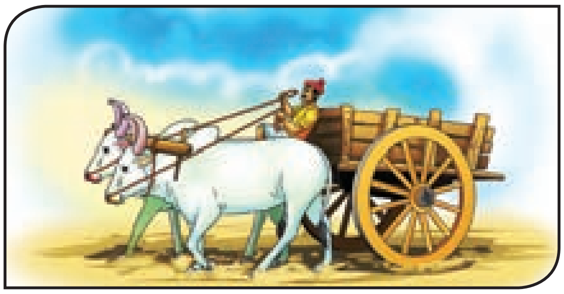


What happens when we apply a force on an object?

What happens when you apply a force on an object? Say, you push a book on the table. The book moves. Application of force in an object results in motion from a state of rest.

What happens when a batsman hit a ball? The ball is already in motion, but with the strike, the speed of the ball increases. Moreover the direction of the ball changes. Application of force on an object results in a change in its speed and change in its direction.

When we crush a balloon or press roti dough or pull a rubber band, the shape of the object changes on application of force. Application of force in object results in expansion or contraction.



Look at this picture. The person is applying force to stop the cart from moving. When the force is applied against the direction of the motion, the speed can be reduced, or even the motion is stopped completely. Discuss what happens when you apply break in a speeding bicycle.

In a nutshell, we can say that the applied force is an interaction of one object on another that causes the second object to move from rest, speed up, slow down, stop the motion, change the direction, compress or expand.

Forces can

1. Change the states of a body from rest to motion or motion to rest.
2. Either change the speed or direction or both of the body.
3. Change the shape of the body.

Activity 3

Fill in the empty spaces

Force can

- move objects at rest
- ______
- change the speed
- ______
- ______
- compress or expand

Can you give example for contact and non-contact forces?

Force

Contact Force	Non-Contact Force
Examples	Examples
Kick a football	Magnet attracts nails
______	______

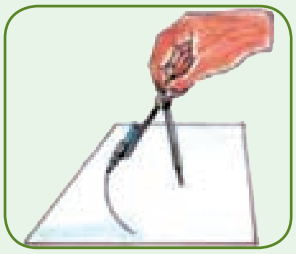
2.2. Types of motion

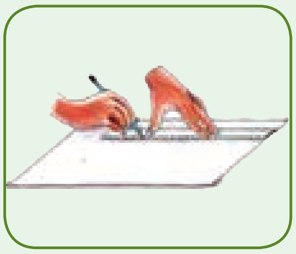
Activity 4

Play with pencil

Do what Shanthi did...

(i) Shanthi took a pencil and sharpened it with a sharpener. (ii) Then she drew a circle using the pencil and a compass. (iii) Later she took her ruler (scale) and drew a straight line in another paper. (iv) Then she kept the pencil between her fingers and moved it back and forth.





Now, look at the motion of the pencil in all these four cases. How was it?

(i) In the first case, the pencil **rotated in its axis.**

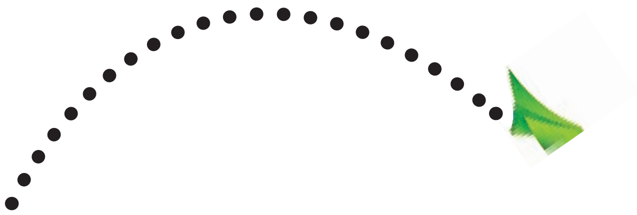
(ii) In the second case, it went in **a circle.**

(iii) In the third case, the pencil travelled in **a straight line.**

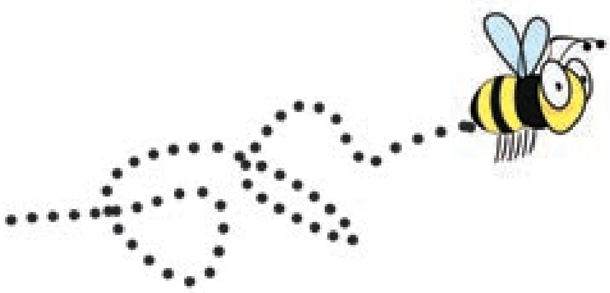
(iv) In the fourth case, the pencil tip moved **back and forth,** that is it oscillated like a swing.

We can say that the motion of the pencil was rotational, circular, straight line or linear and later oscillatory.

Throw paper aeroplanes or paper dart. Watch its flight path when you throw it at an angle. The path curves i.e the paper flight is moving ahead but its direction is changing while moving. Such paths are called curvilinear.



A fly buzzing around the room is a combination of all these motions and flight path is zigzag.



You can classify the motion according to the path taken by the object.

a. Linear motion - Motion in a straight line. Eg. A person walking on a straight path.

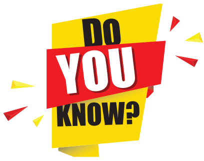
b. Curvilinear motion - Motion of a body moving ahead but changing direction. Eg. Motion of a ball thrown.

c. Circular motion - Motion in a circle. Eg. Swirling stone tied to the rope.

d. Rotatory motion - Motion of a body about its own axis. Eg. Rotating top.

e. Oscillatory motion - A body coming back to the same position after a fixed time interval. Eg. A pendulum.

f. Zigzag (irregular) - The motion of a body in different direction. Eg. People walking in a crowded street.

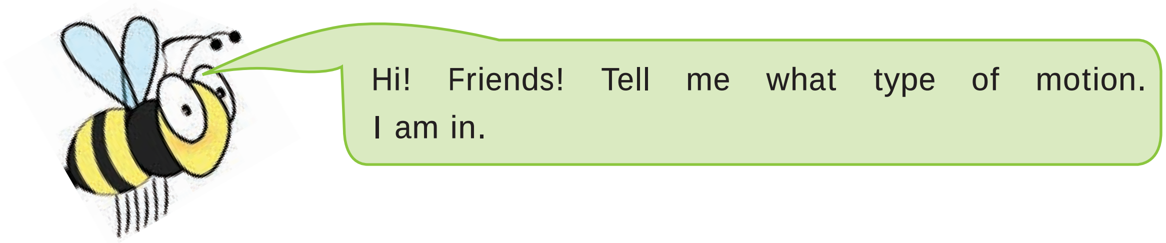


Oscillations at Greater Speed

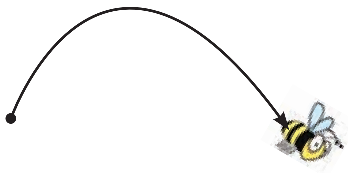
Ask your friend to hold the two ends of a stretched rubber band. Strike it in the middle. Do you see that it oscillates very fast? When the oscillation is very swift, it is called as vibration.

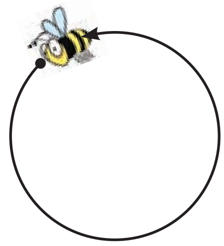
Fast oscillations are referred to as vibrations.

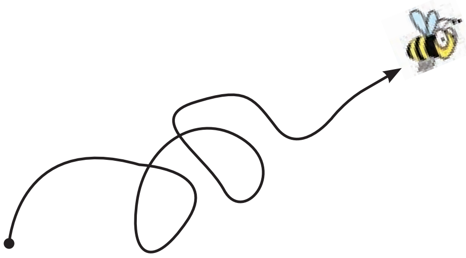
Activity 5

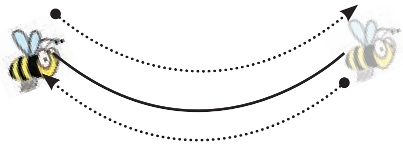


Linear Motion









Activity 6

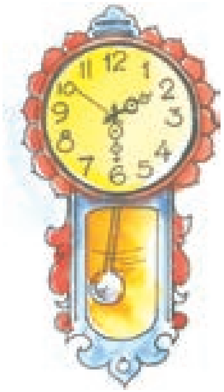
Classify the following according to the path it takes.

Linear, Curvilinear, Circular, Rotatory, Oscillatory, Zigzag (irregular)

• A sprinter running a 100 m race	
• A coconut falling from a tree	
• Striking a coin in a carom board game	
• Motion of flies and mosquitoes	
• Beating of heart	
• Children playing in a swing	
• The tip of hands of a clock	
• Flapping of elephant's ears	
• A stone thrown into the air at an angle	
• Movement of people in a bazaar	
• Athlete running around a track	
• Revolution of the moon around the earth	
• The movement of a ball kicked in a football match	
• Motion of a spinning top	
• Revolution of the earth around the sun	
• Swinging of a pendulum	
• Children skidding on a sliding board	
• Skidding down a playground slide	
• Wagging tail of a dog	
• Flapping of a flag in wind	
• A car driving around a curve	
• Woodcutter cutting with a saw	
• Motion of water wave	
• Motion of piston inside a syringe	
• Bouncing ball	
[Add five motions you observe to this list]	

Periodic and non-periodic motions

Take the case of the hour-hand of a clock. In one day it makes two rounds. Look at a bouncing ball. It bounces a certain number of times for a given time interval or period. Look at the water waves. In a given period that is in a time interval, a fixed number of waves hit the shore. Motion repeated in equal intervals of time is called as periodic motion.



Let us take the example of sapling swing in wind. This motion is not in uniform interval. Such motions are called non-periodic motion.

Revolution of the Moon around the Earth is periodic but not oscillatory. However, the children playing in a swing is both periodic and oscillatory.

All oscillatory motions are periodic, but not all periodic motion are oscillatory motion.

Fast Vs Slow?

Look at a tall tree. When the wind is gentle, its branches are dancing slowly; but if the gentle wind becomes strong, the branches shake violently, and if the speed increases further, the branch may even break and fall. That is the motion can be slow or fast. Can we say a motion is slow or fast without comparing anything?

Compared to walking, cycling is fast, but a bus is faster than a cycle. The aeroplane is much faster than a bus. So, slow or fast is a relative concept which depends upon the motions we are comparing. Then how do we say a body moves at a particular speed?

Speed.

Taxi Driver: I have travelled 160 km in two hours.

Bus Driver: I have travelled 200 km in four hours.

Truck Driver: I have travelled 300 km in five hours.

Can you say who travelled with highest speed?

Let us calculate how long they travelled in one hour?

- Distance travelled by the car in one hour = ____80____ km (160/2)
- Distance travelled by the bus in one hour = __________ km
- Distance travelled by the truck in one hour = __________ km

Have you found out? Say now.

Who is fast? __________,

Who is slow? __________

Have you noticed that saying who is fast or slow is easy when we calculate the distance they travelled in one hour? In other words, you divide the distance travelled by the time taken to get the speed.

> The distance travelled by an object in unit time is called speed of the object.
>
> If an object travelled a distance 'd' in time 't' then, its speed is given as:
>
> $$\text{Speed (s)} = \frac{\text{Distance travelled}}{\text{Time taken}} = \frac{d}{t}$$

Suppose a car travels 300 km in one hour. Then we say that the speed of the car is '300 kmph' (We read it as 'three hundred kilometres per hour').

If an object travelled 10 metre in 2 second, then its speed is given as:

Speed (s) = Distance travelled (d) / Time taken (t)

= 10 metre/ 2 second

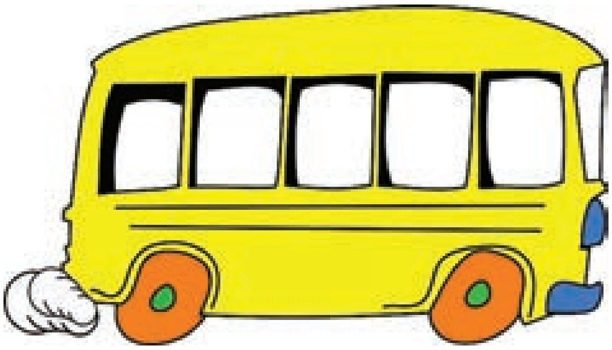
= 5 metre / second

A bus takes three hours to cover a distance of 180 kilometres. Then its speed is given as:

Speed (s) = Distance travelled (d) / Time taken (t)

= 180 kilometre/ 3 hour

= 60 kilometre / hour



Note that metre/second or kilometre/hour comes next to our answer for speed. What is it?

Observe the formula for speed. If we denote the distance in metre and time by second then the unit of speed is metre/second. If we denote the distance in kilometre and time in hour then the unit of speed is kilometre/hour. Sometimes we use units like centimetre/second.

In science we generally use SI units. In SI units the unit of distance is metre and the unit of time is second. So, the SI unit of speed is metre/second.

Let us calculate

1. A car travelled 150 metre in 10 second. What is its speed?
2. Priya rides her bicycle 40 km in two hours. What is her speed?

Our speed...

Let us play a small game. Go to the playground with your friends. Mark 100 metre distance for a race. Conduct a friendly running race and calculate the time taken by them to complete the distance. Now record the time in the table.

S. No	Name of the Student	Distance	Time taken (in seconds)	Speed = $\frac{\text{Distance travelled}}{\text{Time taken}}$	Speed (m/s)
1	Murugesan	100 m	12 S	100 M / 12 S	8.3 m/s
2		100 m			
3		100 m			
4		100 m			
5		100 m			

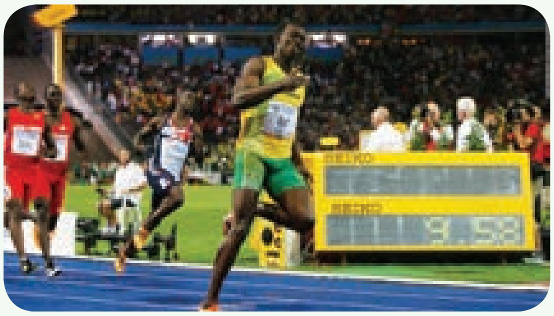
If you know the speed of an object and the time taken by it, then we can compute how much distance it had travelled.

We know that,

$$\text{Speed} = \frac{\text{Distance travelled}}{\text{Time taken}}$$

s = d/t or st = d

Therefore, the distance travelled = speed × time.



Usain Bolt crossed 100 metre in 9.58 seconds and made a world record. If you are able to run faster than him, then Olympic Gold Medal is waiting for you.

If a ship travelled at a speed of 50 kmph and it sailed for five hours, how much distance it has travelled?

Distance = s × t

= 50 kmph × 5 h = 250 km

If we know the speed and distance travelled we can compute the time taken.

s = d/t or t = d/s

Time taken = Distance travelled / Speed

Suppose a bus travels at a speed of 50 kmph and has to cover a distance of 300 km, how much time will it take?

t = d/s = 300 km/50 kmph = 6 h.

Compute the following Numerical Problems.

1. If you travel 10 kilometres in 2 hours, your speed is ______ km per hour.
2. If you travel 15 kilometres in 1/2 hour, you would travel ______ km in one hour, and your speed is ______ km per hour.
3. If you run fast at 20 kilometres per hour for 2 hours, you will cover ______ km

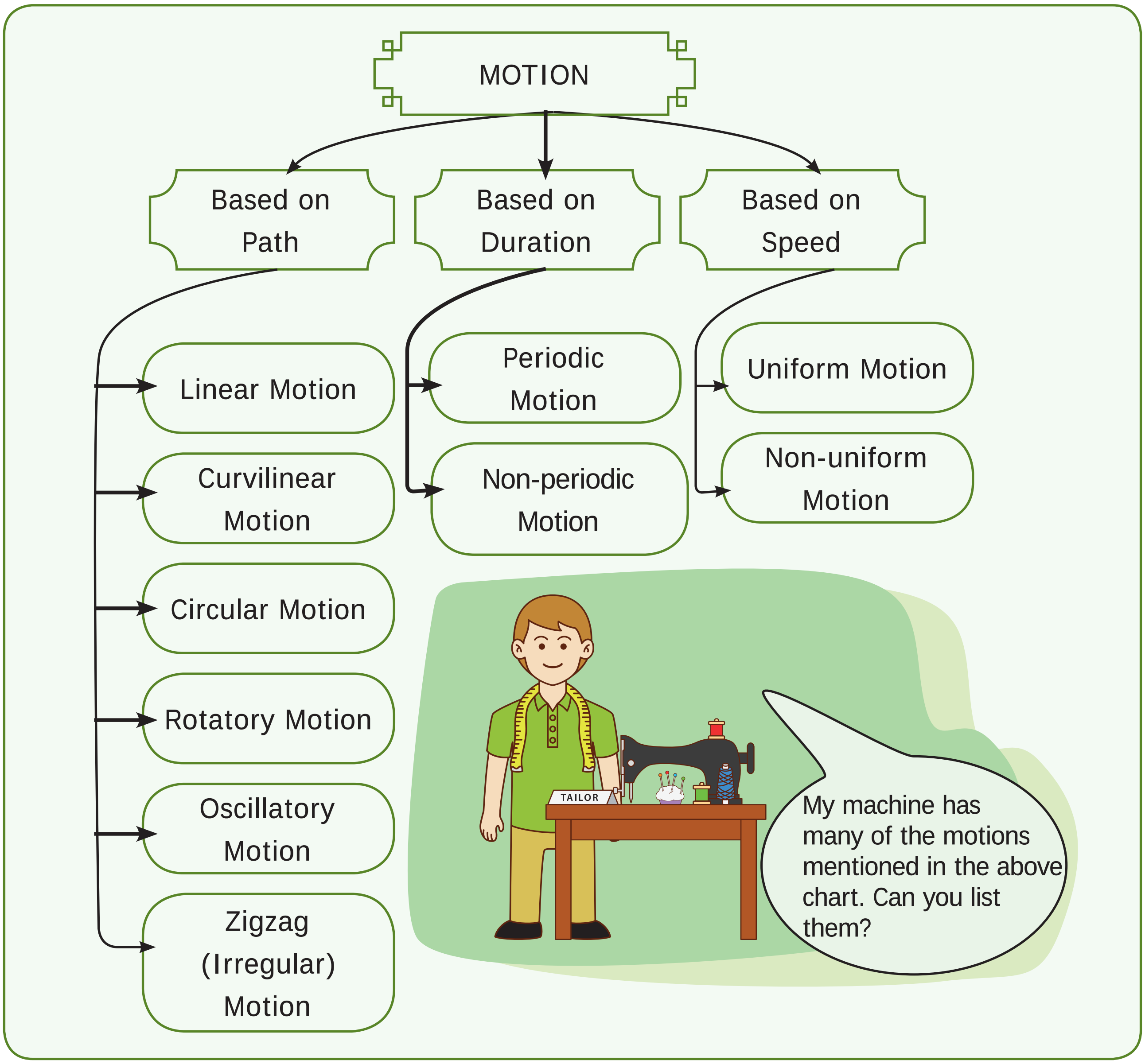
FACT FILE

A Cheetah is the fastest land animal running at a speed of 112 km/h.

Uniform and Non-uniform motion

Suppose a train leaves Thiruchirapalli and arrives at Madurai. Will the train travel in an uniform speed? First, the train will be stationary. When the train leaves the station, the motion will be slow. After it moved some distance it will gather speed. After that it may slow down while crossing bridges and stop at intermediate stations for passengers. Finally, as the train approaches Madurai, again it will slow and finally will come to a halt. It means that the speed is not the same all through the journey. That is, the speed is non-uniform. This motion is said to be non-uniform motion.

However, in between the journey, there may be a stretch where in the train might go at a constant speed. During that interval the train will be moving at uniform speed. That is, its motion is uniform.



Many motions we see in our day to day life are non-uniform. We will learn more about uniform and non-uniform motion in higher classes.

If an object covers uniform distances in uniform intervals then the motion of the object is called uniform motion. Otherwise the motion is called non-uniform motion.

In a nutshell, we can classify the motion in terms of a) path b) if it is periodic or not c) if the speed is uniform or not. However, in real life, the motions are combinations of many types of motion.

Multiple Motion

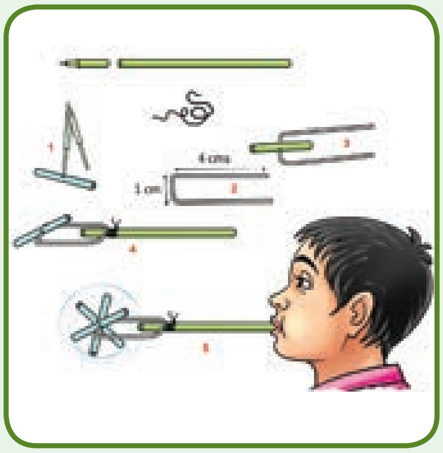
Look at the bicycle in the picture. What type of motion does the wheel perform? What type of motion does the cycle in total perform?

The tyres rotate and make a rotatory motion, but the cycle as such moves forward in a linear path.

Activity 7

Simple Spinner

Let us enjoy by making a simple spinner. Make it by the following instruction.



Cut a 2cm long piece from an old ball-pen refill and make a hole in its center with a divider point (Fig. 1).

Take a thin wire of length 9cm and fold it into a U-shape (Fig. 2).

Weave the refill spinner in the U-shaped wire (Fig. 3).

Wrap the two ends of the wire on the plastic refill, leaving enough clearance for the spinner to rotate (Fig. 4).

On blowing through the refill, the spinner rotates (Fig. 5).

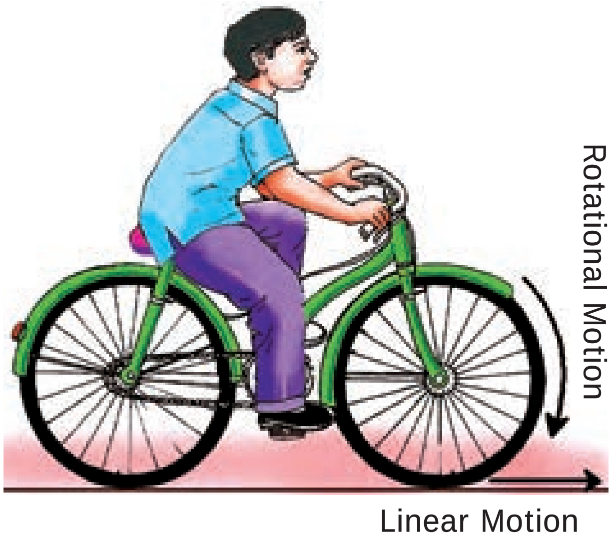
For obtaining maximum speed adjust the wires so that air is directed towards the ends of the spinner.

Have you enjoyed with simple spinner? Do you observe the motions in the toy? Can you answer the following questions?

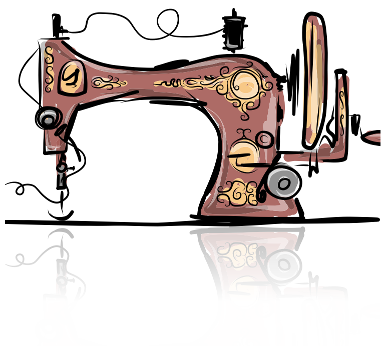
1. Motion of the air in tube is _____________ motion.
2. Motion of the refill stick is _____________ motion.
3. The toy converts _____________ motion into _____________ motion.

Think

In a simple spinner linear motion is converted into rotatory motion. Can you make a toy which converts rotatory motion into linear motion?



Multiple motion in a sewing machine



- Motion of the needle

  ____

- Motion of the wheel

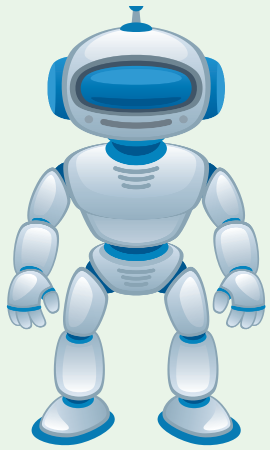
  ____

- Motion of footrest

  ____

2.3 Science Today - Robot

Robots are automatic machines. Some robots can perform mechanical and repetitive jobs faster and more accurately than people. Robots can also handle dangerous materials and explore distant planets.



A bipedal humanoid robot.

The term 'robot' comes from a czech word, ‘robota’ meaning ‘forced labour’. Robotics is the science and study of robots.

What can Robots do?

Robots can sense and respond to their surroundings. They can handle delicate objects or apply great force. For example, they can perform eye operations guided by a human surgeon, or assemble a car. With **artificial intelligence**, robots will also be able to make decisions for themselves.

How do Robots sense?

Electronic sensors function as robot’s eyes and ears. Twin video cameras give the robot a 3-D view of the world. Microphones detect sounds. Pressure

The quadrupedal military robot

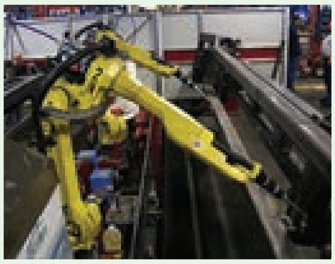
sensors give the robot a sense of touch, to judge how to grip an egg or heavy luggage. Built-in computers send and receive information with radio waves.

Artificial Intelligence

Artificial intelligence attempts to create computer programs that think like human brains. Current research has not achieved this, but some computers can be programmed to recognize faces in a crowd.

Can Robots think?

Robots can think. They can play complex games, such as chess, better than human beings. But will a robot ever know that it is thinking? Humans are conscious - we know we are thinking. But we do not know how consciousness works. We do not know if Robots can ever be conscious.



Articulated welding robots (industrial)

Nanorobotics

Nanobots are robots scaled down to microscopic size in order to put them into very small spaces to perform a function. Future nanobots could be placed in the blood stream to perform surgical procedures that are too delicate or too difficult for standard surgery. Imagine if a nanobot could target cancer cells and destroy them without touching healthy cells nearby.

Future of Nanorobotics

Points to Remember

- Motion and rest are relative.
- All things that are at rest may seem to be in motion from a different point of view, and all motion may seem to be at rest from a different perspective.
- Application of forces is implemented by a push or pull. Forces can be applied by animate as well as inanimate agency.
- Application of forces result in motion of an object at rest, increase or decrease its speed, change its direction, and distortion of the shape.
- Some forces act only when they are in contact. There are some forces which can even have effect at a distance.
- Speed = Distance travelled / Time taken ($s = d/t$)
- The motion can be classified according to the path (periodic or non-periodic) or according to speed (uniform or non-uniform).
- Unit of speed is m/s.

Evaluation

YDQX5

I. Choose the correct answer.

1. Unit of speed is

   a. m b. s c. kg d. m/s

2. Which among the following is an oscillatory motion?

   a. Rotation of the earth about its axis.

   b. Revolution of the moon about the earth.

   c. To and fro movement of a vibrating string.

   d. All of these.

3. The correct relation among the following is

   a. Speed = Distance × Time

   b. Speed = Distance / Time

   c. Speed = Time / Distance

   d. Speed = 1 / (Distance × Time)

4. Gita travels with her father in a bike to her uncle's house which is 40 km away from her home. She takes 40 minutes to reach there.

   Statement 1 : She travels at a speed of 1 km / minute.

   Statement 2 : She travels at a speed of 1 km/hour.

   a. Statement 1 alone is correct.

   b. Statement 2 alone is correct.

   c. Both statements are correct.

   d. Neither statement 1 nor statement 2 is correct.

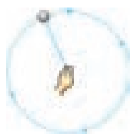
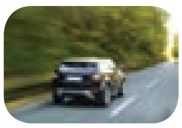
II. Fill in the blanks.

1. A bike moving on a straight road is an example for ______________ motion.
2. Gravitational force is a ______ force.
3. Motion of a potter's wheel is an example for __________ motion.
4. When an object covers equal distances in equal interval of time, it is said to be in ______ motion.

III. State True or False. If false, correct the statement.

1. To and fro motion is called oscillatory motion.
2. Vibratory motion and rotatory motion are periodic motions.
3. Vehicles moving with varying speeds are said to be in uniform motion.
4. Robots will replace human in future.

IV. Match the following.

1.		a. Circular motion
2.		b. Oscillatory motion
3.		c. Linear motion
4.		d. Rotatory motion
5.		e. Linear and rotatory motion

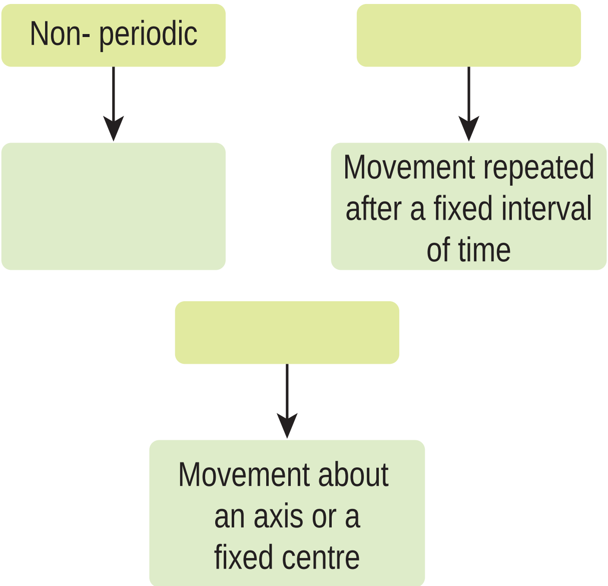
V. Given below is the distance-travelled by an elephant across a forest with uniform speed. Complete the data of the table given below with the idea of uniform speed.

Distance (m)	0	4		12		20
Time (s)	0	2	4		8	10

VI. Complete the analogy.

1. Kicking a ball : Contact force :: Falling of leaf : _______?
2. Distance : metre :: Speed : ______ ?
3. Circulatory motion : A spinning top :: Oscillatory motion : ___________?

VII. Complete the web chart.



VIII. Answer in a word or two.

1. The force which acts on an object without physical contact. ___________
2. A change in the position of an object with time. ____________________
3. The motion which repeats itself after a fixed interval of time. ____________
4. The motion of an object which covers equal distances in equal intervals of time. ______________________________
5. A machine capable of carrying out a complex series of actions automatically. ______________________

IX. Answer briefly.

1. Define force.
2. Name different types of motion based on the path.
3. If you are sitting in a moving car, will you be at rest or motion with respect your friend sitting next to you?
4. Rotation of the earth is a periodic motion. Justify.
5. Differentiate between rotational and curvilinear motion

X. Answer in detail.

1. What is motion? Classify different types of motion with examples.

XI. Problems.

1. A vehicle covers a distance of 400km in 5 hour. Calculate its speed.

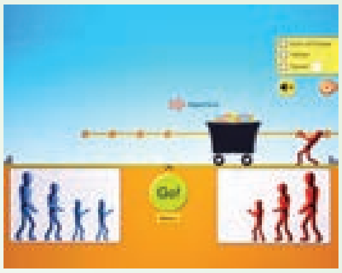
XII. Give examples.

Linear motion	
Curvilinear motion	
Self rotatory motion	Motion of the wheel in a cart
Circular motion	
Oscillatory motion	
Irregular motion	

ICT CORNER

Force and motion

Play with force and motion.

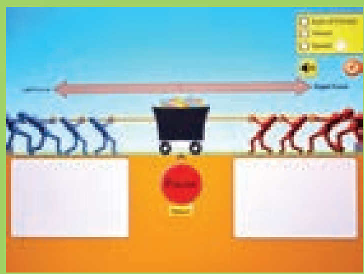


Steps:

- Lets learn force and motion on **PhET** in Google browser. Download and install.
- Drag any one side and place him in the knot portion of the rope. Now click **go**.
- If placed on the right side then the load will move in that direction. The place of the man and the number of man can be changed. The direction of force and the unit of force will display on the screen.
- If we place equal number of men on both the sides the load will not move.
- By changing the number of men the strength of force can be changed.

Step1

Step2



Step3

URL:

https://phet.colorado.edu/en/simulation/forces-and-motion-basics

O9Y2R

*Pictures are indicative only