PHYSICS

Standard IX

Part-2

Government of Kerala
Department of Education

State Council of Educational Research and Training (SCERT) Kerala
2019

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The National Anthem

Jana-gana-mana adhinayaka jaya he
Bharatha-bhagya-vidhata,
Punjab-Sindh-Gujarat-Maratha
Dravida-Utkala-Banga
Vindhya-Himachala-Yamuna-Ganga
Uchchala-Jaladhi-taranga
Tava subha name jage,
Tava subha asisa mage,
Gahe tava jaya gatha.
Jana-gana-mangala-dayaka jaya he
Bharatha-bhagya-vidhata,
Jaya he, jaya he, jaya he,
Jaya jaya jaya jaya he!

Pledge

India is my country. All Indians are my brothers and sisters.

I love my country, and I am proud of its rich and varied heritage. I shall always strive to be worthy of it.

I shall give my parents, teachers and all elders respect, and treat everyone with courtesy.

To my country and my people, I pledge my devotion. In their well-being and prosperity alone lies my happiness.

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Dear students,

You were provided with opportunities to observe your surroundings and engage in simple experiments and investigative activities in earlier classes. The classroom experience, undoubtedly, might have helped you to record the information systematically and assimilate ideas through discussion and analysis. While understanding the scientific approach, there should also be the attitude to take forward the skills to apply them in day-to-day life. Moreover, an eco-friendly perspective must be adopted too. All these, through direct experiences, enquiry and understanding preferably. This textbook presents ideas in accordance with this.

'Samagra', the education portal and technology enabled QR Code printed textbooks would definitely make your learning activity in classrooms easy and joyful. The National Skills Qualifications Framework, the current relevance of Disaster Management and the possibilities of ICT have also been considered while modifying the textbook.

Go ahead, thinking, asking questions, approaching ideas critically and quizzing with teachers and friends.

Make learning a joyful experience.

Regards,

Dr. J. Prasad
Director, SCERT

CONSTITUTION OF INDIA

Part IV A

FUNDAMENTAL DUTIES OF CITIZENS

ARTICLE 51 A

Fundamental Duties- It shall be the duty of every citizen of India:

(a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;

(b) to cherish and follow the noble ideals which inspired our national struggle for freedom;

(c) to uphold and protect the sovereignty, unity and integrity of India;

(d) to defend the country and render national service when called upon to do so;

(e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;

(f) to value and preserve the rich heritage of our composite culture;

(g) to protect and improve the natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures;

(h) to develop the scientific temper, humanism and the spirit of inquiry and reform;

(i) to safeguard public property and to abjure violence;

(j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievements;

(k) who is a parent or guardian to provide opportunities for education to his child or, as the case may be, ward between age of six and fourteen years.

Contents

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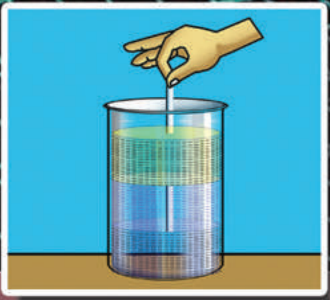



Certain icons are used in this textbook for convenience

For further reading (Evaluation not required)

ICT possibilities for making concepts clear

Let us assess

Extended activities

NSQF

5

Work, Energy and Power

Listen to the conversation going on in a house:

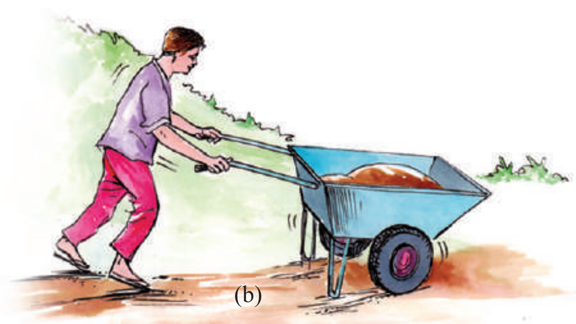
Mother : Inspite of installing the new pump, there is still delay while filling the tank.

Father : We should have bought a 1 HP pump instead of a ½ HP pump.

Son : Daddy, what do ½ HP and 1 HP mean?

Can you give an answer to this?

(a)



(b)

(c)

Fig.5.1

Observe Fig. 5.1. Try to write down the activities shown in them.

- A man pushes a trolley.
-

Write down more activities which are familiar to you.

- A man carrying a load.
-

You have understood that a force is to be applied on a body to do an activity. Find out the source of applied force for each activity and note them down in the table.

Activity	Source of applied force
• Falling of a mango	• The Earth
• A trolley being pushed	• The person who is pushing
•	•

Table 5.1

Objects undergo displacement only when force is applied on them.

- Does the displacement take place always in the direction of the force applied? Is there any situation in which no displacement takes place even when a force is applied? Write down in the table.

Displacement takes place in the direction of force applied	No displacement for the body in the direction of force applied
• A cricket ball when hit by a bat •	• A wall is pushed

Table 5.2

Though forces are applied on the bodies in all the above situations, displacement does not take place in all. Work is said to be done in situations where displacement takes place in the direction of the force.

Work

Work is said to be done only when a body undergoes displacement in the direction of the applied force.

Fig 5.2

Observe Fig 5.2 and write down the situations where work is said to be done.

-

Consider the cases given below which are connected with work.

- A boy pushed an object of mass 30 kg horizontally across a floor through 50 m. Another boy pushed an object of mass 50 kg across the same floor through 50 m. Both of them gave the same speed for moving the objects.

- Who applied the greater force here?
- In which case was the work greater?

Based on this, write down a factor influencing work.

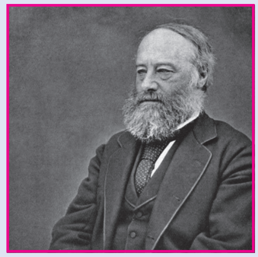
- A child pushed an object of mass 30 kg across a horizontal floor through 20 m. Another child pushed the same object through 30 m, on the same floor with the same speed. Both of them gave the same speed for moving the objects.

- Who pushed the object to a greater distance here?
- What about the force applied by them?
- In this case who did greater work?
- Which is the factor influencing work here?

What are the factors to be considered to determine the work done by the force? Discuss.

- force
-

James Prescott Joule (1818-1889)



Joule was a British scientist who did research on the relation between mechanical energy, electrical energy and heat energy. Joules' Law, Law of Conservation of Energy, etc., were enunciated by him. The unit of work and energy has been named as joule after him.

Haven't you understood that the force applied on a body and the displacement of the body, are to be considered to determine the work done on it?

If a force of F newton is applied continuously on a body and the body undergoes a displacement of s metre in the direction of the force, then the work done by the applied force is $W = F\,s$

- A force of 10 N is applied continuously on a body. If the body undergoes a displacement of 2 m, find out the magnitude of the work done by the force.

$$F = 10\ \text{N}$$
$$s = 2\ \text{m}$$
$$W = Fs$$
$$= 10 \times 2$$
$$= 20\ \text{Nm}$$

We got the unit of work as Nm here. This is called joule (J).

1000 J = 1 kJ (1 kilo joule)

Look at Figure 5.3

- A body of mass m kg is placed on a table. What are the forces experienced by this body?

\- -

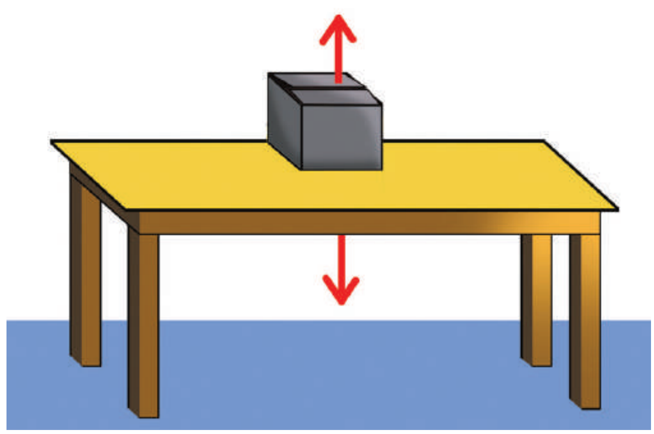


Fig 5.3

- In which directions do these forces act?
- If this body is to be raised through h metre, in which direction has the force to be applied on the body?

You know that the magnitude of the force to be applied against the gravitational pull is $F = mg$.

- If it is raised through h metre, what would be the displacement (s)?

The work done by the force applied against gravitational force,

$$W = Fs$$
$$= mgh$$

When a body is raised to a height h, the work done against the gravitational force would be $W = mgh$.

- A book of mass 100 g is raised to the top of a table of height 1m. Find the magnitude of the work done by the applied force against the gravitational force ($g = 10\ m/s^2$)

$$m = 100\ g = 0.1\ kg$$
$$g = 10\ m/s^2$$
$$h = 1\ m$$
$$W = mgh$$
$$= 0.1 \times 10 \times 1 = 1\ J$$

7DET3V

1 J is the amount of work done to raise a body of mass 100 g through a height of 1m.

- If a force of 50 N is applied continuously on a body and if it undergoes a displacement of 2 m in the direction of the force, calculate the amount of work done.
- (a) If a force of 200 N is applied continuously on a table of mass 50 kg, it undergoes a displacement of 0.5 m in the direction of force. Calculate the amount of work done.

  (b) If the same table is raised through 3 m, what would be the work done against the gravitational force?

Observe Fig.5.4

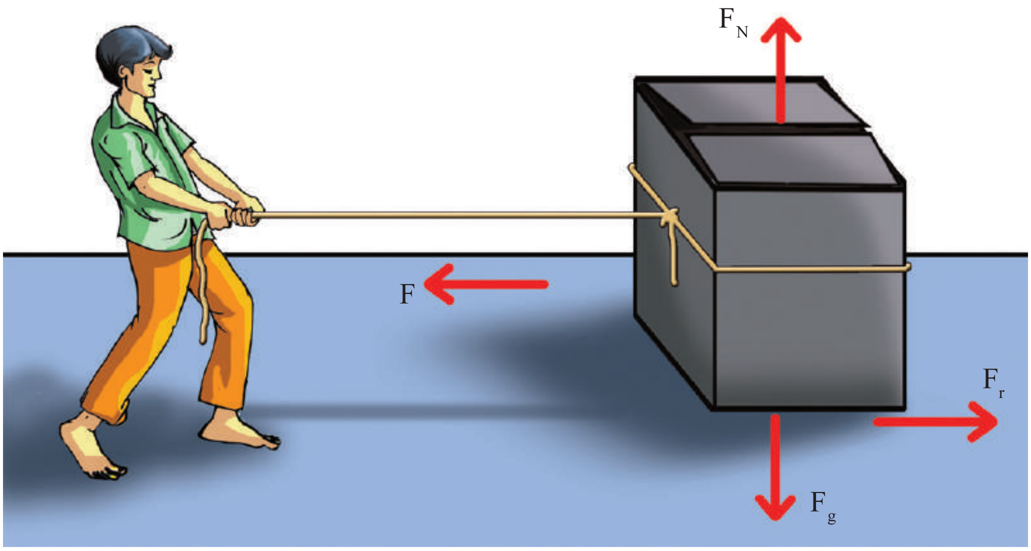


Fig 5.4

Let a body of mass m be pulled by a force F. If the body undergoes a displacement s in the direction of the force, then

7DNP5I

- The work done by the force F, W_F = ...
  Here the displacement produced is in the direction of the force itself. Write down whether this work is negative or positive.
- What will be the work done by the force of friction? Won't it be $W_r = F_r s$?
- Since the displacement is opposite to the frictional force, is the work done by the frictional force positive or negative?
- In which direction does the force of gravity act on the body?

  -
- Is there a displacement for the body in the direction of the gravitational force?

  -

  As the displacement of the body is zero, the work done by the gravitational force (F_g) is $W_g = 0$.
- What about the work done by the reaction force F_N ?

  -

When a body on a floor is pulled and if it is displaced in the direction of the applied force, the work done by the applied force will be positive and the work done by the frictional force exerted by the floor will be negative.

7DXK76

Energy

- What is the work to be done to raise a body of mass m kg through h metre?

Energy is what we have utilised to do work.

Energy is the capacity to do work.

Amount of energy is the amount of work itself. Therefore, the unit of energy is joule (J) .

In daily life we make use of different forms of energy for various activities.

List the forms of energy familiar to you.

- Mechanical energy
- Heat energy
- Electrical energy
-

Let's try to understand more things about mechanical energy. There are two types of mechanical energy.

1. Kinetic energy
2. Potential energy

Kinetic Energy

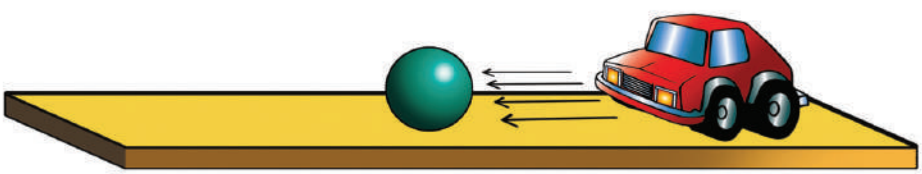


Fig 5.5

Arrange a toy car and a plastic ball as shown in Fig. 5.5.

Pull the toy car backwards a little and allow it to hit the plastic ball.

- What happened to the ball when the moving car hit it?

- How did the car get the energy to move the ball forward?

7E7G8T

Haven't you understood that the car got the ability to do work because of its motion? This implies that moving bodies possess kinetic energy.

The energy possessed by a body by virtue of its motion is the kinetic energy.

7EGCAG

Let's do another activity. Allow a powder tin to slide down over a polished, inclined plane as shown in the figure. Let it hit a toy car. Try to measure the displacement of the toy car. Repeat the experiment by increasing the height of the inclined plane and then by filling the tin with sand.

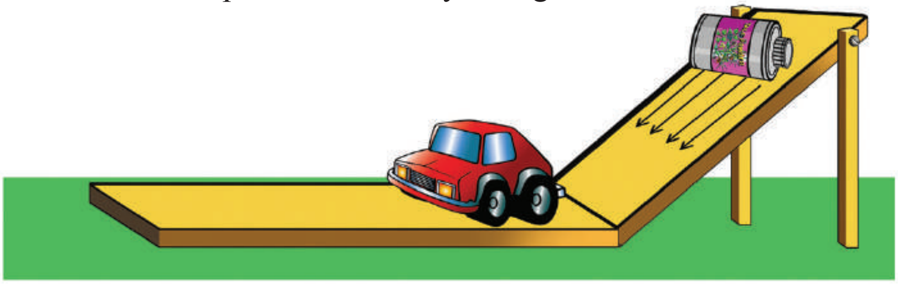


Fig 5.6

Let F be the force exerted on the toy car by the powder tin and s its displacement. If the velocity of the car is changed to v on being hit by the tin,

the work done by the force exerted by the powder tin is

$$W = Fs$$

Since F = ma, by Newton's Second Law of Motion, the work done on the toy car W = mas.

As per the second equation of motion, let's see what is 'as' in this expression

$$v^2 = u^2 + 2as$$

$$= 0+2as. \quad \text{(Initial velocity of the car = 0)}$$

$$= 2as$$

$$as = \frac{v^2}{2}$$

So in W = mas, if we replace 'as' with $\frac{v^2}{2}$

$$W = \frac{mv^2}{2} = \frac{1}{2}mv^2$$

$$W = \frac{1}{2}mv^2$$

Kinetic energy and momentum

Kinetic energy and momentum are inter related

Momentum $P = mv$

So $v = \frac{p}{m}$

Kinetic energy $K = \frac{1}{2}mv^2$

or $K = \frac{1}{2}m\left(\frac{p}{m}\right)^2$

$= \frac{1}{2} \times \frac{p^2}{m} = \frac{p^2}{2m}$

This work is the magnitude of kinetic energy received by the car.

That is, kinetic energy, $K = \frac{1}{2} mv^2$

> When a body of mass m moves with a velocity v, its kinetic energy will be $K = \frac{1}{2} mv^2$.

- A man having a mass of 70 kg is riding a scooter of mass 80 kg. What will be the total kinetic energy if the velocity of the scooter is 10 m/s?

$$m = 70 \text{ kg} + 80 \text{ kg} = 150 \text{ kg}$$
$$v = 10 \text{ m/s}$$
$$K = \frac{1}{2} mv^2 = \frac{1}{2} \times 150 \times 10^2$$
$$= 7500 \text{ J} = 7.5 \text{ kJ}$$

- A car of mass 1500 kg is moving with a velocity of 20 m/s. What will be its kinetic energy?
- A boy of mass 50 kg is riding a bicycle with a speed 2 m/s. The bicycle has a mass of 10 kg. Calculate the total kinetic energy.

When the bodies are at rest, don't they possess energy?

Work Energy Principle

An object of mass 'm' moves with a velocity 'u'. When a force is applied in the direction of motion its acceleration becomes 'a'. If 's' is the displacement of the object in the direction of force,

what is the work done by the force?

$W = F \times s$

According to Newton's Second Law of Motion, $F = ma$

If so,we can have $W = ma \times s$.

According to equation of motion,

$$v^2 = u^2 + 2as$$
$$v^2 - u^2 = 2as.$$
$$\text{ie,} \quad a = \frac{v^2 - u^2}{2s}$$
$$W = m\left(\frac{v^2 - u^2}{2s}\right) \times s$$

Intial Velocity	=	u
Final Velocity	=	v
Acceleration	=	a
Displacement	=	s
v^2	=	$u^2 + 2as$

$$W = m\left(\frac{v^2 - u^2}{2}\right)$$

$$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

Workdone = Change in kinetic energy. This is Work-Energy principle.

- A body of mass 2 kg is kept at rest. If a force of 5 N is applied on it for 10 s,what will be the work done?

$$m = 2\text{ kg}$$
$$F = 5\text{ N}$$
$$t = 10\text{ s}$$
$$u = 0\text{ m/s}$$
$$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$
$$F = ma$$
$$a = \frac{F}{m} = \frac{5}{2} = 2.5\text{ m/s}^2$$

on substituting these values in the equation, $v = u + at$

$$v = 0 + 2.5 \times 10 = 25\text{ m/s}$$
$$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$
$$= \frac{1}{2} \times 2 \times 25 \times 25 - 0$$
$$= \frac{1}{2} \times 2 \times 625$$
$$= 625\text{ J}$$

Potential Energy

Take a look at Fig 5.7. Isn't work to be done to lift the bodies?

- Against which force is work done here?

- -

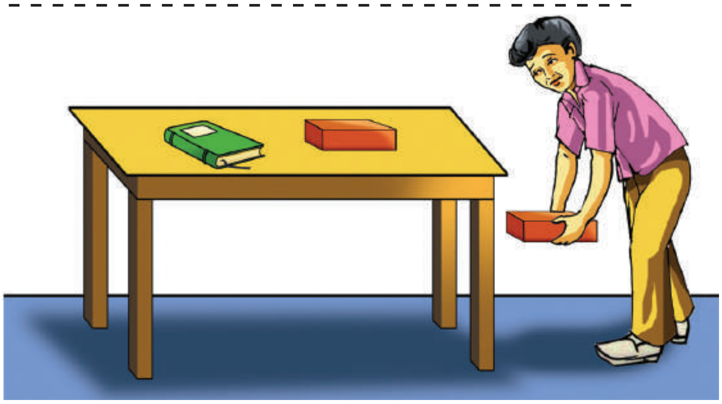


Fig 5.7

Note the amount of work done to raise a body of mass m kg to different heights in Fig. 5.8.

Position and potential energy

The potential energy of a body at a specific height depends on the position at which the potential is considered zero. The ground is considered as the position for zero potential, unless and otherwise other methods are mentioned.

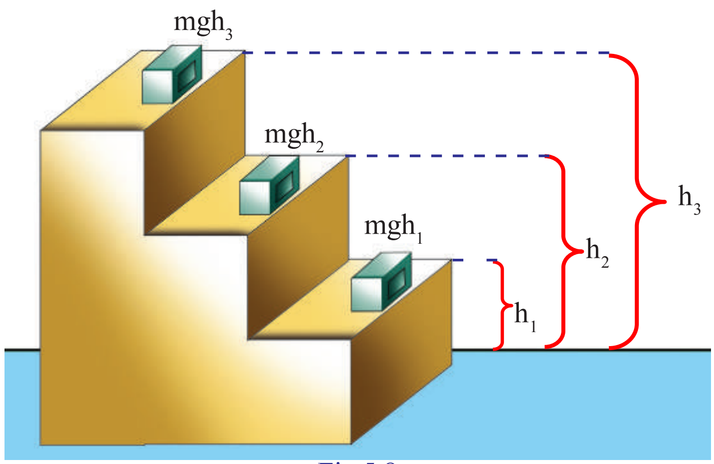


Fig 5.8

- At which height from the floor is maximum work done on the body ?

Isn't the energy received by the body equal to the work done on it?

- If so, in which position does the body get the maximum energy?

When height from the floor increases/decreases.

The work done against the force of gravity to raise a body is preserved as excess energy in the body. So the energy increases as the height increases.

The energy possessed by a body by virtue of its position is the potential energy.

i.e., potential energy $U = mgh$

7EQ8C4

Identify more situations in which potential energy is acquired by virtue of position and write them down.

- Coconut in a coconut tree
-

When the height varies, the potential energy also varies. Try to write down situations in which potential energy varies.

- A coconut falls down from a coconut tree.
- Water is pumped to an overhead tank at a height.

What is the potential energy of a book of mass 200 g kept on a table of height 1m?

$m = 200\text{ g} = 0.2\text{ kg}$

$g = 10\text{ m/s}^2$

$h = 1\text{m}$

$U = mgh$

$= 0.2 \times 10 \times 1 = 2\text{ J}$

- An object of mass 40 kg is at a height 5 m from the ground.
  a) What is its potential energy?
  b) While falling, if it travels half the distance downward what will be its kinetic energy?

  a) $U = mgh = 40 \times 10 \times 5$

  $= 2000\text{ J}$

  b) When it travels half distance downward (height 2.5 m) the potential energy will become half (1000 J).

According to the Law of Conservation of Energy, the total energy will be a constant. So kinetic energy = 1000 J

- Calculate the potential energy of a body of mass 1 kg at a height of 6 m from the ground.
- A bird of mass 0.5 kg is flying with a constant speed maintaining the same height of 5 m. In this state, if its kinetic energy and potential energy are equal,
  a) What is the potential energy of the bird?
  b) What is the velocity of the bird?

Do bodies get potential energy due to their position alone? Let's see. Take a look at Fig.5.9.

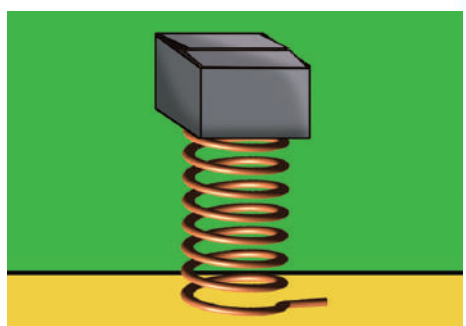


Fig 5.9

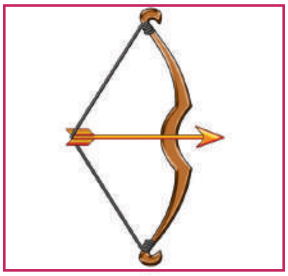
When the spring is compressed or elongated, it gets the ability to do work on the wooden block.

Aren't we doing work on the spring when a spring is compressed or elongated?

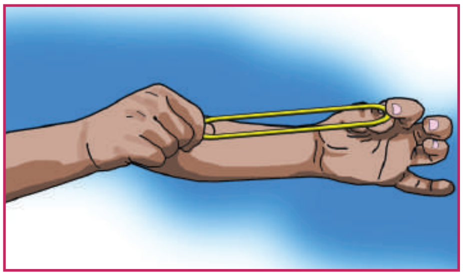
The work we have done on the spring to change its shape would remain in it as its energy. This energy is called the potential energy due to strain.

Write down other examples for potential energy due to strain.

- A stretched bow
- A rubber band in stretched posion
-



(a)



(b)

Fig 5.10

Are there any situations where one form of energy is transformed into other forms? Is there destruction of energy also in such situations? Let's see.

Law of Conservation of Energy

Energy transformations in certain equipment when they are being operated are given in the table.

Equipment	Energy transformation
Electric generator	Mechanical energy $\rightarrow$ electrical energy
Fan	Electrical energy $\rightarrow$ Mechanical energy
Electric iron box	Electrical energy $\rightarrow$ Heat energy
Electric bulb	Electrical energy $\rightarrow$ Light energy

Table 5.3

What happens when one form of energy is thus transformed into another form? Observe Fig. 5.11.

- Which form of energy does the flower pot have when it is on the sunshade of a building?

  -

- While the flower pot is falling down, which forms of energy does it possess?

  -

- Does its potential energy increase/ decrease when the pot falls down?

  -

- Will the kinetic energy increase/ decrease at that time?

  -

- What is the energy transformation that takes place just before the flower pot touches the ground?

  -

Fig 5.11

- Let the mass of the flower pot be 15 kg and the height of the sunshade 4 m. When the flower pot is on the sunshade, what is its potential energy? ($g = 10\ m/s^2$).

  $U = mgh = \ldots\ldots\ldots\ldots\ldots\ldots$

- When it is on the sunshade, what is its kinetic energy?

- If so, what is its total energy?

- While falling down, when the flower pot is at a height of 2 m from the ground, what will be its kinetic energy?

$$K = \frac{1}{2} mv^2$$

$$u = 0,\ g = 10\ m/s^2,\ \ s = 4 - 2 = 2\ m$$

$$v^2 = u^2 + 2\ as$$

$$= 0 + 2 \times 10 \times 2$$

$$= 40$$

$$K = \frac{1}{2} \times 15 \times 40$$

$$= \ldots\ldots\ldots\ J$$

7F8ZFE

- What will be the potential energy when it is at a height of 2 m from the ground?
- What is the total energy now?
- What will be the kinetic energy of the flower pot just before it touches the ground?

$$K = \frac{1}{2} mv^2$$

$$v^2 = u^2 + 2as$$

$$= 0 + 2 \times 10 \times 4 = 80$$

$$K = \frac{1}{2} \times 15 \times 80 = 600\ J$$

- The potential energy $U = mgh = 15 \times 10 \times 0 = 0$. What will be the total energy?
- To sum up the amount of energy at each situation:

  1. When on the sunshade = ...
  2. When at a height of 2 m from the ground = ...
  3. Just before hitting the ground = ...

From this what inference do you arrive at?

Energy can neither be created nor destroyed. Energy can only be transformed from one form to another. This is the Law of Conservation of Energy.

Sun is a major source for different forms of energy that we make use of in our daily life.What are the different ways in which solar energy is utilised? Based on the figure, prepare a note and write it down in your science diary.

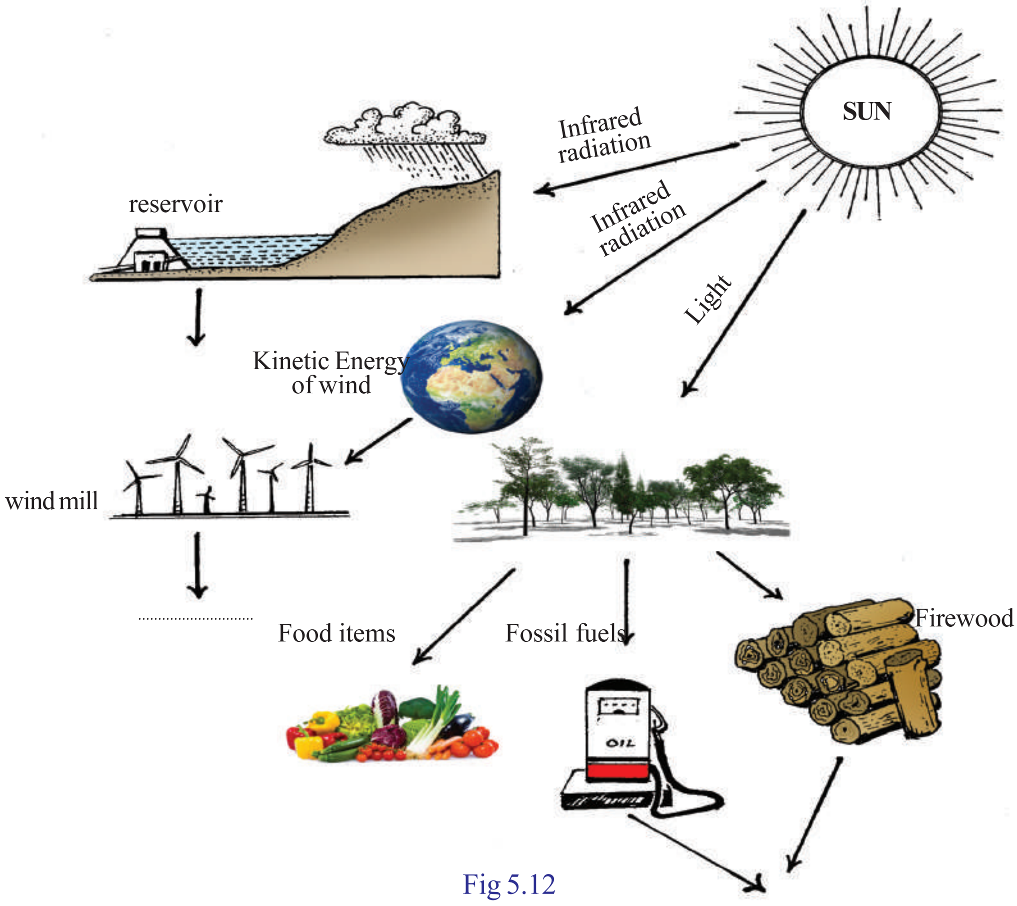


Fig 5.12

Power

Given below is the information regarding the working of pumps in three neighbouring houses. Complete the table (g = 10 m/s^2).

Pump	Water that can be contained		Hegiht from the water level in well (h)	Time taken for the tank to be filled	Work W = mgh
	Volume	Mass m			
A	1000 L	1000 kg	15 m	100 s	150000 J
B	1000 L	1000 kg	15 m	200 s	....
C	1000 L	1000 kg	15 m	400 s	....

Table 5.4

- Is the amount of work done by the pump to fill water in the three tanks same?

Now let's find the amount of work done per second by each pump.

Pump	Work done (J)	Time (s)	Work done by second J/s
A			
B			
C			

Table 5.5

You have got the amount of work done per second by each pump. That will be the power of each pump.

Work done per unit time or rate of doing work is power.

$$\textit{Power} = \frac{\text{work}}{\text{time}}, \quad P = \frac{W}{t}$$

$$\textit{Unit of power} = \frac{\text{Unit of work}}{\text{Unit of time}} = \text{J/s}$$

joule per second is called watt (W).

1 kW = 1000 W

1 HP = 746 W

You may have now understood the meaning of ½ HP and 1 HP.

- If a man of mass 70 kg climbs up a mountain of height 30 m in 5 minute, what is his power?
- If a man of mass 50 kg takes 60 s to climb up 20 steps, each of 15 cm height, calculate his power.

You have understood several facts regarding work, energy and power. Electricity is a form of energy used extensively in daily life. You will learn more, in higher classes, about how the amount of electrical energy is calculated.

Horse Power

In the early days horses were used for pulling carts and other purposes. A horse power or 1 HP is the power of a horse. This is estimated as about 746 W.

Let us assess

1. A boy is trying to push the concrete pillar of a building using a force of 300 N. Calculate the amount of work done by the boy.
2. From what you have learnt of potential energy and kinetic energy, write down the form of energy possessed by the following:
   (a) water in a dam
   (b) stretched rubber band
   (c) mango falling down from a tree
3. Calculate the kinetic energy of an athlete of mass 60 kg running with a velocity 10 m/s.
4. A stone of mass 2 kg is thrown upwards from the ground with a velocity of 3 m/s. Calculate its potential energy when it reaches maximum height.
5. The heart of a healthy person beats 72 times per minute and each beat consumes about 1 J of energy. Calculate the power of the heart.
6. Which among the following is a vector quantity?
   - work
   - momentum
   - power
   - energy
7. If the velocity of an object is doubled, its kinetic energy becomes
   - 2 times
   - ½
   - 4 times
   - ¼
8. An object of mass 1 kg is falling from a height 10 m. What will be the work done while falling?
   - 10 J
   - 1 J
   - 100 J
   - 1000 J
9. Which one among the following is correct?

$$W = \frac{F}{s}, \quad W = \frac{s}{F}, \quad W = P \times t, \quad W = \frac{P}{t}$$

10. A roller weighing 1 tonne is being dragged along a road. What is the work done against gravity? Why?
11. Is it possible for an object to possess energy without momentum? Give one example for such a situation.

12. Say whether the following are positive work or negative work.

    1) The work done by a person drawing water from a well using a rope without a pulley.

    2) work done by gravitational force in this situation.

    3) Work done by the frictional force while an object is sliding down along an inclined plane.

    4) Work done by the force acting in the direction of motion on an object which is moving along a plane surface.

13. How much joule is 1 kWh?

14. Find out the work done against the gravitational force in the situations given below:

    1. A child is standing still with a bundle of books of mass 5 kg.

    2. With the same bundle of books, she travels 1 m along a plane surface with a speed 5 m/s.

    3. The bundle of books is lifted onto the top of a cupboard having 1m height ($g = 10\ m/s^2$).

15. A ball of mass 0.4 kg is thrown vertically upward with a velocity 14 m/s. Calculate its kinetic energy and potential energy after 1s.

    (Hint : $v = u + at$, $s = ut + \frac{1}{2}at^2$)

16. An object of mass 1000 kg is travelling with a velocity 72 km/h. Calculate the work done to bring it to rest.

17. Estimate the work done on an object of mass 80 kg to change its velocity from 5 m/s to 10 m/s.

Extended activities

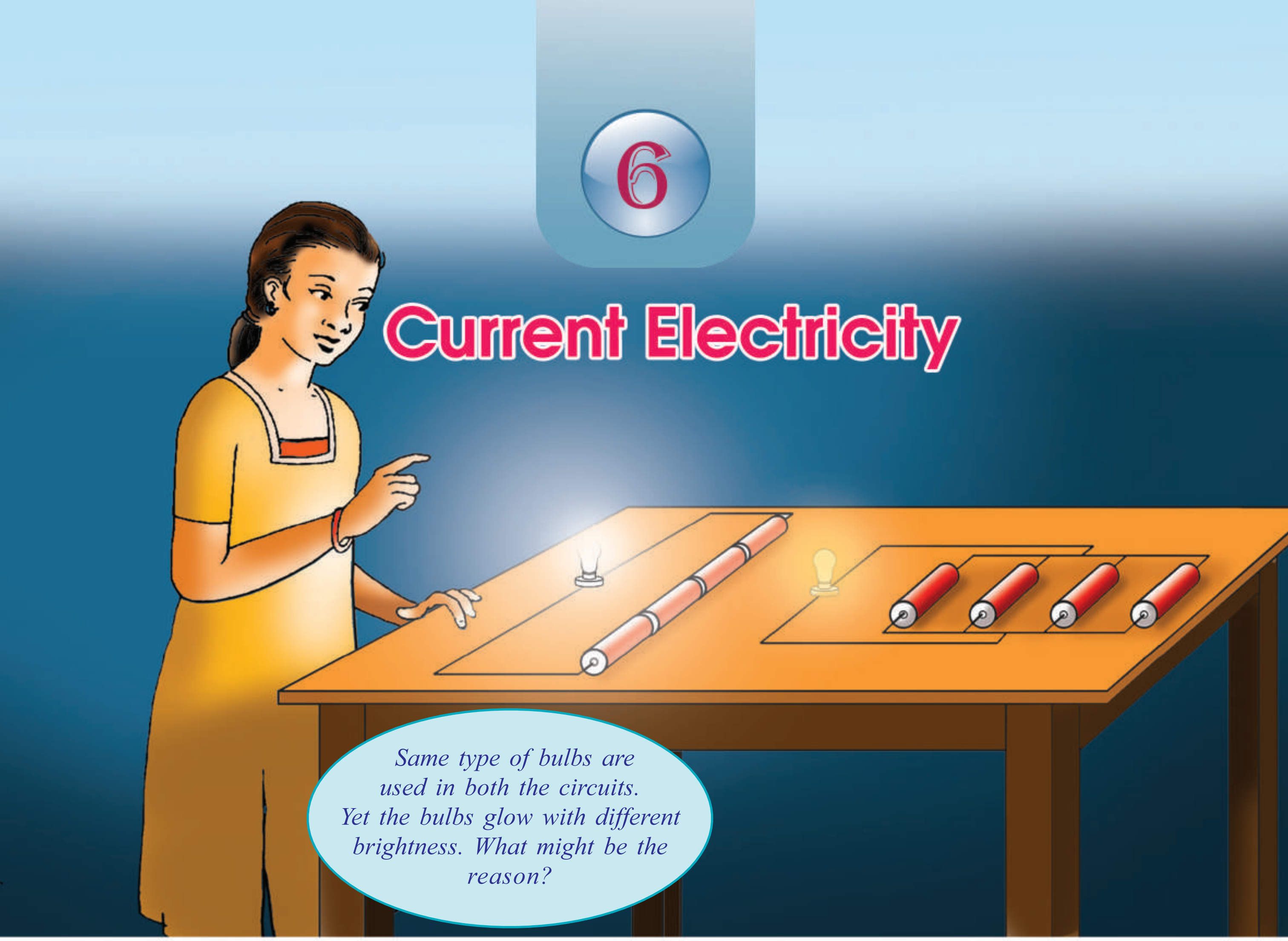
1. Complete the table.

Energy	Transformation
1. Mechanical Energy $\rightarrow$ Electrical Energy	A generator works
2. Electrical energy $\rightarrow$ Mechanical Energy	
3. Electrical energy $\rightarrow$ Heat energy	
4. Electrical energy $\rightarrow$ Light energy	

2. Check whether the power marked in the motor used for pumping water from the well in your home and the power received while it is working are equal. For arriving at a conclusion consider the time taken to fill the tank and the height to the tank.

6

Current Electricity



This doubt was raised by a child when she was observing an experiment at a science fair. What may be the reason for the difference in the intensity of light from the bulbs in the two circuits? Let's examine.

We have learnt that objects can be charged by rubbing and such charged objects can be used for charging other objects. Observe Fig. 6.1(a).

A positively charged electroscope is connected to the earth through a switch using a conductor as shown in the figure.

- What kind of charge is present in this electroscope?

  Moving/ Static

- What happens to this charge when the switch is turned on?
- Will the flow of charge be sustained in this arrangement?

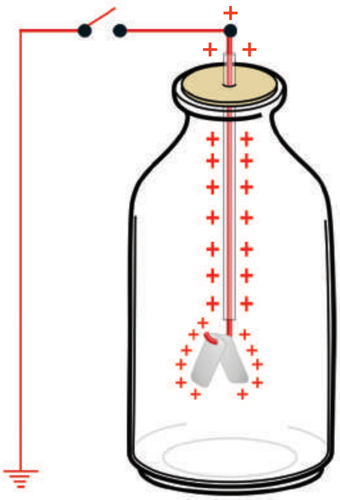


Fig 6.1(a)

Observe Fig. 6.1(b).

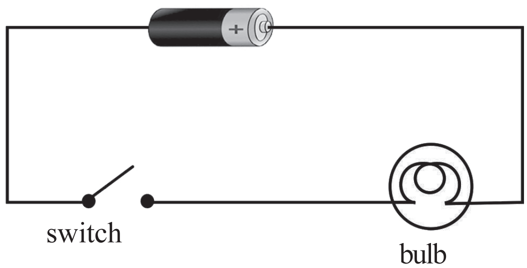


Fig 6.1(b)

A simple circuit with a cell, a bulb and a switch is given in Fig. 6.1 (b).

- Will the flow of electric current be sustained in the circuit when it is switched on?

One Coulomb Charge

The unit of electric charge is coulomb. If the repulsive force between two identically charged point objects kept at a distance 1 m is 9×10^9 N, then the charge in each of them will be is 1 coulomb. This is equal to the charge of 6.25×10^{18} electrons.

A force of 9×10^9 N is equivalent to the force exerted by the Earth on an object of mass 10^9 kg kept on the surface of the Earth. If 10^4 kg is approximately the mass of one elephant, 10^9 kg mass is approximately equal to the mass of one lakh elephants.

What difference is there in the flow of current in Fig.6.1 (a) and Fig. 6.1(b)?

In the first circuit, there is a flow of charge for a short interval of time and there is a continuous flow of charge in the second.

The motion of charges creates current. Current is formed in conductors by the flow of free electrons in it and by the flow of ions in gases and electrolytes.

How does the electric charge flow? Let's see.

Observe Fig 6.2.

Complete the table based on different situations as shown in Fig 6.2.

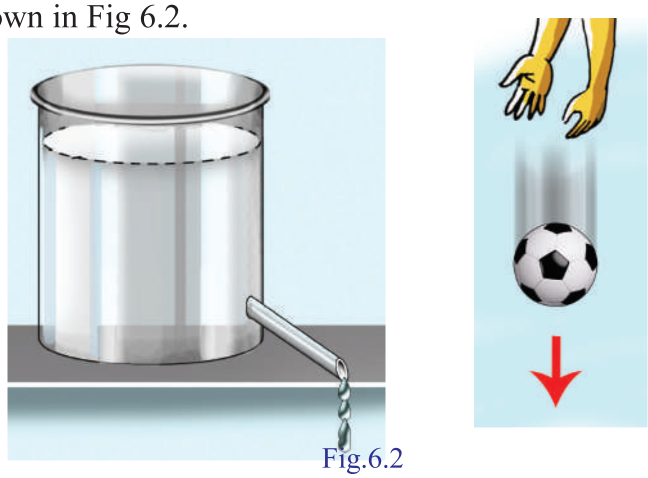


Fig.6.2

Situation	Direction of flow/motion
Ball falling down	Downwards from a higher level to a lower level
Flowing of air	From a region of high pressure to a region of low pressure
Flowing of water	

Table 6.1

You might have understood now that there should be a difference in energy levels between two points if any type of flow is to occur.

Observe Figs. 6.3(a) and (b).

- If the valve is opened, in which one will it be possible to have water flow ?

- Why?

  In Fig. 6.3(a) isn't the water level at A greater than that at B? Then the potential energy at A will be greater. It is due to the difference in the energy level or the gravitational potential difference that flow of water has become possible.

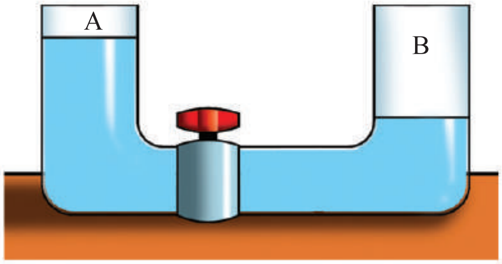


Fig 6.3(a)

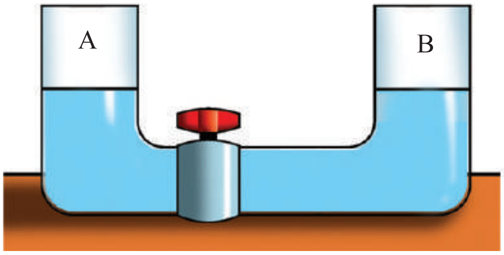


Fig 6.3(b)

Observe Fig. 6.4.

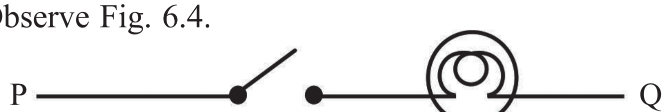


Fig. 6.4

A bulb is connected to a switch, using a conductor.

- Will the bulb glow if the switch is turned on? Why?

  There is no potential difference between P and Q. Hence there is no flow of current and the bulb does not glow.

For a bulb to glow in a circuit, as shown in Fig. 6.4, shouldn't a potential difference be maintained between P and Q?

Potential difference and Current

There should be a potential difference between two points of a conductor, if there is to be a flow of current between them. Current flows from a point of high electric potential to a point of low electric potential.

The unit of potential difference is volt (V). Voltmeter is the device to measure this.

If 1 joule of work is done to move one coulomb charge from one point to another, then the potential difference between the points is 1 volt.

Electromotive force-emf

Electromotive force (emf) is the ability to maintain the potential difference between the ends of a conductor. The emf of a source of current is the potential difference between its ends when the source is in an open circuit. The emf of a cell is measured in the unit volt.

Observe Fig. 6.5.

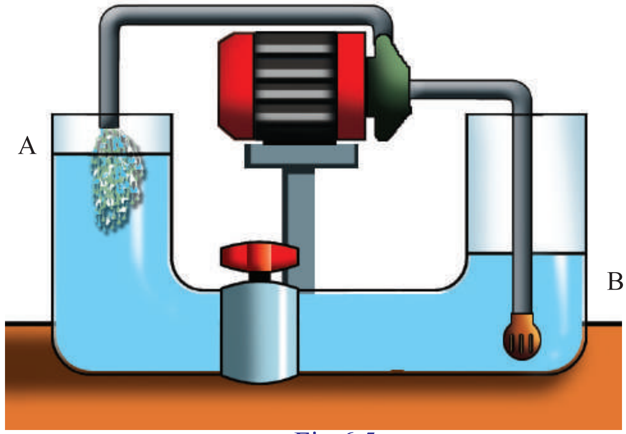


Fig 6.5

The pump has been used in such a way that the same quantity of water that flows from A to B per second is returned to A from B.

- Why is there a continuous flow of water when the valve is opened?

  \- -

Here, is it not due to the working of the pump, which is an external source of power, that the potential difference was maintained and the flow of water was made possible continuously?

If the bulb shown in Fig. 6.4 is to glow continuously, shouldn't there be an external source? Such sources are called the sources of emf.

Write down some sources of emf that are familiar to you.

- Generator
-

Write down the energy change in each.

- Generator : mechanical energy $\rightarrow$ electrical energy
- Cell:

Compare Fig 6.5 and Fig 6.1(b) and complete the table.

Voltmeter

Voltmeter is a device used to measure the potential difference and emf. It should be connected in a circuit with its positive terminal to positive of the cell and the negative terminal to the negative of the cell. The voltmeter should be connected across the points where the potential difference is to be measured. The symbol of voltmeter is —Ⓥ—

Water circuit	Pump	....	Valve
Electric circuit	Cell	Flow of electric charge	....

Table 6.2

Haven't you understood that a source of emf is essential to maintain a potential difference between the ends of a conductor and to maintain the flow of current through the conductor?

Make the circuit given in Fig. 6.6, using a voltmeter, a 6 V, 3 W bulb, a cell and a switch. Activate it.

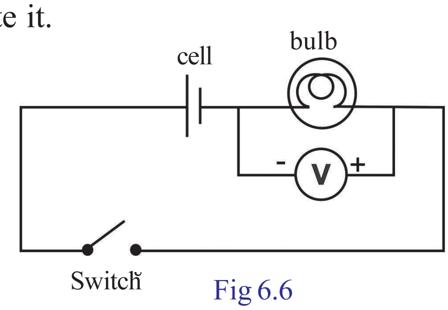


Fig 6.6

- In which mode is the voltmeter connected in the circuit?

- Connect 1.5 V,3 V and 6 V batteries in the circuit (Fig 6.6) and find out the voltage available to the bulb in each case and record it in the table.

Cell used/ Battery	Voltage the bulbs get
1.5 V	
3 V	
6 V	

Table 6.3

Different types of batteries were used to increase the voltage. Let's examine how this can be done by connecting cells.

- In which mode are the cells connected within the remote control of a TV?

- If 4 cells of 1.5 V each are connected in series, what is the total voltage?

- How can you connect 4 cells of 1.5 V each to get 3 V? Draw the circuit. What is the advantage of doing so?

Combination of cells

A battery is a combination of two or more cells connected in a suitable manner. Cells can be connected in two ways.

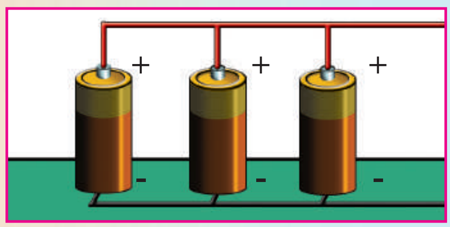
1. Series connection

This is the method of connecting cells one after the other in such a way that the positive of one cell is connected to the negative of another cell.

Salient features

- The total emf is the sum of the emf of all the cells.
- The current passing through each cell is the same.
- The internal resistance developed in the circuit by the battery increases.
- The current in the external circuit increases under high voltage.

2. Parallel connection



This is the method of connecting similar poles together.

Salient features

- If all the cells have equal emf then the emf of the circuit is the same as that of a single cell.
- The total current flowing in the circuit splits up and flows through each cell.
- The internal resistance of the circuit is very low.
- More current can be made available for a longer time under low voltage.

7G1MKC

Flow of current through a conductor

In any conductor, there are positively charged ions at rest as well as free electrons. These free electrons are in random motion. When a conductor is connected to a source of emf, the free electrons start moving uniformly from the negative terminal to the positive terminal. But the free flow is hindered by the positive ions. As a result, the increased speed is reduced. Still the push from one terminal is experienced at the other end simultaneously. Hence the electrons that come out from the other end of the conductor are not the ones that have entered it. The same number of electrons entering a conductor returns to the source at the same time. These electrons drift with a slow speed (0.01 m/s) named drift velocity. Because of this, drifting electric signals are transferred at the speed of light in the circuit. Remember that the speed at which a person walks alongside a current carrying conductor is 100 times that of the speed of these electrons!

What is the need to use sources of emf in circuits?

Electric Current

Electric current is the flow of electric charges. If 10 coulomb charge flows in a circuit in 5 s, how much will be the charge flowing in the circuit in one second?

Charge Q = 10 C

Time t = 5 s

Charge flowing in one second = $\frac{10}{5} = 2$ C/s

Current or intensity of current is the quantity of charge that flows through a conductor in a circuit in one second.

If a charge of Q coulomb flows in a time t second,then how much will be the quantity of charge (current) that flows in one second?

$$\text{Current (I)} = \frac{\text{Quantity of charge}}{\text{Time taken}}$$

$$\text{That is } \frac{Q}{t}$$

$$I = \frac{Q}{t}$$

$$\text{Unit of current} = \frac{\text{Unit of charge}}{\text{Unit of time}}$$

$$= \frac{\text{coulomb}}{\text{second}}$$

$$= \text{ampere(A)}$$

Draw a diagram of the circuit containing an ammeter, switch, cell and a bulb connected in series.

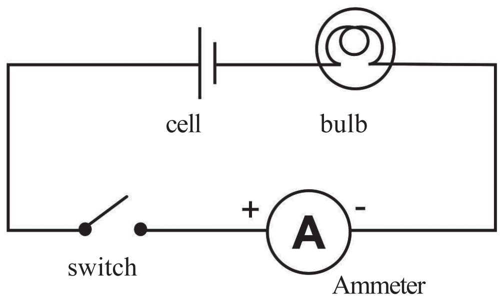


Fig 6.7

Compare the diagram you have drawn with the circuit diagram given in Fig 6.7. Ensure the correctness and construct the circuit. Turn on the switch and record the ammeter reading.

Include more cells in series and repeat the experiment.

Number of cells	Ammeter reading
1	
2	
3	

Table 6.4

- What was the change in the ammeter reading when the number of cells was increased?

- What about the intensity of light from the bulb?

- How are the current and the intensity of light related to each other?

Ammeter reading indicates the current flowing through the bulb. The intensity of light from the bulb increases with the increase in the current.

- What will be the current in the circuit if 2 C charge flows through a conductor in 10 s?

Haven't you understood that there must be a potential difference between the ends of a conductor if current should flow through it? If so, is there any relation between current and potential difference? Let's examine.

Ohm's Law

Let's try an activity.

Draw a circuit diagram by including a nichrome wire (30 cm), cell, switch, ammeter and voltmeter.

Compare the circuit you have drawn with the one given in Fig 6.8. Ensure the correctness and complete the circuit. Measure current(I) and potential difference(V) and record them in the table.

Repeat the activity by increasing the number of cells in series.

Ammeter

Ammeter is a device used to measure the current in a circuit. The positive terminal of it must be connected directly to the positive of the cell and the negative terminal, to the negative of the cell. Ammeter should be connected in series in the circuit. The needle of the device moves in accordance with the current in the circuit. We can measure the current by checking the position of the needle.

Unit of current is ampere(A). It is also written as C/s.

mA(milli ampere) and µA(micro ampere) are smaller units of current. The symbol of ammeter is —Ⓐ— .

7GAILZ

See Ohm's Law in PhET, IT @ School Edubuntu

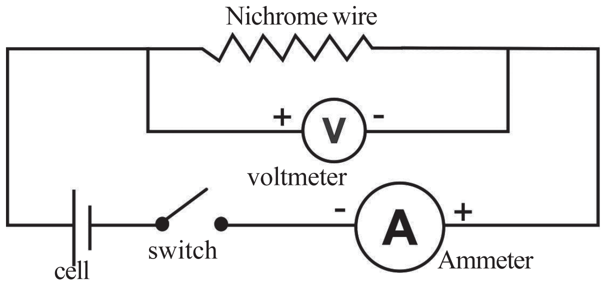


Fig 6.8

Analyse the table and record the findings.

Sl.No	Number of cells	V (volt)	I (Ampere)	$\frac{V}{I}$
1	1			
2	2			
3	3			

Table 6.5

- What change occurs in the current as voltage increases?
- Do you see any peculiarity in the value of $\frac{V}{I}$?

Current increases with increase in voltage.

$$V \propto I$$

$$V = \text{a constant} \times I$$

$$\frac{V}{I} = \text{a constant}$$

This constant is the resistance of the conductor. This is indicated by the letter R.

$$\therefore R = \frac{V}{I}$$

When temperature remains constant, the current through a conductor is directly proportional to the potential difference between its ends. In other words the ratio of potential difference to the current is a constant.

This was found out by George Simon Ohm, a scientist. Hence this is known as Ohm's Law.

Resistors are conductors used to include a particular resistance in a circuit. Its symbol is —\/\/\/— .

- On the basis of the information gathered from Table 6.5, draw a V – I graph. Mark I along the X axis and V along the Y axis.
- Is the graph a straight line?
- Analyse the graph and compare it with Ohm's Law.

$$\text{Unit of resistance} = \frac{\text{Unit of voltage}}{\text{Unit of current}}$$

$$= \text{volt/ampere}$$

volt/ampere is ohm. The symbol of this is Ω (Greek letter omega). $1\,\Omega = \frac{1V}{1A}$. From this what do you mean by 1 ohm?

When the potential difference between the ends of a conductor is 1 V and if a current of 1 A flows through it, then the resistance of the conductor is 1 Ω.

Complete the following table based on Ohm's law.

Voltage (volt V)	Current (I) (ampere A)	Resistance (R) (ohm Ω)
12	....	4
....	2	3
6	3	....

Table 6.6

Resistors

Arrange a circuit as shown in the figure.

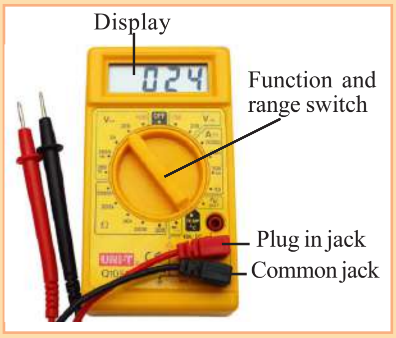
Among the conductors fixed on the wooden plank, PA is iron, PB is aluminium, PC, PD and PE are nichrome. They are of same length. PE is of double length. The thickness of PD is double that of the others. Touch the free end J at A,B,C,D and E and record in the table the ammeter reading at each instance.

George Simon Ohm (1789 -1854)

George Simon Ohm is a well-known German physicist. He was appointed Professor of Mathematics in the Erlangen University and later as Professor of Physics in Munich University. It was he who found out the relation between potential difference, current and resistance. This is known as Ohm's Law. The unit of resistance is named after him.

7GJENH

Digital multimeter



This device is used to measure DC voltage, current, AC voltage and current and resistance of a conductor.

- **Function and range switch:** For adjusting the function to be measured and its range
- **Display:** To display the value digitally and directly
- **Common jack:** Negative test lead *(black)*
- **Plug in Conductor:** Positive test lead *(red)*
- **Plug in jack:** for 10 A current *(red)*
- **Jacks :** The reading can be understood by connecting them properly, turning the switch to the required function and then by touching the ends of the jack.

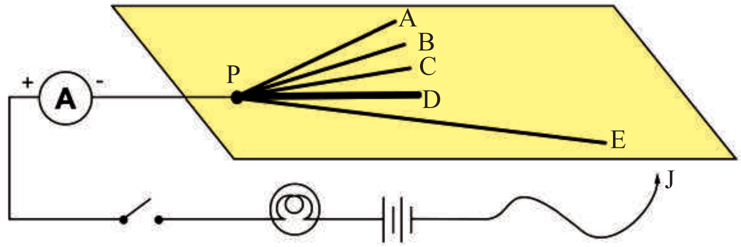


Fig 6.9

Serial Number	Resistor in the circuit	Ammeter reading (A)
1.	Iron (PA)	
2	Aluminium (PB)	
3	Nichrome (PC)	
4	Nichrome (PD)	
5	Nichrome (PE)	

Table 6.7

Complete the worksheet based on the information collected from the table.

- Is the intensity of light from the bulb the same in each situation?

  -

- Was the ammeter reading the same when different conductors of the same length and thickness were included?

  -

- What change has occurred in the ammeter reading when the area of cross section (thickness) of the same conductor is altered?

  -

- Is there a change in the ammeter reading when the length of the same conductor is altered? Note it down.

  -

- Is the applied potential difference the same in all cases?

  -

- According to Ohm's Law, $\frac{V}{I}$ must be a constant (resistance, R). If so, what is the reason for the changes in the ammeter readings?

Connect a 6 V bulb to a 6 V source through a switch.

Using a multimeter, measure the resistance of the bulb when the circuit is switched off. Switch on the bulb for one minute, then switch it off and immediately measure its resistance.

- Is the resistance the same in both the situations?
- When the circuit was switched on, did the temperature increase or decrease?
- When the temperature was increased, did the resistance increase or decrease?

Write down the factors affecting the resistance of a conductor, based on the completed worksheet.

- Area of cross section
- Nature of the material
-

The resistance of metals increases with the increase in temperature.

Let's examine the role of a resistor in controlling the current in a circuit.

In the activity conducted above (Fig 6.9), touch the free end J at end E of nichrome and slowly slide it from E to P. Based on the observations, write down the answers.

- What was the change in the intensity of light of the bulb?

- What may be the reason behind the change?

If the potential difference is constant, then the current is inversely proportional to the resistance. For a conductor of uniform area of cross section, the length of the conductor and its resistance are directly proportional to each other.

Rheostat is a device designed on the basis of this principle.

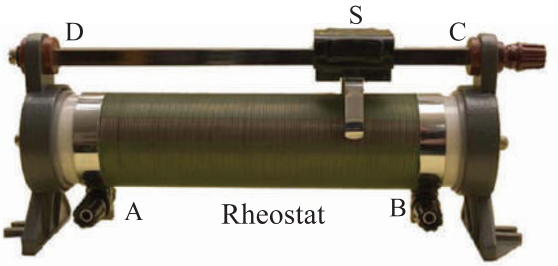


Fig 6.10

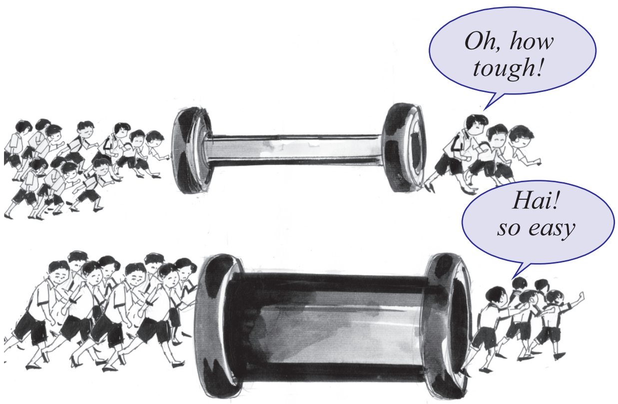
Let's see what is the use of a rheostat.

In the figure, AB is a wire wound over an insulator. The resistance of a circuit can be continuously changed by the sliding contact S. The change in the resistance regulates the current. The symbol of a rheostat is  .

Make a circuit having a bulb, a cell, ammeter, rheostat and a switch in series. Switch on the circuit and adjust the sliding contact slowly. Observe the change in the brightness of the bulb.

Rheostat is a device used to regulate the current in a circuit by changing the resistance gradually.

Given below is a table related to the resistance of a conductor. Complete the table suitably.



Length (l) m	Area of cross section (A) m^2	Resistance (R) Ω
1	1	R
2	1	2R
1	2	½R
2	2	....
1	½	....

Table 6.8

Analyse the completed table and write down the inferences.

The resistance of a conductor increases with the increase in the length (l) of the conductor and decreases with increase in the area of cross section(A).

$$R \propto l \text{ and } R \propto \frac{1}{A}$$

That is $R \propto \frac{l}{A}$

$$R = \text{a constant} \times \frac{l}{A}$$

$R = \rho \frac{l}{A}$ (the constant is indicated by the Greek letter ρ (rho)).

If so $\rho = \frac{RA}{l}$

ρ is the resistivity of the material with which the conductor is made of.

The length of a conductor of resistance R Ω is 1 m and its area of cross section is 1 m^2. Calculate the resistivity of the material with which the conductor is made of.

Length l = 1 m

Area of cross section A =1 m^2

$$\text{Resistivity } \rho = \frac{RA}{l} = \frac{R \times 1}{1}$$

$$\rho = R$$

In this mathematical problem you have seen that $\rho = R$. Can you formulate a definition for resistivity?

Resistivity of a substance is the resistance of the conductor of unit length and unit area of cross section. The resistivity of a substance is a constant at fixed temperature. But it will be different for different materials.

Unit of resistivity =

$$\frac{\text{Unit of resistance} \times \text{Unit of area of cross section}}{\text{Unit of length}}$$

$$= \frac{\Omega \times m^2}{m} = \Omega m$$

The unit of resistivity is Ωm.

Conductivity

The conductivity of a conductor is the reciprocal of its resistivity. This is denoted by the symbol σ *(from the Greek letter sigma).*

$$\sigma = \frac{1}{\rho}$$

Unit of conductivity =

$$\frac{1}{\text{Unit of resistivity}}$$

$$= \frac{1}{\Omega m} = \Omega^{-1} m^{-1}$$

Let's get acquainted with some of the tools related to electric current:

We use many electric devices in our every day life. Different tools are needed to connect these devices with the electric line and to perform maintenance. They are enlisted here.

Screw driver 	It helps in fixing and removing the screws. Screw drivers are available in different sizes. It is used to combine a wide range of screws with -,+,* shaped edges.
Electric tester 	It is used to check whether current is coming into the sockets or other devices in the houses. Some of these can be used as screw driver. The bulb inside the tester will glow if there is presence of current.
Wire stripper 	It is used to remove insulation of wires while combining insulated electric wires or when they are to be connected to the devices.
Pliers 	It is used to join wires by twisting them together or for cutting or removing wires. Pliers are available in different shapes and sizes.
Gloves 	While doing the work related to electric power, gloves are worn in the hand as a protection from electric shock.
Multimeter 	It is used to measure current,voltage,and resistance in a circuit and to understand whether the circuit is open, closed or any connection is left. Besides, it also helps to check whether the various elements in an electronic circuit are functioning properly.

Clamp ammeter

It helps to measure the current in a circuit without connecting wires or devices in the circuit.

Insulation tape

When connecting the wires or connecting it with a device, this is used to provide insulation in those parts where it has been damaged.

Spanner

It is used for fixing nut and bolt. They are available in different sizes.

Soldering iron

It is used to solder electronic components in a circuit

Hammer

It is used for fixing and removing nails.

Drill machine

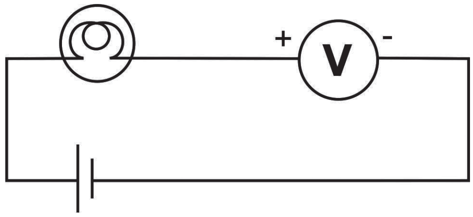
It is used to drill holes on hard surfaces. It can be used to fix and remove screws as well.

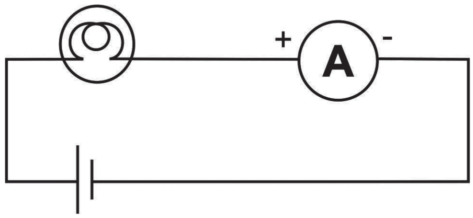
Let us assess

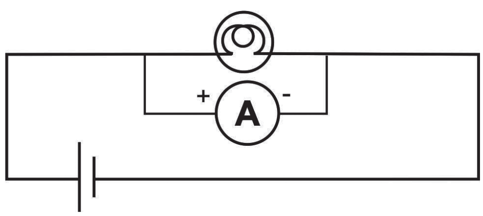
1. Complete the table properly

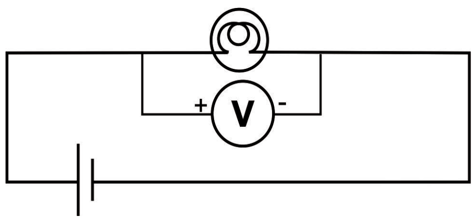
Component	Measuring device	Unit	
potential difference		joule/ coulomb	
	ammeter		ampere

2. Given below are the diagrams showing the connection of ammeter and voltmeter in a circuit. Pick out the correct circuits.





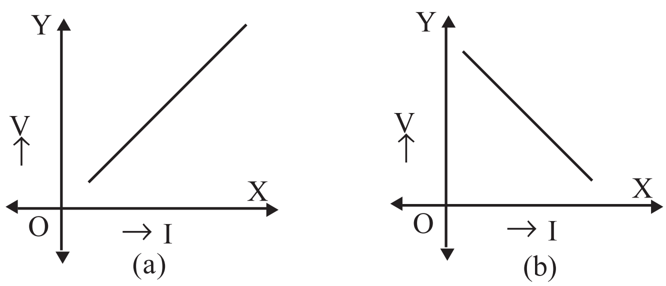




3. Complete the table. The conductor is made of the same material

Length of conductor	Area of cross section of conductor	Resistance of the conductor
1 cm	2 cm^2	10 Ω
2 cm	......	20 Ω
1 cm	4 cm^2	.....

4. In an electrical circuit if 100 J work is done to move 10 C electric charge from point A to the point B, find out the potential difference between the points A and B.
5. 6 electric cells are connected in series in an electronic device which works at 9 V potential difference. Find out emf of one cell.
6. An ammeter that connects to an electronic circuit shows a reading of 2 A. Find how many charges flows through the ammeter in 10 s.
7. When a conductor is stretched, its length becomes double. Find out how many times the resistance changes.
8.



In the given graphs which is the graph depicting Ohm's Law? Justify your answer.

9. A conductor of 5Ω resistance has length 2 m and area of cross section 2 m^2. If so, find out the resistivity of the material of the conductor.
10. Draw a circuit diagram describing how 6 torch cells should be connected to a bulb and a switch to obtain effective voltage of 9V.

Extended activities

1. Connect a 3 V torch bulb to a 3 V cell. Then connect the cell in such a way that the current flows in opposite direction. Note down the observations in both the situations. Repeat the

experiment by connecting LED instead of torch bulb. Write down the observation.

2. Connect a 12 V cell with a torch bulb, rheostat, ammeter and voltmeter through a switch. Record and tabulate the ammeter reading for different voltages. Draw a graph by marking current along X axis and voltage along Y axis.
3. Using a digital multimeter, find out the resistance of 1 m and 2 m long nichrome wire. Identify the relation between length and resistance.
4. The resistance of a 10 cm long conductor is 12Ω. If it is folded into two parts of equal length and included in a circuit,what will be the resistance produced?

7

Wave Motion

After placing a paper boat in the pond, the child is continuously making ripples in the water to push it away from the shore. But the boat moves only up and down and it doesn't move forward. What may be the reason?

You might have seen ripples formed in water when a stone is dropped into it. How does the disturbance produced by the stone in water spread to other areas? Doesn't it spread like expanding concentric circles? Let's examine the motion of the water particles, in these water waves.

7GTAQA

Fill a trough with water to about half of its capacity. Put some thermocol balls in it.

With your finger make ripples on the surface of the water.

What do you observe?

Don't you see the disturbance spreading from its origin to other places? This is wave motion.

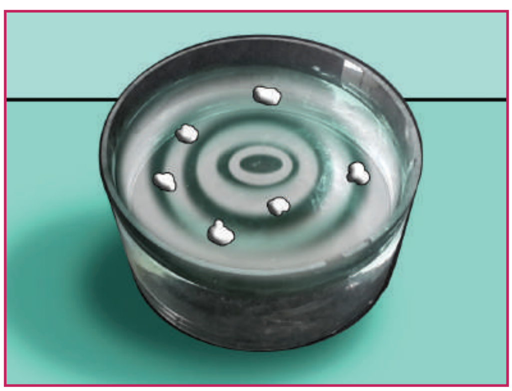


Fig 7.1

- Has there been a displacement for the thermocol balls?
- What type of movement will each water particle have?

Water particles move up and down about their mean position but without any displacement in the direction of propagation of the wave. Wave motion is one of the means to transfer energy from one region of the medium to another. In a wave motion, the energy received by one particle is transferred from particle to particle, thus spreading all over.

Wave motion

Wave motion is the propagation of disturbances, produced in one part of a medium to the other parts by the vibration of its particles.

Write down examples of wave motion that you are familiar with.

- Waves formed on water surface
- Radio waves
- Light waves
- Sound waves

Do all these waves need a medium for their propagation ? Let's tabulate.

Those which need medium for propagation	Those which need no medium for propagation
• Waves formed on water surface •	• Radio waves •

Table 7.1

The waves which need a medium for their propagation are mechanical waves. Let's know more about mechanical waves.

There are mainly two types of mechanical waves.

(1) Transverse waves

(2) Longitudinal waves

Transverse wave

Let's try out an activity.

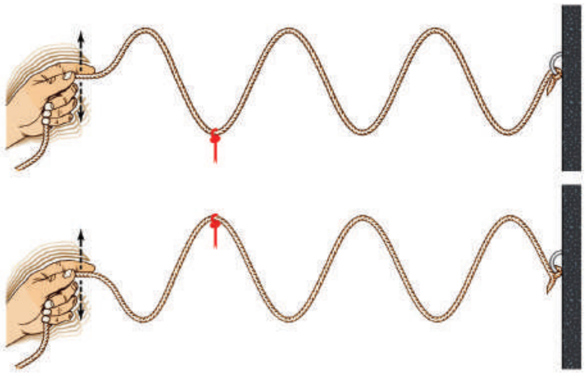


Fig 7.2

Tie one end of a rope to a window. Wind a ribbon or paper on the rope in such a way that you can see it clearly. Hold the other end of the rope and move it up and down. Observe the resultant wave motion.

- How does the ribbon/ the piece of paper move?
- What about the wave's direction?

When the wave is formed in the rope, all that happens is just the moving up and down of the ribbon whereas its position on the rope does not change at all. The ribbon is vibrating in a direction perpendicular to the direction of propagation of the wave. That is, each particle of the wave vibrates in a direction perpendicular to the direction of propagation of the wave.

A transverse wave is a wave in which the particles of the medium vibrate in a direction perpendicular to the direction of propagation of the wave.

Now, will you be able to explain why the disturbances in water could not make the paper boat move away from the shore?

Characteristics of waves

Amplitude

Amplitude is the maximum displacement of a particle from its mean position. This is denoted by the letter 'a'.

Wavelength

Wavelength is the distance advanced by the wave by the time a particle completes one vibration. This is equivalent to the distance between two consecutive particles which are in the same phase of vibration. The Greek letter λ (lambda) is used to denote wavelength. The unit of wavelength is metre (m).

Period

Period of a wave is the time taken for a particle in a medium to make one complete vibration .This is represented by the letter T. The unit of period is second (s).

7LNFYN

Frequency

Frequency is the number of vibrations in one second.

$$\text{Frequency (f)} = \frac{\text{Number of vibrations}}{\text{Time taken}}$$

If frequency and period are interrelated, we can write it down as

$$f = \frac{1}{T}$$

The unit of frequency is hertz (Hz)

Speed of a wave

The speed of a wave is the distance travelled by the wave in one second.

Write down the equation for finding speed

$$\text{speed} = \frac{\dots\dots\dots\dots}{\dots\dots\dots\dots}$$

- Wavelength (λ) is the distance travelled by a wave in a time of one period (T)

$$\text{so, speed of wave} = \frac{\lambda}{T}$$

$$ie,\ v = \frac{1}{T}\times\lambda$$

$$v = f\lambda$$

The unit of speed is m/s.

- Observe the graphic representation of a transverse wave at a particular instant.

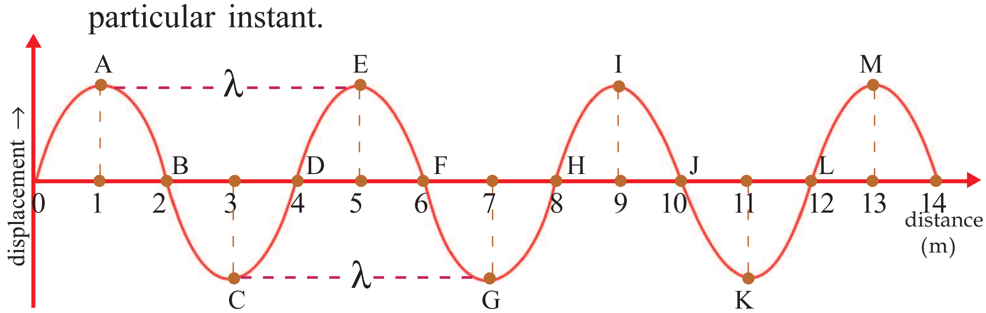


Fig 7.3

In the above figure, the portions shown elevated from the mean position are the crests. The depressed portions are the troughs.

- In the figure, which are the points of the highest displacement (amplitude)?

  A, C, ---- , ----, ----, ----
- How many crests and troughs are there in the figure?
- Are all the particles in the same phase of vibration at a particular time?
- Which are the particles in the same phase of vibration as that of A?
- Which are similar to C?
- What is the wavelength of the wave shown in the figure?

Waves are formed because of the vibration of particles of a medium. In the figure what is the frequency of the wave if the particle A makes 100 vibrations in 5 s?

....

The graphical representation of two waves of the same amplitude, generated at specific intervals of time, is given below.

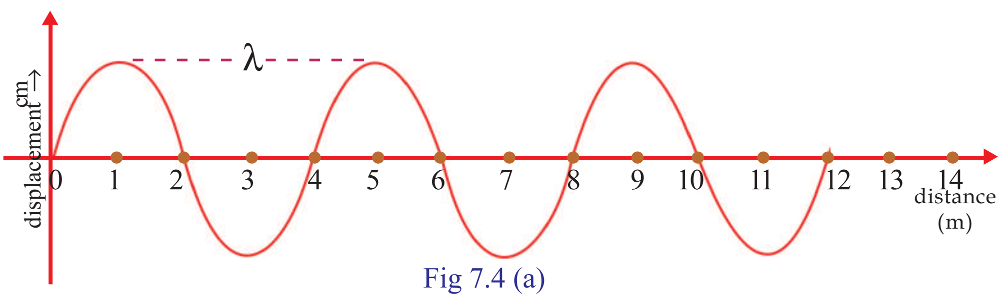


Fig 7.4 (a)

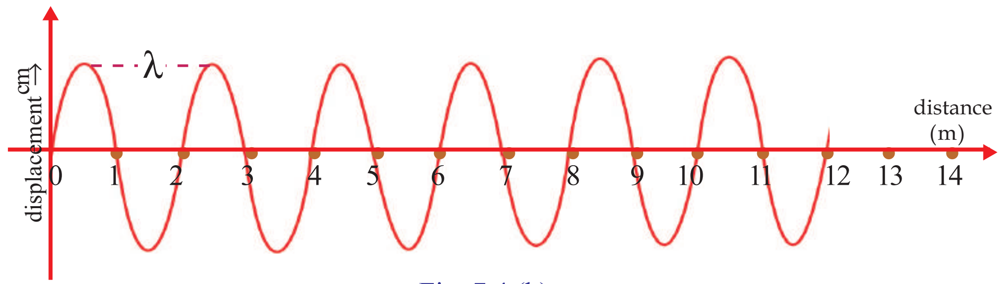


Fig 7.4 (b)

- What is the wavelength of the first wave? What about that of the second one?
- Which wave has a higher wavelength?

- Calculate the frequency of each wave if they have travelled this distance (12 m) in 0.25 s.
- What happens to the wavelength when the frequency increases?increases/deceases.

From this, it can be understood that when frequency of a wave with constant speed increases, its wavelength decreases. That is, frequency is inversely proportional to the wavelength.

Observe the graphic representation of a wave motion given below.

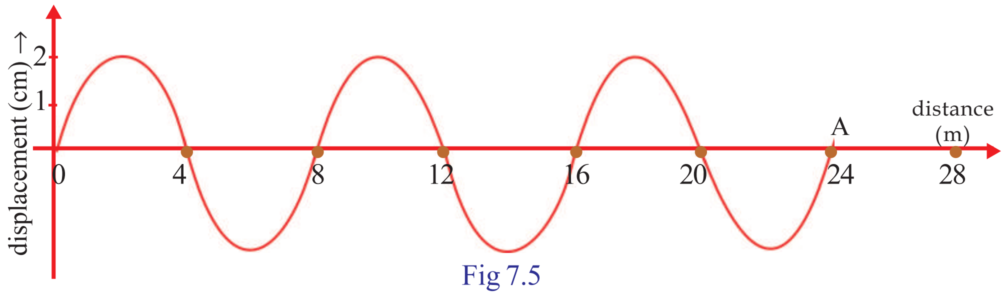


Fig 7.5

a) What is the amplitude of the wave?

b) What is the wavelength?

c) Calculate the frequency of the wave if it took 0.2 s to reach A.

d) Calculate the speed of the wave.

Is there any mode of wave propagation other than the transverse mode? Let's examine.

Longitudinal wave

Let's do an activity using a slinky.

Fix one end of a slinky to a wall. Suspend some pieces of paper on the coils at equal distances. Press a few coils on the free end held in the hand and then release them.

What do you observe?

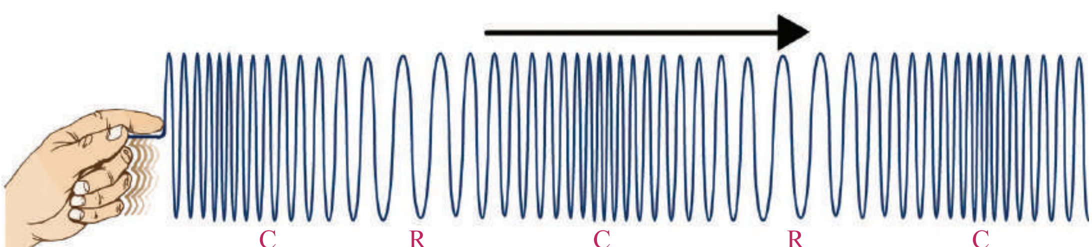


Fig 7.6

- Won't the air particles vibrate to and fro when such waves pass through air ?

High pressure is experienced in places where the air particles are close to each other. Such regions are the compressions (C). In that case, what about the part in which the molecules are wide apart?

Regions of low pressure are the rarefactions (R).

A longitudinal wave is a wave in which the particles of the medium vibrate in a direction parallel to the direction of propagation of the wave. This creates compressions and rarefactions alternately in the medium.

See Sound & Waves in PhET, IT @ School Edubuntu

Let's see how we hear a sound from a source.

Listen to the sound from an excited tuning fork. Take a look at Fig. 7.8 which illustrates how the sound waves reach our ears.

Won't the vibrations of the tuning fork make the air particles around it to vibrate?

Compare the waves formed in the slinky with the longitudinal waves produced by a tuning fork in the air.

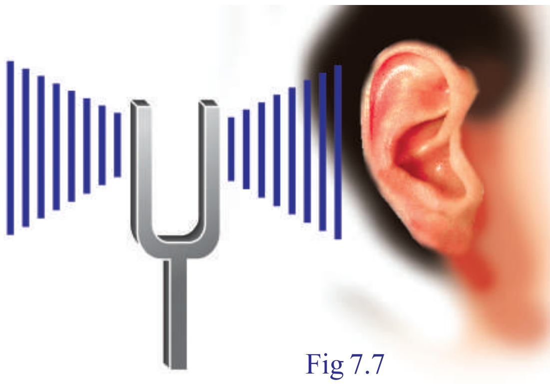


Fig 7.7

Fig 7.8

7LXC1B

- How many compressions are there in the longitudinal wave shown in the figure?
- Find out the differences between transverse and longitudinal waves and complete the table.

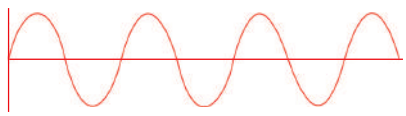
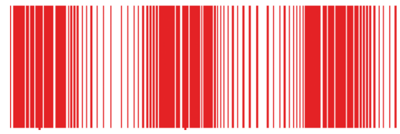
Transverse waves	Longitudinal waves
1. 	1. 
2. Particles vibrate in a direction perpendicular to the direction of propagation of the wave.	2. Particles vibrate in a direction parallel to the direction of propagation of the wave.
3.	3. Compressions and rarefactions are formed.

Table 7.2

Sound

Haven't you learnt that a medium is essential for the propagation of sound? Let's see how sound waves are propagated through a medium. Observe the direction in the graph which shows how sound coming from a source produces continuous variations in the pressure on a medium.

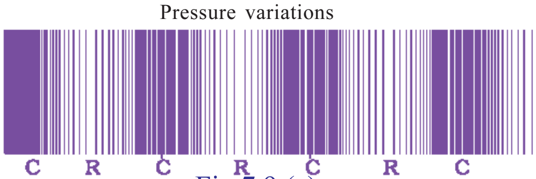


Fig 7.9 (a)

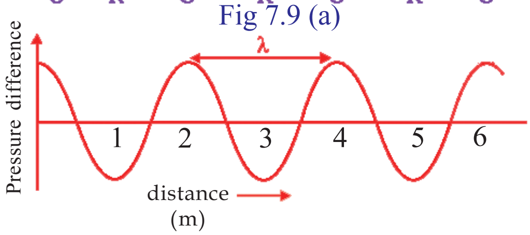


Fig 7.9 (b)

Wavelength of Longitudinal Wave

The distance between corresponding points of two consecutive compressions or two consecutive rarefactions is the wavelength of the longitudinal wave.

- What do C and R in the Fig.7.9 (a) indicate?
- Find out the wavelength in Fig.7.9 (b) and write it down.
- What will be the speed of the wave if its frequency is 92 Hz?

Speed of sound

Ask your friend to tap continuously on a desk.

Do you hear any sound?

What is the medium through which the sound reached you?

Now repeat the activity, keeping your ear closely pressed to the desk.

Sound had travelled through various media before reaching your ear. What are they?

Haven't you understood that sound can travel through air and wood?

- Does sound travel with the same speed through all media?

  Analyse Table 7.3 and find out.

- At which state of matter will the speed of sound be greater? When will it be less?

You now know that speed of sound is different in different media.

	Medium	Speed of Sound (m/s) (20°C)
Solid	Aluminium	6420
	steel	5941
Liquid	Pure water	1482
	Sea water	1522
Gas	Air	343
	Helium	965

Table 7.3

Temperature and Speed of Sound

Speed of sound changes along with the change in temperature of the media through which it travels. Whatever be the media,when the temperature rises, speed of sound through it also increases. For example, in the case of air, sound travels with a speed 331 m/s at 0^{o}C. But when the temperature becomes 20^{o}C, speed of sound rises to 343 m/s and at 25^{o}C, speed is 346 m/s.

Haven't you understood the characteristics of sound waves? Now let's see some phenomena of sound.

Reflection of sound

Haven't you learnt that light is reflected when it hits smooth surfaces? Can sound waves get reflected like this? Let's see.

Arrange two PVC pipes, a glass plate and a stop clock as shown in the figure.

- What may be the reason behind hearing the sound from the clock through the pipe B?

Isn't it due to the reflection of sound from the glass plate? Sound gets reflected very well from smooth surfaces.

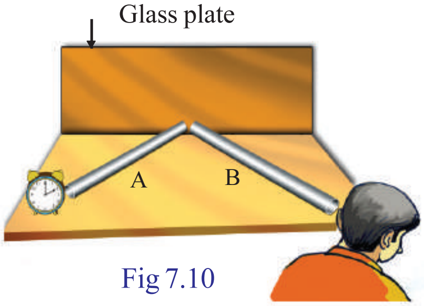


Fig 7.10

Multiple reflection of sound

Fig 7.11 shows how sound from a source reaches a listener or receiver in a closed room or hall.

- Does sound from a source reach a listener only directly?
- Is there a chance of reflected rays getting reflected again?

- What will be the auditory effect of such a sound?

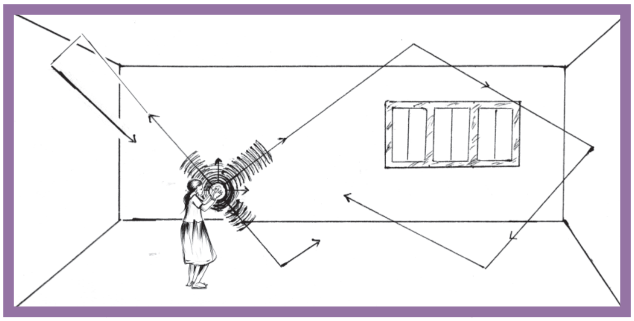


Fig 7.11

Sound getting reflected repeatedly from different objects is multiple reflection.

Situations making use of multiple reflection

- Devices like megaphone, horns, musical instruments like shehanai and trumpets, are made in such a way that the sound produced from them travels in a certain direction only without spreading to other directions. In such devices there is a conical shaped open end which enables the reflected sounds to travel in a particular direction alone, thus enabling us to hear it louder.

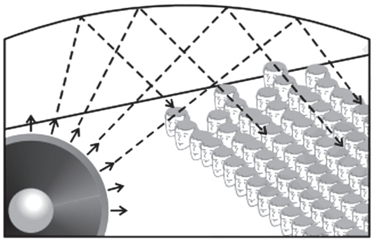
- Stethoscope

  Helps us to detect beats in our body, especially the heart beats.
- The ceilings of halls are given a curvature.

  Sound generated from a source spreads all over the hall due to multiple reflection.

- Sound boards

  The curved sound boards placed behind the screen makes the sound undergo multiple reflections and spreads everywhere in the hall. The boards in musical instruments like guitar, violin etc., also act as sound boards.



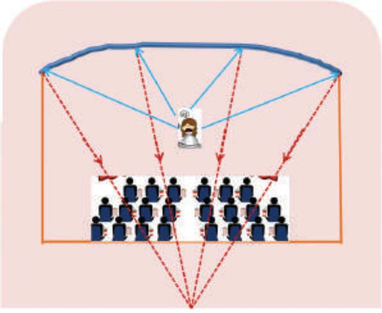


Fig 7.12

Reverberation

Haven't you experienced a booming sound when sound is produced in empty rooms? What may be the reason?

- Which are the regions in a room from where sound waves get reflected? Observe Fig 7.13.
- Do these repeatedly reflected sound waves reach the ears of a listener simultaneously?

Persistence of audibility

The sensation of hearing produced by a sound is retained for a period of $\frac{1}{10}$ s= 0.1 s. This characteristic of the ear is the persistence of audibility. If another sound reaches the ear within 0.1 s, one can hear both the sounds simultaneously.

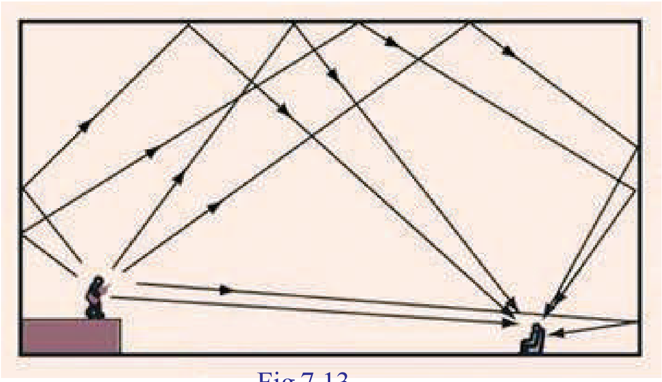


Fig 7.13

- Will you be able to hear all these sounds clearly due to the persistence of audibility? Won't you be hearing only a boom of all the sounds?

Boom thus produced is reverberation.

Reverberation is the persistence of sound as a result of multiple reflection.

Let's see what should be the minimum distance between a listener and the reflecting surface to hear the first sound clearly after reflection.

Echo

After hearing a sound for the first time, how long does it take to hear clearly its reflected sound?

What distance will the sound travel by this time? What should be the minimum distance to the reflecting surface if the velocity of sound in air is 340 m/s?

Fig 7.14

Aren't you convinced that the same sound can be heard again, if the reflecting surface is at a distance of more than 17 m? This phenomenon is known as echo.

Echo is the phenomenon of hearing a sound by reflection from a surface or obstacle, after hearing the original sound .

Write down the situations in which echo is heard.

- A person who bursts a cracker hears its echo after 1 s. What is the distance to the reflecting surface if the speed of sound in air is 340 m/s?

  Let d be the distance to the reflecting surface. If so, the total distance travelled by the sound in this time is 2d.

$$\text{Speed of sound} = \frac{\text{Total distance travelled}}{\text{Time}}$$

$$V = \frac{2\,d}{t}$$

$$D = \frac{v \times t}{2} = \frac{340 \times 1}{2} = 170\,m$$

- What should be the minimum distance between the source and the reflecting surface if the echo were to be heard while under water? (speed of sound in water is 1482 m/s)

Acoustics of buildings

Haven't you seen that walls have rough surfaces in big halls like the cinema theatre ? Why are the walls made rough?

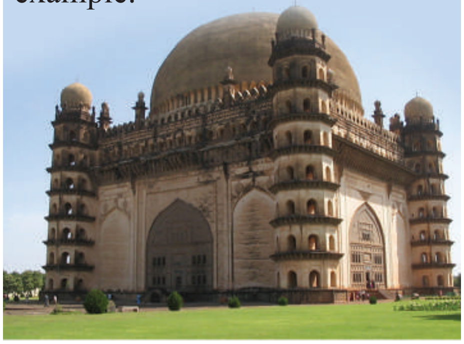
- What will be the problems related to reflection of sound if the distance between walls in a room is more than 17 m?
- What are the methods to solve the problems that occur due to reflection of sound?
- What all things can we do in halls to increase audibility?
    - Make the floor rough.
    -

Acoustics of buildings is the branch of science that deals with the conditions to be fulfilled in the construction of a building for clear audibility.

Whispering gallery

The Whispering Gallery at St. Paul's Cathedral in London is the best example for the sound getting reflection. Even if you are just whispering near the circular wall below the dome, the sound will be heard loudly everywhere inside the gallery.

This is due to the multiple reflection of sound from the circular walls. The Gol Gumbas in Bijapur of Karnataka is another example.



Can we hear sounds of all frequencies?

What are the limits of audibility of a person with normal hearing? What is the name of sound waves with a frequency greater than the limit of audibility? What about those with less frequency? Write them down in your science diary.

Ultrasonic Sound

Sound with a frequency greater than 20000 Hz, ie, above the higher limit of audibility is called ultrasonic sound.

Uses of Ultrasonic waves

- Ultrasonic waves are used to clean spiral tubes, machine parts without a definite shape and electronic components. Objects to be cleaned are dipped in a cleaning solution. Ultrasonic waves are passed through this solution. Due to the high frequency of vibration of ultrasonic waves, dust and grease like substances get detached and are removed from the object.

Spiral tube
Fig 7.15

- Ultrasonic waves are used to detect cracks and flaws in large metal blocks

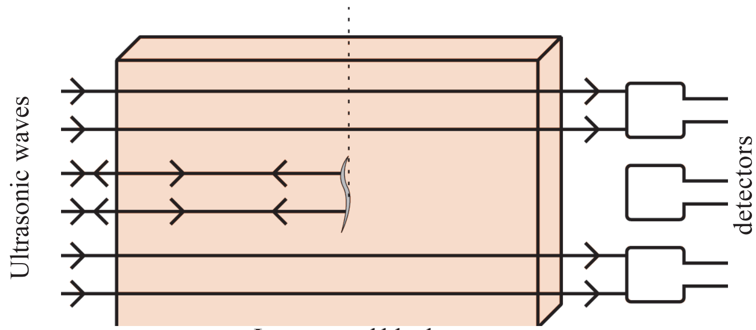


Fig 7.16

Ultrasonic waves, passed through a metal block, are allowed to reach the detectors. If there is any crack or flaw, ultrasonic waves will reflect back from that part. So they do not reach the detectors. Audible sound waves of longer wavelength cannot be used for this purpose as they bend around the corners of the defective location to reach the detectors.

- Echocardiography

Ultrasonic waves are used for taking images of heart. This is known as Echocardiography (ECG).

- Ultrasonography

Ultrasonic waves are used for getting images of internal organs such as kidney, liver, gall bladder and uterus. Ultrasonic waves travel through the tissues of the body and get reflected from the region where there is a change in tissue density. These waves are then converted into electrical signals and are used to form images of the organs. This technology is called ultrasonography

- Ultrasonic waves can crush small stones formed in the kidney into fine grains.

SONAR (Sound Navigation and Ranging)

SONAR is a device that uses ultrasonic waves to measure the distance, direction and speed of objects under water.

See Fig.7.17. In the figure, ultrasonic waves are sent out from a SONAR which is installed in a ship and they get reflected back after striking an object at the bottom of the sea.

- Which part of the SONAR produces and transmits ultrasonic waves ?
- What happens to the ultrasonic waves after striking the object on the seabed?

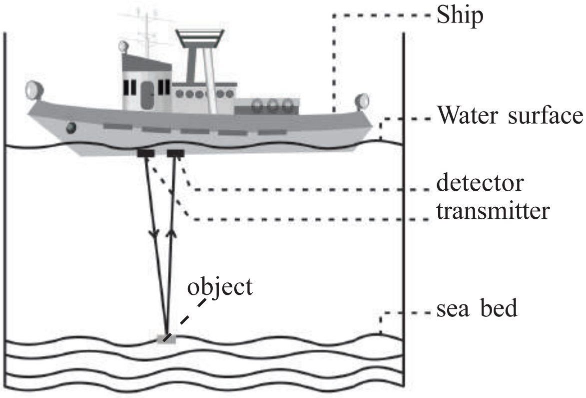


Fig 7.17

Ultrasonic waves that are reflected back after striking the object reach the detector. The detector converts the ultrasonic waves into electrical signals.

- The distance travelled by a wave can be calculated by knowing the speed of ultrasonic sound in sea water and the time taken for the wave to return. Try to write it down.
- Ultrasonic waves from a ship hits a rock at the bottom of the sea and comes back after 0.5 s. Calculate the distance to the rock from the ship. Consider speed of sound through sea water as 1522 m/s.
- Bats make use of ultrasonic sounds for catching prey. How do bats catch prey? Observe Fig.7.18 and write down in your science diary.

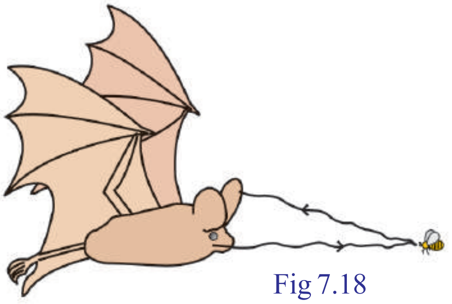


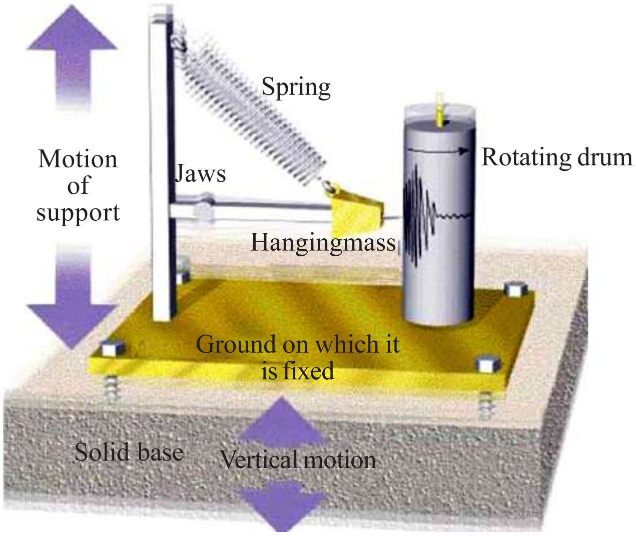
Fig 7.18

Seismic Waves and Tsunami

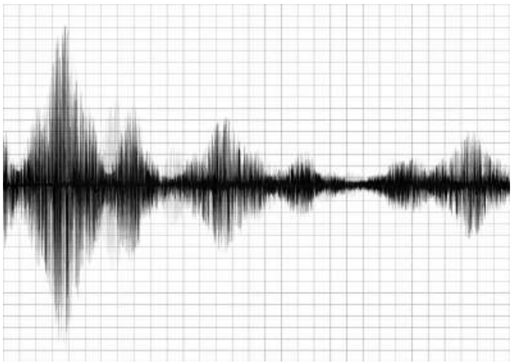
Seismic waves formed in nature are responsible for the disaster depicted in Fig 7.19. Earthquakes cause large scale distruction in several regions of the world. Seismic waves are those waves of energy travelling through Earth's layers as a result of the earth quakes, man made explosions and volcanic eruptions. The seismic waves


A Scene from Nepal Disaster
Fig 7.19

originate from the epicentre of the earthquake . Seismology is the branch of science that deals with the study of seismic waves. Scientists dealing with the study of seismic waves are called seismologists. As you know the intensity of earthquake is measured in Richter scale.



The seismograph device



The waves recorded by seismometer at the time of earthquake

Fig 7.20

Seismic waves formed as a result of earthquake are classified into three : Primary waves (p waves), Secondary waves (S waves) and surface waves. Among these, primary waves travel fastest. Secondary waves are slower than the primary waves. In a seismograph, the difference in the arrival time of the primary and secondary waves can be used to determine the approximate distance to the epicentre. The amplitude of the waves, obtained using seismograph determines the intensity of an earthquake. Two surface waves, Rayleigh waves that travel only through the Earth's surface and Love waves, are also formed as a result of earthquake. Surface waves are the reason for major damages caused by earthquake, though the speed of surface waves is less than that of secondary waves.

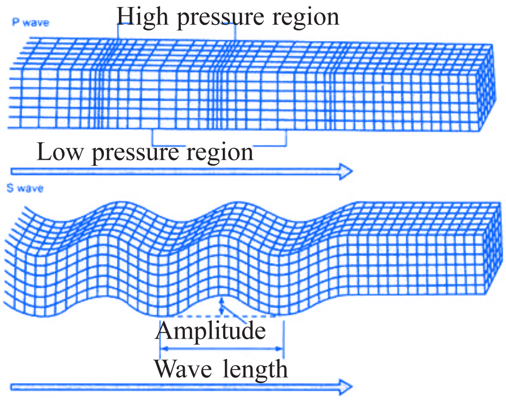


Fig 7.21

Chance of occurrence of highly intense earthquakes in Kerala is very remote. Yet, earthquakes occurring in faraway places may sometimes cause Tsunami waves. Tsunami may affect us since Kerala has long coastal regions. Havn't you heard of the huge Tsunami waves that lashed our coast on 26^{th} Dec 2004? Tsunami is a series of gigantic waves in a water body caused by the displacement of large volume of water in the deep regions near the sea bed. Tsunamis are caused by underwater earthquakes, volcanic eruptions, meteorite impacts and other such disturbances. The term Tsunami is coined by combining two Japanese words 'Tsu',which means 'harbour' and 'nami' ,which means 'long wave'. In the bay region, the speed of Tsunami ranges from 600 to 800 km/h and their wavelength from 10 to 1000 km. The amplitude is less in the deep sea. Hence Tsunami is not felt by passengers in ships. As waves approach the seashore, the trough of the waves rub against the land. As a result the speed and wavelength of the waves drop down suddenly, amplitude increases and the coastal region gets submerged.

7HYV7H

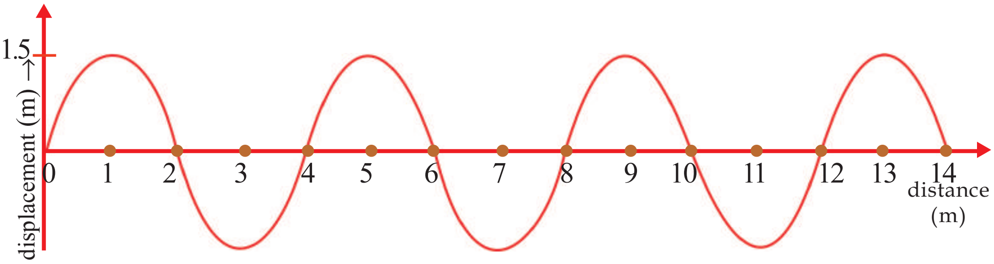
Tsunami height depends on the geographical nature of the coast and the depth of the seabed. As Tsunami approaches the shore from the deep sea, the energy lost is not significant. Hence the magnitude of destruction will be very high. If it is the crest of the wave that first reaches the shore, the waves rise high and if it is the trough that reaches first, the sea will be in a state of retreat. The system that gives advance warning about Tsunami is known as DART (Deep Ocean Assessment and Reporting of Tsunami).

What are the methods to be adopted to escape from Tsunami? Discuss.

- Move to a higher plain taking the unusual receding of the sea from the sea shore as a warning of the approaching Tsunami.
- Don't assume for yourself that the danger is over; instead, wait for the official announcement.
- Try to save your life and not your belongings, as life is precious.
- If caught in Tsunami, try to save yourself by latching onto some floating objects.
-

Let us assess

1. Observe the graph.



- Find out the amplitude of the wave.
- What is the speed of the wave if it travels 800 m in 2 s?
- What is the frequency of the wave?

2. What do you mean by acoustics of buildings? Suggest four steps that can be taken, while constructing buildings, to avoid problems which may occur due to multiple reflection of sound.
3. A sound signal from a ship floating on water, hits a rock at the bottom of the sea and comes back to the ship after 4 s. Calculate the distance from the surface of water to the rock. The speed of sound in water is estimated to be 1500 m/s.
4. Wavelength of a wave that travels with a speed 339 m/s is 1.5 km. What will be its frequency?
5. Wavelength of a sound wave having frequency 2 kHz is 35 cm. How much time will it take to travel a distance 1500 m?
6. For a person with normal hearing, the limit of audibility is 20 Hz to 20000 Hz. If so, what will be the limit of wavelength of sound waves that are audible to human beings? Assume that the speed of sound is 340 m/s.

Extended activities

1. Visit a nearby cinema theatre, find out the arrangements that have been made there in connection with acoustics of buildings and prepare a short note.
2. Prepare a write up about the damages caused in the coastal areas of Kerala by the gigantic Tsunami waves on 26th Dec 2004.

Notes

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While using electricity...

Electricity has become an indispensable part of our day-to-day life. Its consumption has increased and hence the hazards due to this have also increased. Of all the electrical hazards reported in India 10 per cent are from our state. Hence there is no need for specific mentioning to ensure the importance of precautionary measures from electricity related hazards.

Safety measures to be adopted:

- Do not operate switches with wet fingers.
- Do not dry hair using a table fan.
- Do not touch the inner part of the adaptor of a TV. Ensure that the adaptor has a cap which is a non-conductor.
- Do not touch on broken electric wires.
- Do not fly kites near electrical lines.
- Do not use metallic pipes or iron hooks carelessly near electric lines.
- Do not lean against electric posts or stay wires. Cattle should not be tied to them. Do not allow plants or creepers grow on them.
- Switch off the main switch in case of fire on electric appliances or on their vicinity.
- Do not pour water over electric lines or appliances to put out fire. Instead, use dry sand or dry powder type fire extinguishers.
- Use only the electric appliances carrying ISI mark.
- Do not use plastic wires for temporary connections to decorations.
- If a person succumbs to electric shock, he/she should be touched only after disconnecting the electrical contact.
- Detach the victim from the electric connection using dry wooden planks or some dry material which is not a conductor.
- Switch off the main switch immediately, in case electric shock is noted.

Electricity saved is equivalent to electricity generated