PHYSICS

Standard X

Part 2

Government of Kerala
Department of General Education

Prepared by

State Council of Educational Research and Training (SCERT), Kerala
2025

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 respect to my parents, teachers, and all elders, 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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PREFACE

Dear learners,

This book is designed to help you understand the basic concepts and principles of Physics, and inspire you to pursue inquisitive exploration to attain the ability and confidence to apply them in real life situations and contexts.

This textbook will lead you through the frontiers of knowledge and awe–inspiring experiences to the depths of Physics. Your science laboratories will sprout new life when each sight raises the question in you - how and why? The ideas and concepts thus acquired will enable you to have lofty dreams to contemplate on and fulfill them through action.

Each activity in this book will change your perspective from **I** to **We**, upholding the notion that science is for the betterment of society. May you be able to raise new questions, share knowledge, arrive at the apt concepts, impart them to the society and lay the scientific foundation for countering superstitions with science.

Dr.Jayaprakash R K
Director
SCERT, Kerala

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Contents

Certain icons are used in this textbook for convenience

- For further reading (Evaluation not required)
- Questions that may be raised by students
- Continuous assessment questions
- ICT Possibilities
- Let's Assess
- Extended Activities

THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a [1]**[SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC]** and to secure to all its citizens :

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the [2][unity and integrity of the Nation];

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949 do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

---

1. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Sovereign Democratic Republic" (w.e.f. 3.1.1977)
2. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Unity of the Nation" (w.e.f. 3.1.1977)

5 Electric Energy: Consumption and Conservation

You have noticed a situation where electricity is wasted in homes, haven't you?

Do you waste electricity?

Which are the appliances in houses that operate using electricity?

- Tube light
- Fan
-
- Electric kettle
- Electric iron

Fig. 5.1

Are all electrical appliances used for the same purpose?

These appliances convert electric energy into different forms of energy.

What forms of energy are produced when a mixie operates? Write them down.

- Mechanical energy
- Sound energy
-

Isn't the electric energy we supplied that is transformed into various forms when the mixie is operated?

However, the useful form of energy into which an appliance mainly converts electric energy is considered the effect of electric current in that appliance.

Observe the appliances in figure 5.1 and the appliances already listed. Based on their function, identify the effect of electric current utilised in each and complete table 5.1.

Name of the appliance	Function	Energy conversion	Effect of electric current
Electric kettle	Heats water	Electric energy $\rightarrow$ Heat energy	Heating effect
Mixie			
Electric iron			

Table 5.1

From the table, you may have understood that electric current can produce various effects. Which of these appliances produce heat?

- Electric iron
-

Heating Effect of Electric Current

The conversion of electric energy mainly into heat energy is the heating effect of electric current. Appliances that utilise this effect are electric heating appliances.

Let's do an experiment.

Connect a 5 cm long nichrome wire to a 9 V battery as shown in figure 5.2.

- Switch on and observe the nichrome wire. What change do you notice?

When current passes through the nichrome wire, heat energy is produced.

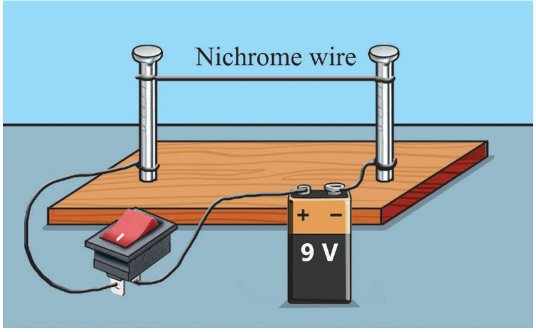
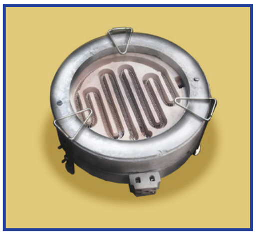


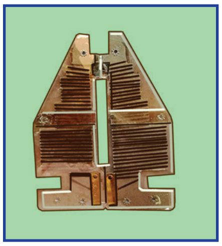
Fig. 5.2

The process of production of heat, when electricity flows through a conductor is Joule heating or Ohmic heating. The part used to produce heat energy in heating appliances is the heating element.

Observe the pictures of the given electric heating appliances.



Electric heater



Heating coil in an iron box

Fig. 5.3

You may have noticed that the part common to all these appliances is the heating coil (heating element).

The heating coil is made of an alloy, nichrome.

What are the characteristics of nichrome that make it suitable for a heating element?

- High oxidation resistance (oxidation resistance is the ability of a material to resist corrosion due to contact with oxygen or other oxidisers at high temperature).
- Ability to provide heat energy for a long time in a red hot state.
- High resistivity (due to this property even a nichrome wire of short length can provide sufficient resistance)
-

Resistivity of certain materials

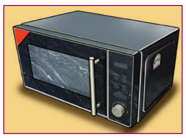
Material	Resistivity (Ωm)
Silver	1.59×10^{-8}
Copper	1.68×10^{-8}
Aluminium	2.65×10^{-8}
Tungsten	5.6×10^{-8}
Iron	9.71×10^{-8}
Lead	22×10^{-8}
Nichrome (Ni, Cr, Fe)	100×10^{-8}

Heating appliances that operate without heating coils are also available. Examples are induction cooker, microwave oven, etc.

Induction Cooker

The induction cooker works on the principle that a continuously varying magnetic field produces heat in a magnetic substance.

Microwave Oven



Only foods with water content can be cooked using a microwave oven. Foods are cooked by converting microwave into heat energy.

We know that all materials do not conduct electricity in the same way.

Resistivity is one of the intrinsic properties of a material that mainly determines the resistance which is the characteristic of a conductor. Resistivity is different for each material.

The resistance of a conductor with an area of cross section of one square metre and a length of one metre is the resistivity of the material of the conductor. It is denoted by the Greek letter ρ (rho). Its unit is ohmmetre (Ωm). You have learnt in standard IX that the factors which influence the resistance of a conductor are length of the conductor (ℓ), area of cross section (A) and the nature of the material (ρ). The relation of resistance (R) with these factors is given by the equation $R = \frac{\rho \ell}{A}$.

Conductivity is the ability of a material to conduct electricity. This is the reciprocal of resistivity.

What are the factors that influence the heat produced in a conductor carrying current?

Let's do an activity.

Construct a circuit which consists of a 5 cm long nichrome wire, 6 V battery eliminator, etc., as shown in figure 5.4. Take 20 mL of water in a boiling tube. Immerse the nichrome wire and a thermometer into it. Adjust the rheostat to vary the current. Record the temperature in table 5.2 every two minutes. Repeat the experiment by replacing the water in the boiling tube each time.

PhET→ Resistance in a wire.

Temperature of water before starting the experiment = ...

Current (A)	Temperature (°C)
0.5	
1	
1.5	

Table 5.2

On analysing table 5.2, didn't you understand that the temperature of water increases with increase in current? In this experiment a fixed quantity of water (20 mL) is heated by passing current. To increase the temperature of a fixed quantity of water more heat is required. Hence as the quantity of heat received by the water increases, the temperature also increases. Therefore, it is understood that when the current increases heat produced also increases.

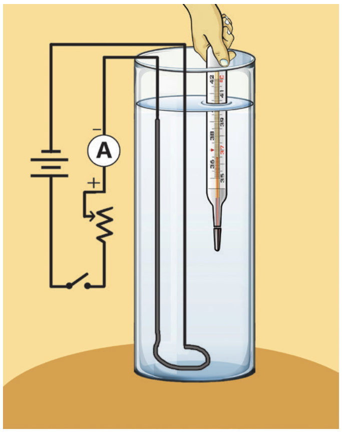


Fig. 5.4

Adjust the rheostat to make the current 1 A. In table 5.3 record the temperature of water, every 2 minutes.

Time (in minutes)	Temperature (°C)
0	
2	
4	
6	

Table 5.3

Didn't the temperature increase because the current flowed for a longer time? From the experiment, you may have understood the relation between the heat produced and the time of flow of current.

- Are there other factors that influence the heat produced in a conductor carrying current? Let's examine.

Take nichrome wire and aluminium wire of equal length (5 cm) and equal area of cross section. Using them make a circuit as shown in the figure. Pass current through the circuit for about 2 minutes using a 9 V, 50 W eliminator. Place a thin paper on both aluminium and nichrome wire. What do you observe?

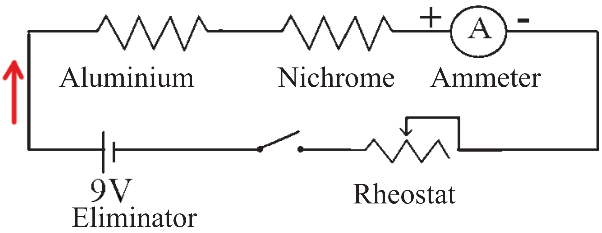


Fig. 5.5

- Which conductor becomes hotter?
- The magnitude of current in the nichrome wire and aluminium wire is
  (the same / different).
- The resistance of nichrome wire and aluminium wire is
  (the same / different).

Didn't the nichrome wire become hotter because its resistance is greater than that of the aluminium wire?

Resistance is another factor that influences the quantity of heat produced in a conductor carrying current.

From the experiments conducted, note down the three factors that influence the quantity of heat produced in a current carrying conductor :

- Current (I)
-
-

The scientist, James Prescott Joule discovered the relation between the heat produced in an electric conductor and the factors influencing the quantity of heat.

Joule's law

The quantity of heat produced in a current carrying conductor is directly proportional to the square of the current (I^2) the resistance of the conductor (R) and the time (t) for which the current flows. This is Joule's law.

If a current I flows through a conductor having resistance R for a time t, according to Joule's law, the quantity of heat produced will be $H = I^2Rt$. Its SI unit is joule (J).

- A current of 0.5 A flows through a conductor with 100 Ω resistance for 5 minutes.

(a) What will be the quantity of heat produced?

(b) If a current of 1 A flows through this conductor for 5 minutes, what will be the quantity of heat produced?

a) $R = 100\ \Omega$

$I = 0.5\ A$

$t = 5 \times 60\ s$

$H = ?$

$H = I^2Rt$

$= 0.5 \times 0.5 \times 100 \times 5 \times 60\ J$

$= 7500\ J$

b) $I = 1\ A, \ H = I^2Rt$

$H = 1 \times 1 \times 100 \times 5 \times 60\ J$

$= 30000\ J$

When the current was doubled, the heat produced in the conductor became 4 times. If so, what happens to the heat produced if the current is halved?

(halved / quartered)

Aren't electrical appliances commonly used in houses operating at 230 V?

- If the resistance of a heating appliance operating at 230 V is 920 Ω, what is the quantity of heat produced in 10 minutes?

The value of current is not given in this numerical problem. In this situation, can we formulate other equations to calculate the quantity of heat?

According to Ohm's law,

$$V = I \times R$$

$$\text{Hence } I = \frac{V}{R}$$

On substituting the value of I in the equation $H = I^2 Rt$

$$H = \left(\frac{V}{R}\right)^2 Rt$$

$$\text{So, we get } H = \frac{V^2 t}{R}$$

Similarly, if we substitute $R = \frac{V}{I}$ in the equation $H = I^2 Rt$

$$\text{we get } H = VIt$$

$$H = I^2 Rt = \frac{V^2 t}{R} = VIt$$

Here

$V = 230$ V, $R = 920\ \Omega$, $t = 10 \times 60$ s,

$$H = \frac{V^2 t}{R}$$

$$= \frac{230 \times 230}{920} \times 10 \times 60 = 34500 \text{ J}$$

If 7500 J of heat is produced in 30 s in a conductor having 250 Ω resistance, what is the current through the conductor?

Calculate the quantity of heat produced if 2 A current flows for 10 minutes through a heating coil of an electric kettle having 100 Ω resistance?

A potential difference of 230 V is applied across a circuit for 5 minutes. If the resistance in the circuit is as given below, calculate the current and heat in each case.

(a) 115 Ω (b) 230 Ω

Observe the circuits given below. Calculate the quantity of heat produced in each, in 5 minutes.

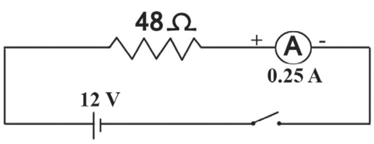


Fig. 5.6 (a)

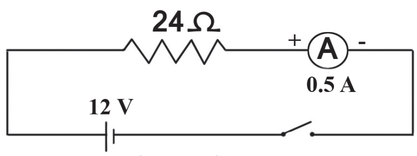


Fig 5.6 (b)

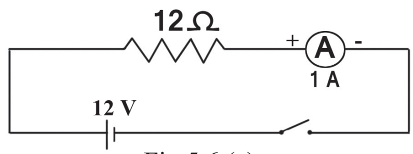


Fig 5.6 (c)

Heat produced in circuit 5.6 (a)	Heat produced in circuit 5.6 (b)	Heat produced in circuit 5.6 (c)
$H = I^2Rt$ $= 0.25 \times 0.25 \times 48 \times 300$ $= 900$ J	$H = I^2Rt$	$H = I^2Rt$

Table 5.4

Analysing the completed table, answer the following questions.

- What is the difference in the quantity of heat in circuits 5.6 (a) and 5.6 (b)?
- Why is there a difference in the quantity of heat produced in these circuits?
- What is the resistance of the circuit in figure 5.6 (c)?
- What is the total heat produced in the circuit in figure 5.6 (c)?
- Less heat is produced in the resistor of higher resistance in the circuit in figure 5.6 (a). Why?
- Among these circuits, in which resistor is the maximum quantity of heat produced?

What are your inferences? Record them in the science diary.

If voltage is constant, when the resistance in the circuit is decreased, the current increases. Hence the quantity of heat produced increases.

If the voltage remains constant, what change will occur in the quantity of heat produced when the resistance varies? Explain based on Joule's law.

Calculate the quantity of heat produced if 2 A current flows through an electric heater operating at 230 V for 15 minutes. What is the resistance of the heater?

An electric iron operating at a potential difference of 230 V has a heating coil of resistance 100 Ω. If this electric iron operates for half an hour, how much electric energy will be converted to heat energy? What is the current through the electric iron?

A heating appliance having a resistance of 92 Ω operates at 230 V. Using various equations, calculate the heat produced by the appliance in 14 minutes and write them down in the table below. What resistance is needed to double the heat energy?

$H = I^2Rt$	$H = \frac{V^2 t}{R}$	$H = VIt$
$V = 230\ V$ $R = 92\ \Omega$ $t = 14$ minute $= 14 \times 60\ s = 840\ s$ $I = \frac{V}{R} = \frac{230\ V}{92\ \Omega} = 2.5\ A$ $H = I^2Rt$ $= (2.5)^2 \times 92 \times 840\ J$ $= 483000\ J$		

Table 5.5

Is there any other method to find the quantity of heat produced by heating appliances?

Observe the values given on the label of the appliance in figure 5.7. What does the marking 750 W indicate?

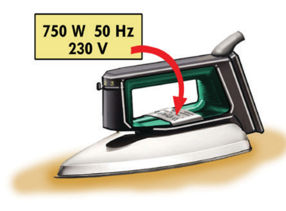


Fig 5.7

Energy conversion occurs when this appliance operates. That is, work is done. The quantity of work done per unit time is power. We have already learned in standard IX that power is the rate of work based on time.

- How can we find the rate of work of an electrical appliance based on time?

Electric Power

Power is the quantity of work done by an electrical appliance per unit time.

The work done by an electrical appliance is the conversion of electric energy into another form of energy.

The function of electric heating appliances is to produce heat. You have learnt that the quantity of heat produced $H = I^2Rt$.

$$\text{Work} = \text{Quantity of heat produced}$$

$$W = H = I^2Rt$$

$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$

$$P = \frac{W}{t} = \frac{H}{t}$$

$$P = \frac{I^2Rt}{t}$$

$$P = I^2R$$

According to Ohm's law $I = \frac{V}{R}$

Then, P = ...

We know that $R = \frac{V}{I}$

Hence P = ...

We will get the equations $P = \frac{V^2}{R}$, $P = VI$ as well

$$P = I^2R = \frac{V^2}{R} = VI$$

If we substitute the value of P in the equations used to calculate heat, $H = I^2Rt$, what will be the value of H?

We get $H = Pt$

It is understood that the quantity of heat produced in a given time can be found if the power of an appliance is known.

The power of each electric appliance is marked on it. Complete the table given below.

Device	Power (P) W	Energy consumed in 1 second ($Pt = P \times 1$)
LED Bulb	9	$= 9 \times 1 = 9$ J
Projector	100	
Fan	60	
Laptop	40	

Table 5.6

While labelling the power of an appliance, the voltage at which it is to be operated is also indicated. In our country, the power obtained while operating at 230 V is labelled on electrical appliances. If the appliance operates above or below 230 V, the power will vary accordingly. That is, if the voltage increases, the power increases and if the voltage decreases, the power also decreases. This may lead to the damage of appliances. (There are also some appliances that operate at 400 V).

Countries design electrical appliances and power according to their power supply voltage. In all electrical appliances, the voltage required for it and its power will be marked on it. The indicated power is available from an appliance only when it operates at the specified voltage.

Power : in watt (W) and volt ampere (VA)

Both are used to indicate power, but there is a small difference.

The actual power consumed by electrical appliances is recorded in watt (W). For example, bulb, electric iron, etc.

But the power that can be supplied by electric power generating devices is given in volt ampere (VA). For example, UPS, solar panel, etc.

1 kW = 1000 W

1 kVA = 1000 VA

If the voltage is constant, according to $P = \frac{V^2}{R}$, appliances with higher resistance will have lower power, and those with lower resistance will have higher power. While solving numerical problems related to household appliances, it is more desirable to use the formula $P = \frac{V^2}{R}$.

In some foreign countries, the supply voltage is 110 V.

At what applied voltage will an electric heating appliance marked 800 W, 240 V produce a power of 200 W?

Calculate the quantity of heat produced when a heating appliance of power 500 W operates for five minutes.

$P = 500\ W$

$t = 5\ min$

$= 5 \times 60 = 300\ s$

$H = Pt = 500 \times 300\ J$

$= 150000\ J$

How much heat energy is produced when an electric heater with 600 W power operates for 20 minutes?

How much heat energy will be produced if a heating appliance with 250 W power operates for 10 minutes?

An electric heater produced 450000 J of heat energy when operated for 5 minutes. What would be the power of this heater?

On a heating appliance it is marked 529 W, 230 V.

a) What do each of these mean?

b) What would be the power of this appliance if 100 V is supplied?

Don't we use many types of electrical appliances in our daily lives? If so, let's see how the quantity of electric energy that we use, is calculated.

Watt - Hour Meter

Fig. 5.8

The quantity of electric energy consumed in houses can be measured directly by a watt hour meter connected to our household electric circuit. In this, electric energy is measured in kilowatt hour (kWh) units. This is the commercial unit of electric energy.

How much electric energy is one kilowatt hour or one unit?

Power is expressed in watt, time in second, and energy in joule. The energy consumed if a 9 W bulb operates for one hour daily for 30 days is $E = Pt = 9 \times 30 \times 3600$ J = 972000 J (nine lakh seventy two thousand joules). So, if we consider the monthly energy consumption of all the appliances in a house, the total would be very large, making it inconvenient to record. Therefore, energy is calculated in kilowatt hour by measuring power in kilowatt and time in hour.

- Calculate the energy consumed by a 1 kW power appliance in one hour.

$$E = Pt = 1\ kW \times 1\ h$$
$$= 1\ kWh$$

One kilowatt hour or one unit of electric energy is the energy consumed by an appliance with 1000 W (1 kW) power in one hour.

Let's see how many joules of energy is one unit of electric energy.

$$1000\ W = 1\ kW$$

Energy consumed, $E = H = Pt$

$P = 1000\ W,\ \ t = 1\ h = 60 \times 60\ s$

$H = 1000 \times 60 \times 60\ J$

$= 3600000\ J = 3.6 \times 10^6\ J$

- How much heat energy will be produced when a heating appliance of 60 W operates for one hour?

$H = Pt$

$= 60 \times 1 \times 60 \times 60\ J$

$= 216000\ J$

The power and operating time of some appliances are given in the table. Complete the table.

Power of device (P) W	**Time (t) h**	**Electric energy spent (Pt) J**	**Energy utilised in unit (kWh)** $= \frac{\text{Power in watt}}{1000} \times \text{hour}$
1000	1 hour	1000 × 60 × 60 = 3600000 J	1 kWh = 1 unit
2000	1 hour		
500	1 hour		
500	2 hour		

Table 5.7

Calculate the electric energy consumed if a 500 W grinder and a 600 W electric iron each operate for 2 hours.

$$\text{Total power in watt} = 500\text{ W} + 600\text{ W}$$
$$= 1100\text{ W}$$
$$\text{Time} = 2\text{ h}$$
$$\text{Electric energy (in kilowatt hour)} = \frac{\text{Power in watt} \times \text{time in hour}}{1000}$$
$$= \frac{1100\text{ W} \times 2\text{ h}}{1000}$$
$$= 2.2\text{ kWh}$$
$$= 2.2\text{ unit}$$

Using this formula, we can calculate the monthly consumption of electricity.

Considering the total power of the appliances used and their operating time, calculate the daily electricity consumption in your house. Similarly, calculate the monthly consumption of electricity and present in class the main findings and suggestions based on the project report.

Let's see if all houses have the same electricity tariff.

Electricity charges are levied at a higher rate from consumers who use more electricity and at a lower rate from consumers who use less electricity. (Table 5.8, page 112)

- Now you have understood one of the reasons for the increased consumption of electricity in the situation depicted at the beginning of the lesson.

Have you noticed the energy consumption recorded in the electricity bill of your house? The amount in the electricity bill can be reduced by lowering electricity consumption.

TOD billing [Time Of the Day billing]

TOD billing is an innovative billing system introduced by KSEB to control electricity consumption during peak hours (6 pm to 10 pm). According to this, a day is divided into three time zones for the calculation of energy consumption. From 6 am to 6 pm, the billing rate is minimum. The time zone from 6 pm to 10 pm is considered the peak time with the highest charge. The time zone from 10 pm to 6 am is considered for normal charge. Therefore, please ensure that high power appliances like electric iron, motor pump, refrigerator, grinder, AC, etc., are operated during the minimum charge time zone.

Energy Star Rating

Normally ratings range from 1 to 5 stars. 5 stars represent the highest energy efficiency.

The energy consumption of higher star rated appliances is low when compared to similar low star rated appliances. Bureau of Energy Efficiency (BEE), an agency under Government of India assigns the star values.

The advantages of choosing higher star rated appliances :

- Lower electricity bills : By consuming less energy, you can reduce your monthly electricity costs.
- Environmental impact : Energy efficient appliances help to reduce greenhouse gas emissions.
- Government benefits : Many governments offer rebates or incentives to purchase higher star rated products.

- What can we do to reduce electricity consumption at home?
  - Use energy efficient electrical appliances.
  - Turn off switches immediately after use.
  - Use LED tubes and bulbs.
  - Choose the size of the fan according to the size of the room.
  - Use BLDC fans. [BLDC – Brush Less Direct Current]
  -

Further activities to reduce energy consumption can be implemented under the leadership of the School Energy Club in collaboration with the Energy Management Centre (EMC).

Energy Crisis

Despite having many small scale electricity projects in addition to large power stations, the electricity they produce is not sufficient for our needs. Though the demand for energy has increased many folds, production has not sufficiently increased. This situation is energy crisis. This is why sometimes power cuts and load shedding are to be implemented.

'Energy crisis is the increase in demand for energy and the decrease in availability.'

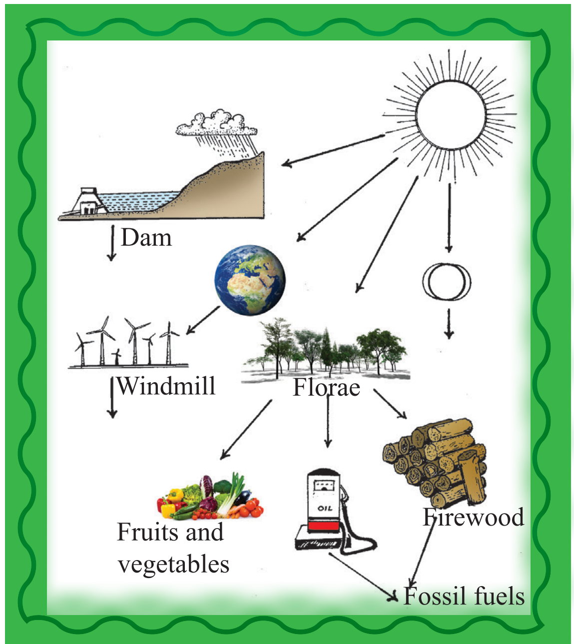


Fig. 5.9

There are hydroelectric power plants, thermal power plants, nuclear power plants, etc., to produce electricity on a large scale. Yet, it is not easy to increase the electricity production. Do large scale electricity generating power plants cause environmental impacts? Discuss

Is there any way to produce electricity without causing pollution?

Observe figure 5.9. You know that the sun is the basis of all energy on the earth.

List the devices that utilise solar energy.

- Solar water heater
- Solar cooker
-

The solar power plant at Cochin International Airport : This energy is used for all airport operations. The remaining is given to KSEB. This green energy initiative received the United Nations' highest environmental award in 2018.

Solar cells are devices that convert solar energy into electric energy. Only negligible voltage and current can be obtained from a single cell. Therefore, a solar panel is constructed by arranging many solar cells suitably to provide electricity as per the requirement. The electricity obtained from such panels can be stored in a storage battery and utilised when needed. Or it can be directly supplied to the electricity distribution agencies. Solar panels are used for energy requirements in artificial satellites. In addition to small scale requirements, large scale solar power plants are also in operation. Cochin International Airport Limited (CIAL) in Nedumbassery, Kerala, produces electricity required for its entire operations from such a solar power plant.

Cochin International Airport is the world's first airport to operate entirely on solar power.

Solar panels can be installed on rooftops of houses and other places receiving sunlight. The Rooftop Power Project is a scheme jointly initiated by the Central Government and KSEB for this purpose.

Rooftop Power Project

List the benefits of installing solar panels.

- Can produce electricity required for homes.
- Can reduce environmental pollution.

Fig. 5.10

- Transmission and distribution losses are minimised as electricity is generated at the place of consumption.

Let's work together for a better tomorrow by implementing such innovative activities and taking measures to reduce the energy crisis.

It is understood that atmospheric pollution is reduced when solar panels are used. We know that the quantity of greenhouse gases in the atmosphere is increasing daily. An increase in such gases cause global warming, resulting in climate change. Each of our interventions in this matter is very important. Global warming can be reduced by reducing the production of major greenhouse gases like carbon dioxide, methane etc. We need activities that can reduce the quantity of carbon and carbon compounds emitted by individuals, organisations, and products.

Carbon footprint

Greenhouse gases are directly and indirectly emitted by individuals, families, organizations, events, services, products, etc. The quantity of such emitted greenhouse gases, converted and expressed as equivalent to the measure of carbon dioxide, is carbon footprint.

Fig. 5.11

Each individual should strive to reduce his/her personal carbon footprint. This can be achieved by paying attention to daily activities. How one travels, what food one eats, what clothes one uses, and how much waste is generated are all important.

What can be done to reduce carbon footprint?

- Reduce domestic energy consumption.
- Avoid wasting food.
- Use public transport.
- Reduce waste by utilising reusable products.
- Educate society about reducing carbon footprint.
- Perform energy consuming activities in an energy saving manner.

Prepare a seminar paper on how to reduce individual carbon footprint and present it in class.

‘Reducing atmospheric pollution and conserving energy is everyone's duty. Energy conservation is equivalent to energy production.’

‘Energy is precious, don't waste it !’

Let's Assess

1. An electric heater operating at 230 V draws 2 A current.

   a) What is the resistance of the heater?

   b) Calculate the heat produced when this heater operates for 10 minutes.

   c) What is the power of this appliance?

2. a) A heating appliance operating at 230 V supply consumes 2 A current. What is the quantity of heat produced in five minutes?

   b) What is the energy consumed by this appliance in five minutes while operating at 115 V?

3. In a house, a 500 W electric iron operates for one hour, two 40 W fans for 8 hours, and five 12 W LED bulbs for 10 hours. Calculate in unit the energy consumption per day in that house.

The tariff of electricity for domestic consumers in Kerala is given below (subject to change).

Monthly Consumption kWh	Fixed Charge Rs./Consumer /Month		Energy Charge per unit	Remarks
	Single Phase	Three Phase		
0 - 40	Nil		1.50	This Rate is Applicable only for BPL Category with Connected load of And below 1000 W
0 - 50	50	130	3.35	Telescopic
51 - 100	85	175	4.25	
101 - 150	105	205	5.35	
151 - 200	140	215	7.2	
201 - 250	160	235	8.5	
0 - 300	220	240	6.75	Non-Telescopic
0 - 350	240	250	7.6	
0 - 400	260	260	7.95	
0 - 500	286	285	8.25	
Above 500	310	310	9.2	
0 - 50	40	100	1.50	BPL family having Cancer Patients or Permanently Disabled person as family members due to polio or accidents with Connected load of And below 2000 W
51 - 100	65	140		

Source : Official website of KSEB

Table 5.8

4. In a house, a 600 W grinder operates for one hour, three 60 W fans for six hours, and ten 10 W LED bulbs for 10 hours daily.

   a) What will be the electric energy consumed in units per month?

   b) If the appliances operate in the same way, calculate the electricity bill for two months in that house. (Use the tariff given in table 5.8)

5. Two heaters A and B operate at 230 V. Heater A draws 2 A current and heater B draws 2.5 A current.

   a) Calculate the power of the heaters in figure 5.12 (a) and (b).

   b) Which heater has higher resistance?

   c) If both heaters operate for 5 minutes each, which heater will produce more heat?

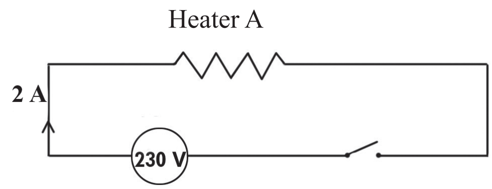


Fig. 5.12 (a)

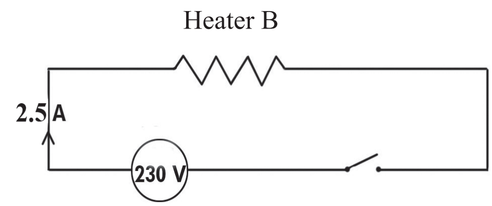


Fig. 5.12 (b)

6. Which of the given statements is correct with regard to the heating element?

   a) Low melting point

   b) High resistivity

   c) Ability to remain in red hot state

   d) Low oxidation resistance

   e) High melting point

   f) High oxidation resistance

   i. abfc ii. abfe iii. bdfe iv. bcef

7. Two bulbs, 230 V, 40 W and 230 V, 60 W are arranged as shown in the figures.

   If 230 V is applied, which bulb will be brighter in each circuit? Explain the reason.

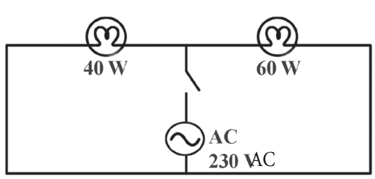


Fig. 5.13 (a)

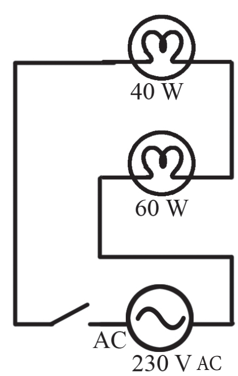


Fig. 5.13 (b)

8. To reduce electricity consumption in our houses, we can maximise the use of sunlight during the day. Do you agree with this statement? Explain how.

9. In the context of the energy crisis, write down any two suggestions that can be implemented to reduce energy consumption in newly constructed houses.

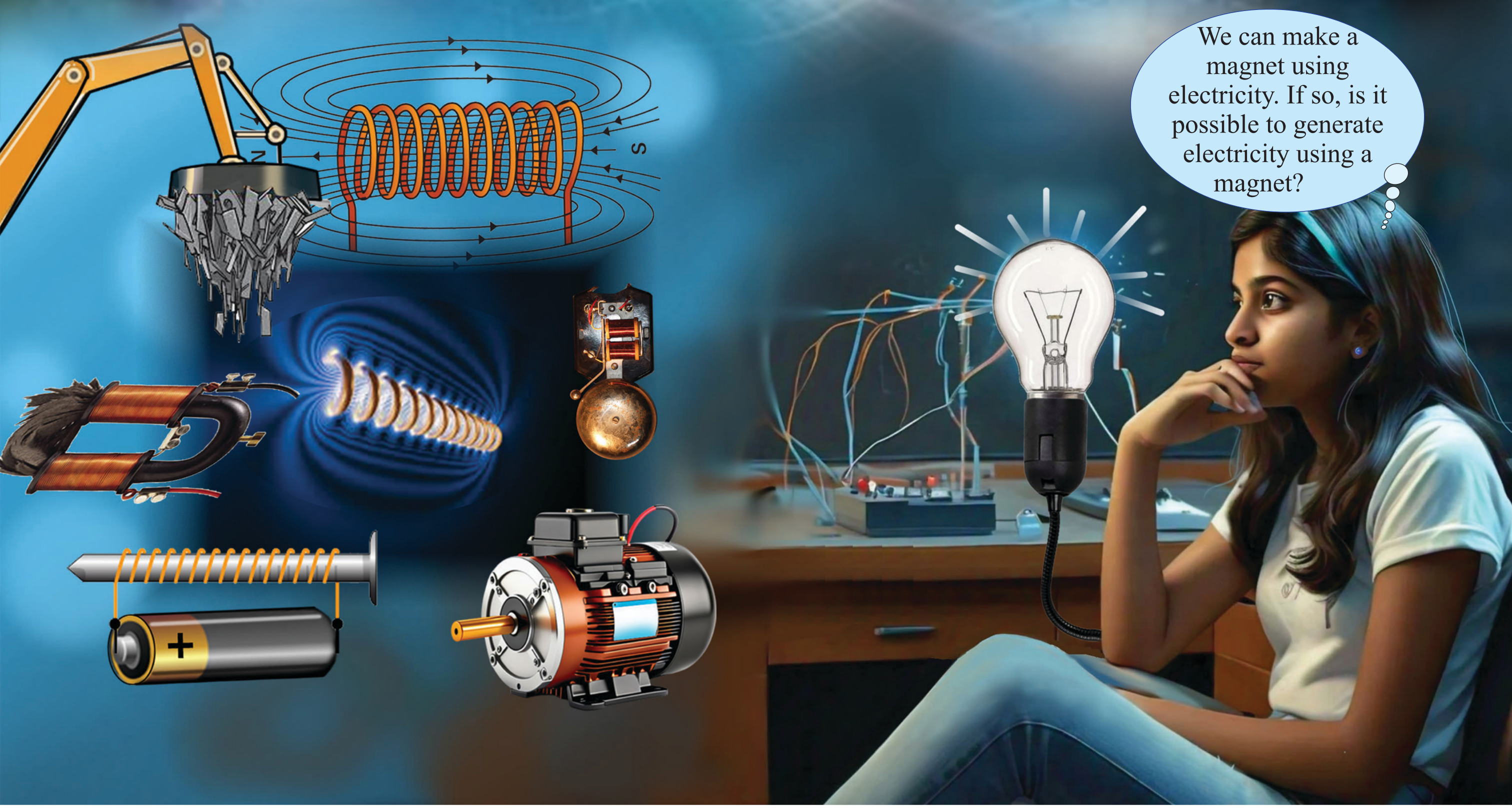
10. What is the necessity for reducing carbon footprint?

Extended activities

1. Observe the electricity bill of your house and find out the monthly electricity consumption. Present activities that can be implemented in your house to reduce electricity consumption in a seminar in the Energy Club. Also, prepare necessary posters for this.

2. List the activities that the School Science Club intends to undertake to reduce the school's carbon footprint.

6 Electromagnetic Induction in Daily Life



Did you notice the doubt of the child in the picture? Have you ever thought like this? Various types of electromagnets are used for different purposes. Some of them are given below. Find out more examples and write them down.

- Electric crane
- Electric bell
-

In all these, electric energy is converted into magnetic energy. You might have made an electromagnet by winding insulated copper wire over a soft iron core and passing electricity through the wire. This demonstrates that magnet can be made using electricity. It was from this thought that Michael Faraday arrived at the principle of electromagnetic induction and the invention of the generator.

Electromagnetic Induction

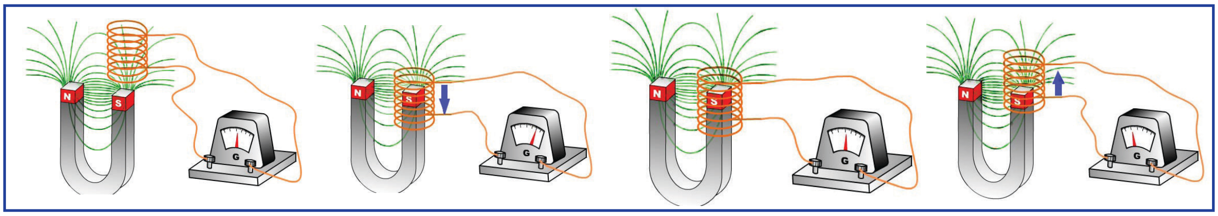
You have learned that a current carrying conductor placed in a magnetic field experiences a force and develops a tendency to move.

If so, what happens when

- a conductor is moved in a magnetic field?
- a magnetic field is moved near a stationary conductor?

Let's do an activity.

Arrange a magnet, a conductor in the shape of a solenoid and a galvanometer as shown in the figure. You know that a solenoid is an insulated coil of wire.



(a) (b) (c) (d)

Fig. 6.1

Do the activities given in table 6.1 and record your observations.

Serial Number	Activities	Galvanometer needle	
		(deflects / does not deflect)	Direction (Left / Right)
1	Solenoid is stationary near the magnet - Fig. 6.1 (a)		
2	Solenoid is moved towards the magnet - Fig. 6.1 (b)		
3	Magnet is stationary inside the solenoid - Fig.6.1 (c)		
4	Solenoid is pulled out from the magnet - Fig.6.1 (d)		
5	Keeping the solenoid stationary, the magnet is moved upwards		
6	Keeping the solenoid stationary, the magnet is moved in the opposite direction		
7	Keeping the magnet inside the solenoid,both the magnet and the solenoid are moved together at the same speed in the same direction.		

Table 6.1

Based on the table, answer the questions given below.

- What happens to the magnetic field lines associated with the conductor when the conductor and the magnet are in relative motion?
  (a change in flux / no change in flux)
- Which are the situations where galvanometer needle deflected?
  (when the magnetic flux associated with the conductor is changed / when there is no change in the magnetic flux associated with the conductor)
- Why did the galvanometer needle deflect?
- When did the direction of deflection of the galvanometer needle change?
- Why did the direction of deflection of the galvanometer needle change?

Whenever the magnetic flux linked with a closed circuit changes, an emf is induced in the circuit. This phenomenon is electromagnetic induction.

It is evident that when the direction of the change in magnetic flux is reversed, the direction of the induced emf also reverses.

The phenomenon of inducing an emf across a conductor due to a change in the magnetic flux linked with the conductor is electromagnetic induction.

The emf (electromotive force) developed due to electromagnetic induction is the induced emf and the current thus produced is the induced current.

It was Michael Faraday who discovered experimentally that electricity can be produced using a conductor and a magnetic field.

Repeat the previous experiment by making the following changes:

- Using strong and weak magnets
- Using solenoids with a different number of turns per unit length
- Moving the magnet or the coils at different speeds

Observe what changes occur in the deflection of the galvanometer needle or in the magnitude of the induced emf in each case.

The induced current resulting from the induced emf caused the deflection of the galvanometer needle.

Activity	Deflection of the galvanometer needle (with respect to the previous experiment)
When the number of turns per unit length of a coil is increased	more / less
When the strength of the magnet is increased	more / less
When the speed is increased	more / less

Table 6.2.

Analyse table 6.2 and write down methods to increase the emf and current.

Is there any difference between the current induced as a result of electromagnetic induction and the current obtained from a battery?

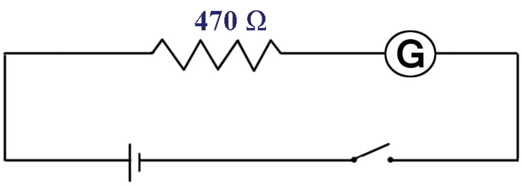


Fig 6.2

Let's do an activity.

Connect a 1.5 V cell, a 470 Ω resistor, a switch and a galvanometer in series. Turn on the switch. Observe the deflection of the galvanometer needle.

- The needle of the galvanometer
  (deflects to both sides / deflects in only one direction)

You have understood that the direction of the flow of current does not change here.

Current that flows only in one direction is Direct Current (DC).

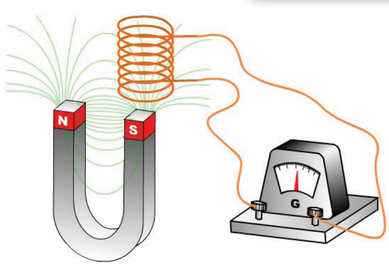


Fig. 6.3

Repeat the activity with the magnet and coil.

Move the solenoid connected to the galvanometer rapidly towards and away from the magnet. Observe the galvanometer needle.

- What change do you observe in the deflection of the galvanometer needle?
- Is the induced current in the same direction?

Record your inference.

While observing the galvanometer needle, it is understood that the direction of the current is changing continuously.

Current that continuously changes direction at regular intervals of time is Alternating Current (AC).

You have understood that there are two types of current, AC and DC.

PhET→ Faraday's Electromagnetic Lab

? Tabulate situations where DC and AC are used.

Operates on DC	Operates on AC
• Mobile phone •	• Mixie •

Table 6.3

Is it in the same manner that electricity is generated on a large scale?

What arrangements are required to generate electricity on a large scale? Write down based on the previous activities.

- Powerful magnet
- Mechanism for movement
-

Generator

Observe figure 6.4. You might have seen this. Can you identify it?

- What is its use?
- What is the energy transformation that occurs here?

Generator
Fig. 6.4

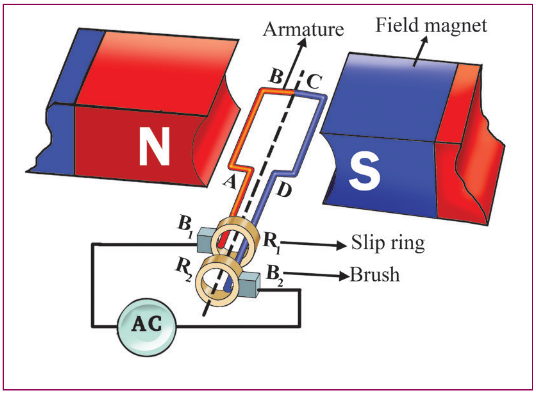
A generator is a device that converts mechanical energy into electric energy based on the principle of electromagnetic induction. Generators are of two types:

- ♦ AC generator
- ♦ DC generator

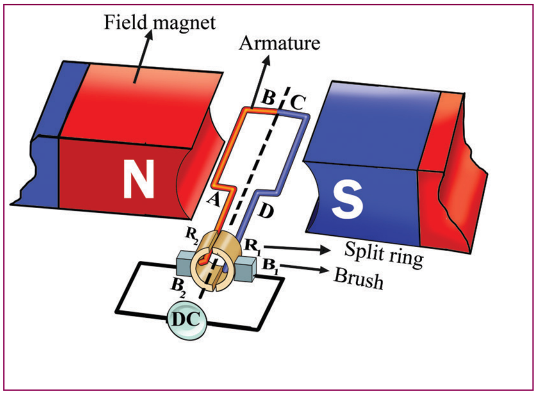
When we move a magnet towards an insulated coil or bring an insulated coil towards a magnet, the work we do (mechanical energy) is converted into electric energy.

Observe the schematic diagrams, identify the main parts of each generator, and note them down in your science diary.

Haven't you already learnt the parts of a motor?



AC Generator
Fig.6.5



DC Generator
Fig 6.6

Parts	AC Generator	DC Generator
NS	Field magnet	
ABCD		
B_1, B_2		
R_1, R_2		Split ring

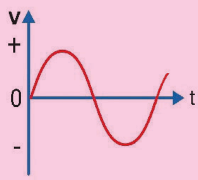
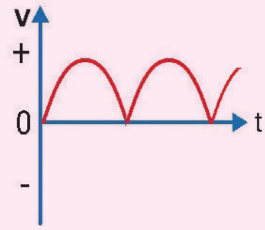
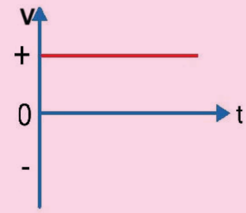
Table 6.4

KITE GNU Linux 22.04 - Desktop - AC- DC Generator

- What happens to the magnetic field lines linked with the armature coil, when the armature of the generator rotates?
- Will current be induced in the armature when there is change in flux?
- Will there be a change in the direction of the current induced in the armature?
- Will the current induced in the armature be AC or DC?
- Which mechanism transfers the current induced in the armature to the external circuit?

  AC generator : Slip rings, Brushes

  DC generator : ...., ...
- What is the function of split rings in a DC generator?
- Write down the similarities and differences between AC and DC generators.
- What type of electricity will be obtained in the external circuit if the armature of a DC generator is kept stationary and the field magnet is rotated? Why?

AC generator	DC generator	Cell
		

Graphical representation of current obtained from AC generator, DC generator and cell

Table 6.5

Is the electricity that reaches our homes produced by the same type of generators used in shops and other establishments?

It is not practical to generate electricity required for homes and large establishments using mini generators. Hence, centres have been established for large scale electricity generation. These centres which produce electricity on a large scale for distribution are power stations. Information about power stations is provided in the table. There are various types of power stations. Power stations are named based on the energy used to operate the generators.

The majority of the world's electricity needs are met by the three types of power stations listed below.

		
Thermal power station Thermal power station is a power station that generates electricity by operating a generator using fuels like CNG, coal, etc. About 75% of electricity generation in India is from thermal power stations.	**Nuclear power station** Nuclear Power Stations generate electricity by using nuclear energy to convert water into steam. This rotates turbines, which in turn operate generators to generate electricity.	**Hydroelectric power station** Hydroelectric power stations utilise the force of water that is collected and stored at a height. This water is then directed downwards through penstock pipes. The immense pressure of the flowing water rotates turbines, which in turn operates generators to produce electricity.
Eg : Mettur (Tamil Nadu), Brahmapuram (Kerala)	Eg : Koodamkulam, Kalpakkam (Tamil Nadu)	Eg : Moolamattom, Pallivasal(Kerala), Thehri (Uttarakhand)

Table 6.6

- By what name are the centres that produce electricity on a large scale using large generators known as?
- Write down the energy transformation that takes place in each power station.

Thermal power station	Heat energy $\longrightarrow$ Electric energy
Nuclear power station	………..... $\longrightarrow$ …….............
Hydroelectric power station	…....….. $\longrightarrow$ ....

Table 6.7

There are power stations that generate electricity using wave energy, wind energy, solar energy, geothermal energy and tidal energy. Find more information about such power stations, including their advantages and limitations, and present a seminar in class.

Write down the similarities and differences between nuclear power station and thermal power station.

Write down in order the energy transformations that occur in a hydroelectric power station.

How does the electricity generated in power stations reach our houses?

Observe the figures.

Fig. 6.7 (a)

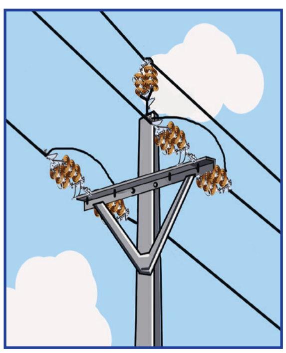


Fig. 6.7 (b)

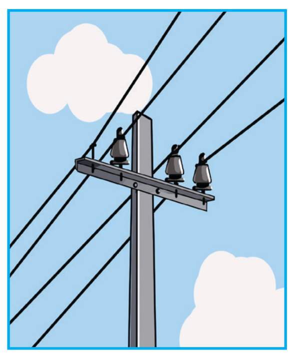


Fig. 6.7 (c)

The AC generated in power stations reach our homes through conducting wires.

- Is there a possibility of energy loss when electricity is transmitted over long distances from power stations through conducting wires? Answer based on Joule's Law.
- The energy loss primarily occurs in the form of heat. How can this be minimised?

Let's see.

What are the three factors that influence the quantity of heat produced when current flows through a conductor?

- Current (I)
-
-

If the values of these factors are reduced, the quantity of heat produced can be reduced and thus energy loss can be minimised.

- ♦ It is not practical to reduce time.
- ♦ To reduce resistance, use materials with low resistivity.

Examine table 6.8 and identify the metals with low resistivity. From these, find out the one with lowest cost and write down the most suitable metal. Reducing resistance beyond a certain limit is not practical.

Current (I) is the third factor that needs to be reduced to minimise energy loss.

- Can current be reduced?
- According to the formula P = VI, if the current (I) is reduced, what change occurs in the power (P)?
  (increases / decreases)
- How can we reduce current without decreasing power?
  (increase the voltage / decrease the voltage)

Metal	Resistivity (Ωm)
Silver	1.59×10^{-8}
Copper	1.68×10^{-8}
Gold	2.44×10^{-8}
Aluminium	2.65×10^{-8}
Tungsten	5.60×10^{-8}
Iron	9.71×10^{-8}

Table 6.8

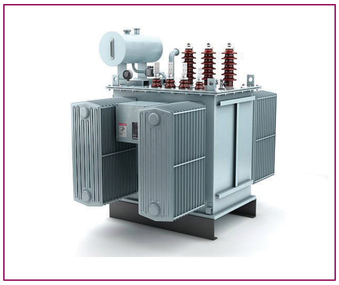
Based on the points discussed above, write down the methods to minimise energy loss while transmitting electricity over long distances through conducting wires.

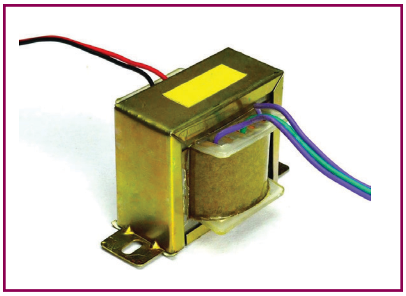
- Use suitable metal wires with low resistivity.
- Increase voltage and decrease current without changing power.

Which is the device that helps to increase voltage without change in power?

Transformer

Observe the different types of transformers.





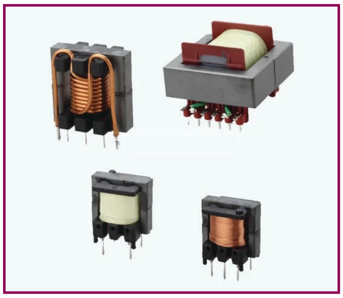


Fig. 6.8

Let's do some activities to understand how transformers work.

Materials needed :

PVC pipe - 1 [12 cm long with 4 cm (1.5") diameter]

PVC pipe - 1 [12 cm long with a 2.5 cm (1") diameter]

Insulated copper wire-28 gauge (250 g)

9 V DC and 9 V AC source

Galvanometer

Soft iron

Wind approximately 600 turns of insulated copper wire around each PVC pipe.

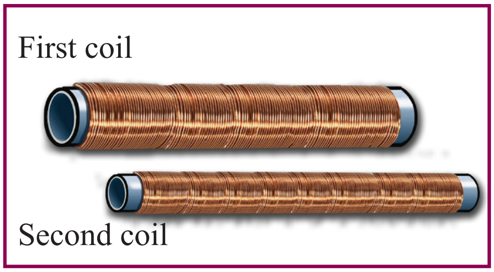


Fig. 6.9

Connect a 9 V DC source and a switch to the ends of the first coil. Connect a voltmeter between the ends of the second coil. Arrange them as close as possible, without touching each other.

Do the activities given below and observe the galvanometer needle. Record your observations.

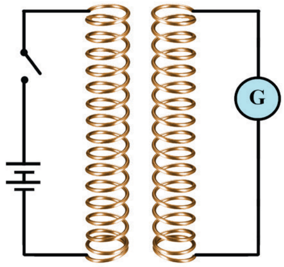


Fig. 6.10

Activity	Galvanometer needle deflects / does not deflect
The switch is turned on	
The switch is in the on position	
The switch is turned off	
The switch is in the off position	

Table 6.9

Based on the activities in table 6.9, answer the questions below.

- In which situations does the galvanometer needle deflect?
- Is there a magnetic field around the coil when the switch is in the off position ?
- What about while turning on the switch?
- While turning on the switch, does the magnetic field linked with the second coil change?
- If so, will current be induced in the second coil due to electromagnetic induction?
- What methods can be adopted to induce current continuously in the second coil?
- Repeat the activity by supplying AC instead of DC to the first coil. What is your observation?

You may have observed that the current is continuously induced in the second coil.

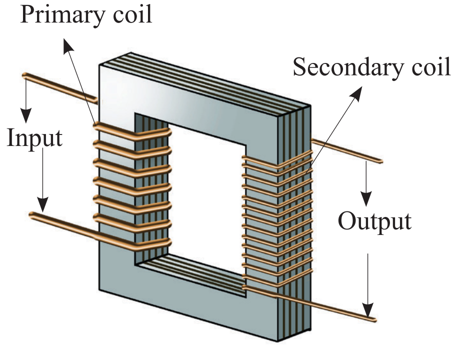
This phenomenon is mutual induction.

Consider two coils kept close to each other. When the intensity or direction of current in one of them changes, the magnetic field around it changes. As a result, an emf is induced in the second coil. This phenomenon is mutual induction.

Repeat the activity in the following ways and observe the change in the induced current.

- By inserting the smaller coil inside the larger coil.
- By inserting a soft iron core inside the smaller coil.

Write down your conclusion.



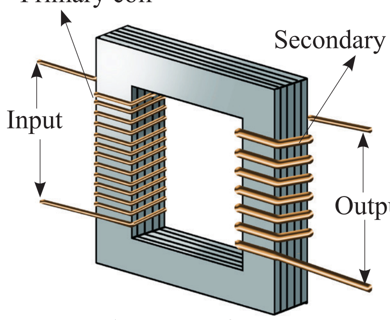
Stepup transformer
Fig. 6.11 (a)

Transformer is a device that works on the principle of mutual induction. Transformers change AC voltage without change in power.

Transformers are of two types.

1. Stepup transformer
2. Stepdown transformer

Stepup transformer is used to increase AC voltage and stepdown transformer to decrease AC voltage.



Stepdown transformer
Fig. 6.11 (b)

Observe the figure and answer the questions given below.

- To which coil of the transformer is AC supplied?
- In which coil is the AC induced?
- What are the structural differences between stepup transformer and stepdown transformer?

Stepup transformer	Stepdown transformer
	• Thin wires are used in the primary
• The primary has lesser number of turns than the secondary.	

Table 6.10

How does a transformer change voltage?

In an ideal transformer, the induced emf per turn is equal in both coils. Based on this, complete the table below.

Number of turns of coils in the primary (N_P)	Voltage applied across primary coil (V_P)	Voltage induced in one turn (e)	Number of turns of coils in the secondary (N_S)	Induced voltage in the secondary ($V_S = N_S \times e$)
100	100 V	1 V	100	100 × 1 V = 100 V
100	100 V	1 V	200	200 × 1 V = 200 V
200	100 V	………	400	…….
200	400 V	…….	100	……
200	…….	2 V	……	400 V

Table 6.11

Analysing table 6.11, what conclusions can you arrive at?

In the transformer, calculate the ratio of the number of turns in the secondary to the primary coil in each case. Also, calculate the ratio of the voltages across the secondary to the primary.

The ratio of the number of turns in the secondary to the primary in the transformer $\left(\frac{N_s}{N_p}\right)$ will be the same as the ratio of the voltages across the secondary to the primary $\left(\frac{V_s}{V_p}\right)$.

That is $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

A transformer with no power loss operating at 240 V AC supplies 12 V to an electric bell connected to it. Calculate the number of turns in the secondary, if the primary coil of the transformer has 4000 turns.

$V_p = 240$ V, $V_s = 12$ V, $N_p = 4000$, $N_s = ?$

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}\ ;\ N_s = \frac{V_s \times N_p}{V_p} = \frac{12 \times 4000}{240} = 200 \text{ turns}$$

A transformer with no power loss operating at an input voltage of 230 V has 120 turns in the secondary and 1200 turns in the primary. What is the output voltage of this transformer?

In a transformer with no power loss (Ideal transformer), the power in the primary is equal to the power in the secondary.

When a transformer is used to change the AC voltage, does the current change?

Let's see.

An appliance connected to a stepdown transformer operating at 200 V consumes 1000 W of power. Suppose 100 V is obtained across its secondary.

Primary Power = Secondary Power	
$P_p = 1000$ W	$P_s = 1000$ W
$V_p \times I_p = 200$ V × 5 A = 1000 W	$V_s \times I_s = 100$ V ×10 A = 1000 W

Table 6.12

- Observe table 6.12 and write down the change that occurs in the current when the voltage decreases.
- What happens to the current, when the voltage increases?

$$V_p \times I_p = V_s \times I_s \quad \text{or} \quad \frac{I_p}{I_s} = \frac{V_s}{V_p}$$

The secondary voltage of a stepup transformer will be higher than its primary voltage and the secondary current will be lower than its primary. The secondary voltage of a stepdown transformer will be lower than its primary voltage and secondary current will be higher.

? **In a transformer with no power loss (Ideal transformer), the primary has 3000 turns and the secondary has 150 turns. The primary voltage is 120 V and the current is 0.1 A. Calculate the secondary voltage and current.**

You have now understood that a stepup transformer can be used to reduce current of AC without power loss. Therefore, transformers play a very important role in AC power distribution.

Power Transmission and Distribution

Observe figure 6.12 and discuss how electricity generated in a power station reaches houses and other establishments.

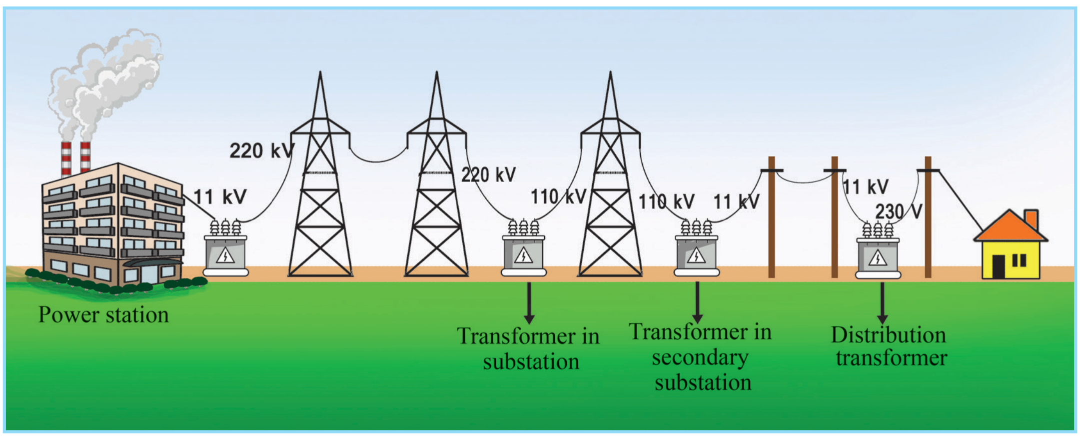


Fig. 6.12

- At what voltage is electricity generated in a power station?
- Which type of transformer is used in a power station?
- 11 kV electricity is generated in the power station. To what voltage is it stepped up? (220 kV/110 kV)
- Where does the electricity reach after travelling through high voltage transmission lines?
- Where are stepdown transformers used?

- To what voltage is 11 kV AC reduced in a distribution transformer?
- What is the voltage of electricity supplied to houses?

Observe figure 6.12, analyse the answers to the questions and prepare a short note on power transmission and distribution.

? **Explain the role of transformers in power transmission.**

? **What is the necessity of increasing the voltage of electricity generated at 11 kV in a power station?**

? **What is the voltage used for domestic distribution?**

How does electricity reach the electrical appliances we use in our homes?

Household wiring

Observe the diagram of a household electric circuit.

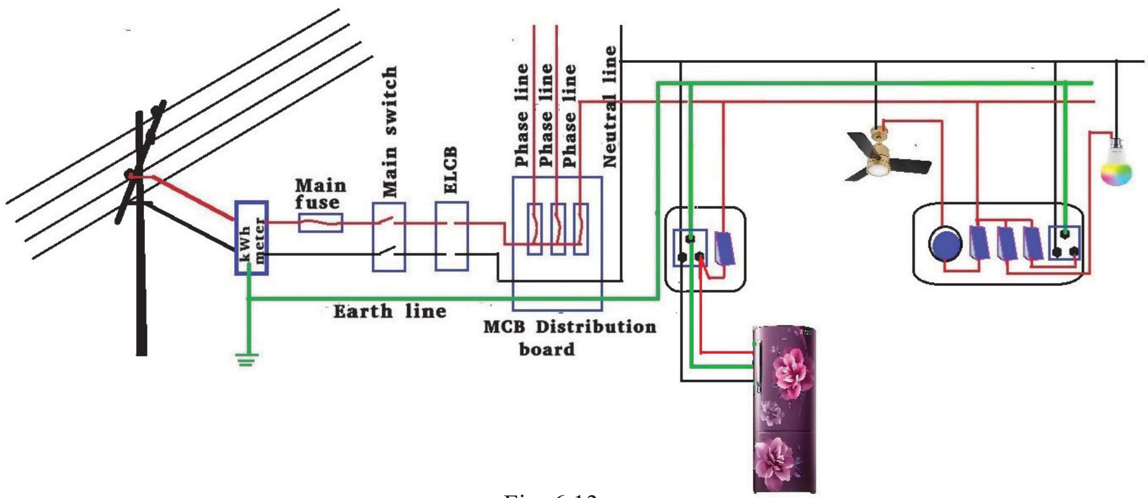


Fig. 6.13

- Where is the watt hour meter connected?
- How many wires reach the watt hour meter?
- Which device is connected between the watt hour meter and the main switch?
- How is it connected? (in series / in parallel)
- Where is the main switch placed?

What are the situations that can cause excess current in a circuit?

A short circuit occurs when the positive and negative terminals of a battery, or two wires in an AC main, come into contact with negligible resistance. This results in excessive current flow, which can lead to various hazards like fire.

Excess current and subsequent dangers can also arise in a circuit when a device with power more than the permissible limit, or many devices that consume excessive power, are connected. This type of excessive current flow in a circuit is overloading.

Why is it that a 2000 W induction cooker is not usually connected to a normal plug?

A normal plug and its connected wires are designed to withstand a current of 5 A.

Will the current in a 2000 W induction cooker operating at 230 V be more or less than 5 A?

$$\text{Amperage} = \frac{\text{Wattage}}{\text{Voltage}} = \frac{2000\text{ W}}{230\text{ V}} = 8.7\text{ A}$$

This means that more current than permissible limit will flow through the circuit. Connecting an appliance with higher power than permitted in a circuit in this manner is overloading. Therefore, connecting a high power appliance from a normal plug or using an extension cord to connect multiple devices, or using a multipin plug to connect more devices, will cause overloading.

The main switch is a device used to connect or disconnect the phase line (live wire) and neutral line reaching the house hold circuit from the electric pole. The position of the main switch is right after the main fuse. Main switch is functioning as a double switch.

In addition, an ELCB (Earth Leakage Circuit Breaker) is connected to ensure more safety for the circuit. From there, the lines reach the MCB (Miniature Circuit Breaker) board and are distributed as branches to each part of the house.

- Appliances are connected across these lines in parallel.
- An appliance and the switch that controls it is connected in series to the phase line.
- When high power appliances are included in the circuit, they should be connected to the earth wire for better safety.
- For high power appliances, separate branch lines should be used with thick wires.
- Power plugs must be used to connect high power appliances.
- Red coloured wires are used commonly for the phase line, black for the neutral line and green for the earth line.

? **Draw a circuit diagram for constructing a branch circuit with two bulbs, one three pin socket, one two pin socket, one fuse or MCB and necessary switches.**

What are the measures to be taken to protect household electrical appliances?

Measures to ensure safety in domestic electricity distribution

Safety fuse, ELCB (Earth Leakage Circuit Breaker), MCB (Miniature Circuit Breaker), three pin plug and earthing are commonly used safety measures in household electrical circuits.

1. Safety Fuse

Fig. 6.14

Overloading, short circuits, lightning, etc., can cause excessive current flow through a circuit. A safety fuse is a device to protect living beings and equipment from the dangers caused by this.

It works based on the heating effect of electricity.

The important part of a safety fuse is the fuse wire.
Generally, alloys (eg : an alloy of tin and lead) are used to make fuse wire. Fuse wire has a relatively low melting point.

For each circuit, use a fuse wire that is appropriate for the current flowing through the circuit.

Which are the situations that could lead to excessive current causing the fuse wire to melt?

How is the fuse wire connected in the circuit? (series / parallel)

2. MCB (Miniature Circuit Breaker)

Fig. 6.15

MCB is a device used in branch circuits instead of safety fuse. When there is excessive current in a circuit due to short circuit or overload, the MCB automatically operates and disconnects the circuit ie., it trips. After resolving the circuit problem, the MCB switch can be turned on to restore the circuit to its original state. MCB works by utilising the magnetic effect and heating effect of electricity.

Fig. 6.16

3. ELCB (Earth Leakage Circuit Breaker)

ELCB helps to disconnect the circuit automatically if there is current leak due to insulation failure or other reasons. This prevents electric shock to those who come in contact with the electric circuit or device. In household electric circuits, branch circuits start after the ELCB. Usually, one ELCB is sufficient for a household electric circuit. Subsequently, each branch starts with MCB.

4. Three Pin Plug and Earthing

The three pin plug is another device to ensure greater safety in household electric circuits.

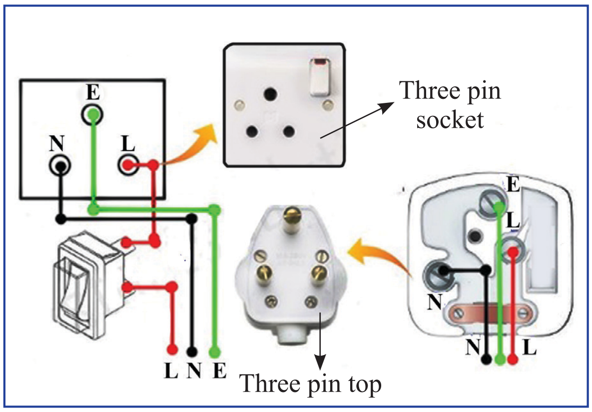


Fig. 6.17 (a)

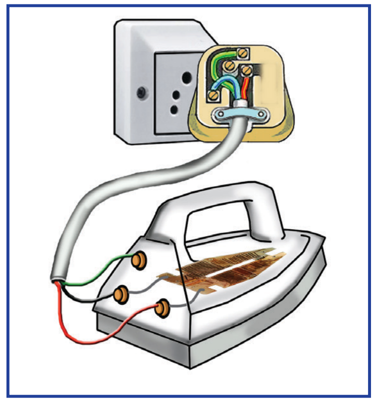


Fig. 6.17 (b)

Observe the figure.

- Which line does the letter E indicate?
- Where should this line be connected to the device?
- Where will the current flow, if a short circuit occurs in the device?
- Will this cause excess current flow?
- If so, what will happen to the MCB / safety fuse?
- Observe the figure and analyse the answers. Then prepare a note on how the three pin plug ensures safety.

RCCB (Residual Current Circuit Breaker)

Instead of ELCB, RCCB (Residual Current Circuit Breaker) is now used to ensure greater safety. It identifies current leaks by detecting the difference between phase current and neutral current and then disconnects the circuit.

What will we do if we get an electric shock due to failure in safety system or carelessness?

Electric Shock

Electric shock is the impact caused by the flow of current through the body.

- What are the circumstances in which electric shock occur?
- What dangers can people face due to electric shock?

Safety must be ensured while working with electric circuits.

- If there is an electric shock, turn off the main switch immediately.
- Separate the person who gets an electric shock from the electric contact using an insulator.
- Under any circumstances do not touch with bare hands a person who received an electric shock.

Let's look at the precautions to be taken to avoid electric shock.

Precautions

- Do not handle electrical appliances or operate switches with wet hands.
- Plug into or unplug from a socket only after turning off the switch.
- Do not operate high power appliances in a normal socket.
- Do not touch the inside of a cable TV adapter. Ensure that the adapter has an insulator cover.
- Do not fly kites near power lines.
- Do not use iron / aluminium ladders, poles, etc., near electric lines.
- While carrying out repairs on household electric circuits, ensure that the main switch is turned off.
- During lightning, do not perform activities that involve contact with electric circuits (there is a possibility of excessive current in the circuit).

- Unplug appliances from sockets if there is a possibility of lightning.
- During rain and wind, transmission lines may touch the ground, creating the risk of accidents. If water enters houses (due to floods or other reasons), disconnect the power supply. After the water recedes, restore power only after the switch boards and the main switch are completely dry.

First Aid for Electric Shock

Provide first aid only after disconnecting the person who gets the shock from the electric wire.

- Rub the body to increase blood circulation and raise body temperature.
- Administer artificial respiration.
- Rub the muscles to restore them to their normal state.
- Start first aid to restart the heart – perform chest compressions rhythmically and forcefully (Cardio Pulmonary Resuscitation). Take the person to the nearest hospital as soon as possible.

Cardio Pulmonary Resuscitation (CPR)

The letters C-A-B are used to remember the sequence for performing the steps of CPR.

C - Compressions
A - Airway
B - Breathing

Compressions: Restore Blood Flow (Chest Compressions)

Compression refers to pressing firmly and quickly on the person's chest in a specific rhythm using your hands. Compressions are the most crucial step in CPR. To perform CPR compressions, follow the steps below:

1. Lay the person flat on a firm surface.
2. Place the palm of one of your hands at the centre of the person's chest.
3. Place your other hand on top of your first hand. Your elbows should be straight and your shoulders should be directly above your hands.

4. Press down on the chest by at least 2 inches (under no circumstances, should it exceed 2.4 inches). While compressing the chest, use not just your hands, but your body weight as well.
5. Press hard and fast at the centre of the chest. Try to perform 30 compressions in 15-20 seconds. Allow the chest to fully return to its original position after each compression.
6. If you are not trained in CPR, continue chest compressions until there are signs of movement or emergency medical help arrives. If you are trained in CPR, begin rescue breaths.

Open the Airway

After 30 chest compressions, perform the following to open the person's airway. This action is called the Head-Tilt, Chin-Lift.

1. Place the palm of your hand on the person's forehead.
2. Gently tilt the head backward.
3. With your other hand, gently lift the chin to open the airway.

Rescue Breathing

After opening the airway using the Head-Tilt, Chin-Lift method, do the following.

1. For mouth to mouth breathing, close the person's nose and cover their mouth with your mouth (you can place a handkerchief with a hole in the middle, between the mouths).
2. Give the first rescue breath. This should last one second – observe if the chest rises.
3. If the chest rises, give another breath. If the chest does not rise, perform the Head-Tilt, Chin-Lift again and give a breath.

After thirty chest compressions, give two breaths. This action is considered one cycle.

Repeat this cycle until there are signs of movement or emergency medical help arrives.

A training session can be organised in your school with the involvement of experts.

Let's Assess

1. Choose the correct answer from the brackets.

   a) What is the working principle of a generator?

   (motor principle, mutual induction, electromagnetic induction, all of these) b What type of electricity is generated in the armature of a DC generator?

(AC, DC, current at constant voltage, none of these)

c) At what voltage is electricity generated in power stations in India?

(11 kV, 11 V, 110 V, 230 V)

d) What is the voltage of electricity supplied for household use in our state?

(230 V, 230 kV, 11 kV, 11 V)

2. Observe the figure.

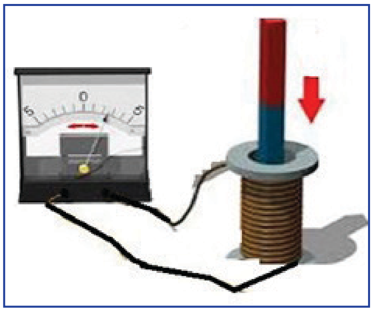


Fig. 6.18

a) If the magnet is rapidly moved into the coil, what will you observe in the galvanometer?

b) What will be the nature of the current obtained if the magnet is rapidly moved up and down inside the coil?

c) What are the ways to increase the current induced in the coil?

d) By what name is this phenomenon known as?

3. Classify the following that operate on AC and that on DC.

torch, grinder, microwave oven, emergency lamp, calculator

4. Observe the figure.

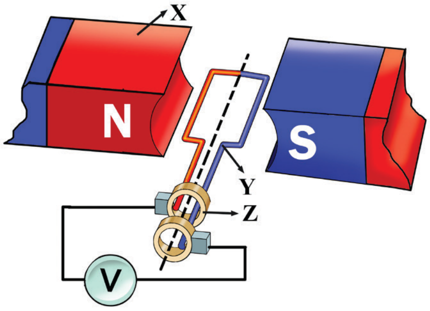


Fig. 6.19

a) Which device is shown in the figure?

b) Name the parts marked X, Y, and Z.

c) Which type of current is obtained in the external circuit?

d) What is its working principle?

5. What are the problems faced while transmitting electricity over long distances using conducting wires? How can these problems be solved?

6. Observe the figure.

   a) Which line is the red coloured wire?

   b) To which part of the appliance is the green coloured wire connected?

   c) What is the advantage of connecting a three pin plug to appliances?

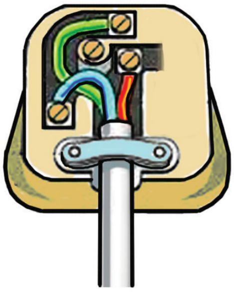


Fig. 6.20

7. Write down any 4 precautions to avoid electric shock.

8. A transformer has 600 turns in its primary and 1800 turns in its secondary. 450 V is obtained across its secondary. Then,

   a) which type of transformer is this?

   b) what will be the voltage supplied across the primary?

9. When 0.1 A current is supplied to the primary of a transformer, 1 A current is obtained in the secondary.

   a) Which type of transformer is this?

   b) If 1000 V is supplied across the primary of this transformer, what will be its power?

   c) What will be the power in the secondary?

   d) What will be the voltage induced across the secondary?

10. a) In a household electric circuit, to which device does the line coming from the electric pole reach first?

    b) What is the key feature of the main switch?

    c) What is the necessity of ELCB in a domestic electric circuit?

Extended activities

1. Open a three pin top, understand how the wires are connected, and then connect wires in another three pin top in the same manner.

2. Which are the types of power stations used to generate electricity in countries worldwide, including India? Calculate the percentage of electricity generated by each category in the total power production and prepare a table in the descending order of their percentage of production.

3. Construct and demonstrate a branch circuit including two electric bulbs, a three pin socket, a two pin socket, a fuse or MCB, electric bulbs operated by a two way switch and switches required for that. (This activity should be done only under adult supervision).

7 Mechanical Advantage in Action

You have listened to the teacher's illustration and the child's doubt. How can this be explained?

Haven't you seen loading a lorry using an inclined plane? When it is difficult to climb stairs, we use ramps. From this, it is understood that inclined planes are used to reduce exertion.

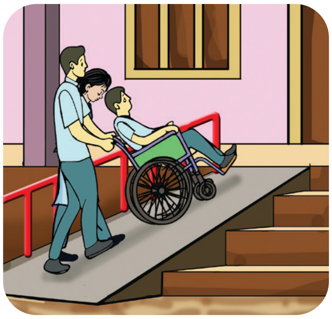


Fig. 7.1 (a)

Let's consider some familiar situations.

Observe the pictures given below.

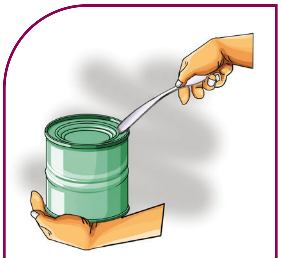


Fig.7.1 (b)

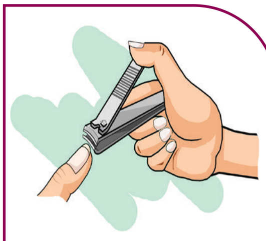


Fig.7.1 (c)


Fig.7.1 (d)


Fig.7.1 (e)

- How did these devices alleviate exertion?

These types of devices that make exertion easier are simple machines.

Simple Machines

What are the ways in which simple machines make exertion easier? Let's examine.

Observe the pictures. Analyse the situations in which a nail is pulled out.

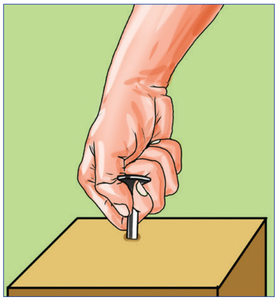


Fig. 7.2 (a)
Removing a nail using hand

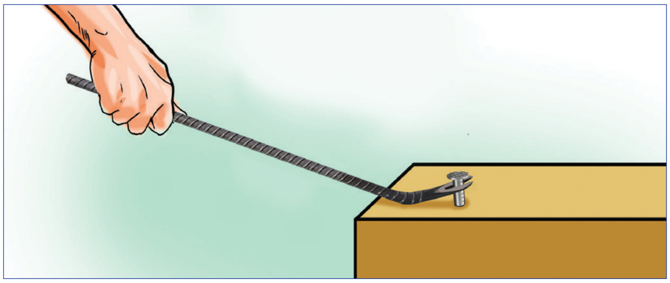


Fig. 7.2 (b)
Removing a nail using nail puller


Fig. 7.3 (a)


Fig. 7.3 (b)

- In which situation [Fig. 7.2 (a), Fig. 7.2 (b)] was more force applied?
- Which device helped to increase the effect of the force we applied many folds?

Observe the two ways of drawing water from a well.

In both the situations [Fig.7.3(a), Fig. 7.3 (b)], is the force applied in the same direction?

- In which direction is it more convenient to apply force?
- What is the benefit of using a pulley?

Analyse the situations in figures 7.2 (a), (b) and 7.3 (a), (b). Answer the questions given below.

- In which situation did the effect of the force we applied increase many fold?
- Which device increased the effect of the applied force many fold?
- Which device helped to change the direction of the applied force?

From these activities note down the advantages of using simple machines.

- Changes the magnitude of the effect of the force.
- Changes the direction of the applied force.

Simple machines are devices that change the magnitude of the effect of force or the direction of the force or both.

Are nail pullers and pulleys the only simple machines?

There are mainly six types of simple machines :

They are lever, pulley, wheel and axle, inclined plane, screw and wedge.

How do they increase the effect of the force many folds?

Squeeze a lemon using lemon squeezer.

- What is the force we apply on the lemon squeezer? (F_1/F_2)
- What is the force the lemon applies against the force we apply? (F_1/F_2)

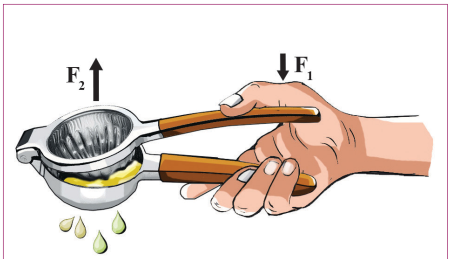


Fig. 7.4

When a lemon squeezer is used as a simple machine, the force we apply to squeeze the lemon is the effort. The force the lemon applies is the load.

The force we apply to a simple machine is the effort (E). The force the simple machine has to overcome is the load (L).

Identify the load and the effort while removing a nail using a nail puller [Fig. 7.2 (b)]. Note them down in your science diary.

Observe the picture of lifting a stone weighing 400 N, using a crowbar.

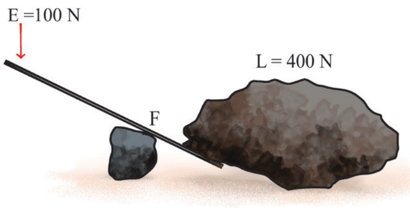


Fig. 7.5

- What is the weight lifted using the crowbar?
- What is the magnitude of force applied?
- How many times did the effect of the force applied increase?
- What is the advantage of using a crowbar?

Consider a simple machine which can lift a load four times the effort. Here, the ratio between the load and the effort is four. Hence the mechanical advantage is four. Here the effect of the effort is increased by four times.

Mechanical advantage (MA) is the ratio of the load to the effort. It is a number indicating how many times of the load is the effort. Mechanical advantage,

$$MA = \frac{Load}{Effort}$$

Mechanical advantage is only a ratio. It has no unit.

- A force of 40 N was applied on a nail puller to pull a nail. If the mechanical advantage of the nail puller was three, what would be the load applied by the nail?

$$\text{Mechanical advantage} = \frac{\text{Load}}{\text{Effort}}$$

$$\text{Mechanical advantage} = 3$$

$$\text{Effort} = 40\text{ N}, \qquad \text{Load} = ?$$

$$\begin{aligned}\text{Load} &= \text{Mechanical advantage} \times \text{Effort}\\ &= 3 \times 40\text{ N}\\ &= 120\text{ N}\end{aligned}$$

Do all simple machines have the same use?

Lever

A famous quote of Archimedes is,"Give me a lever long enough and a place to stand, I will move the Earth." What is your reaction?

Fig. 7.6

Observe figure 7.6.

- Name the position that supports the rod used as the simple machine.
  (effort, load, fulcrum)
- Where is the fulcrum in common balance, seesaw, etc.?


Fig. 7.7 (a)

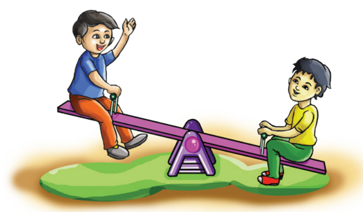


Fig.7.7 (b)

A crowbar, beam of a common balance, seesaw, etc., are rigid rods. In all these, load is at one end and effort at the other end.

A lever is a rigid rod that can rotate around a fixed point called fulcrum.

Let's do an activity to understand the principles related to levers.

Suspend a wooden meter scale on a stand. Balance it as shown in figure 7.8.

Identify the point at which it is to be balanced.

Doesn't the entire weight of the meter scale act through this point? This point is the centre of gravity of the meter scale.

PhET→ Balancing act

The meter scale can be suspended or pivoted along a perpendicular line passing through the centre of gravity as shown in the figure.

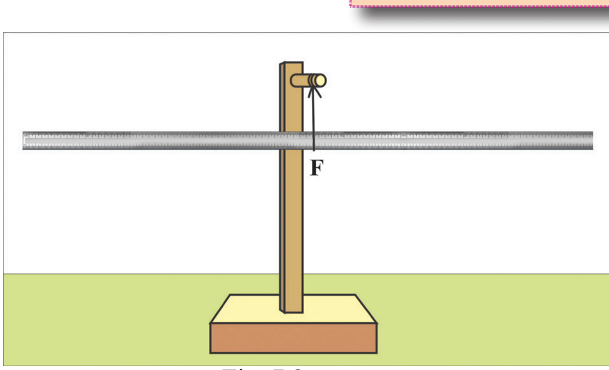


Fig. 7.8

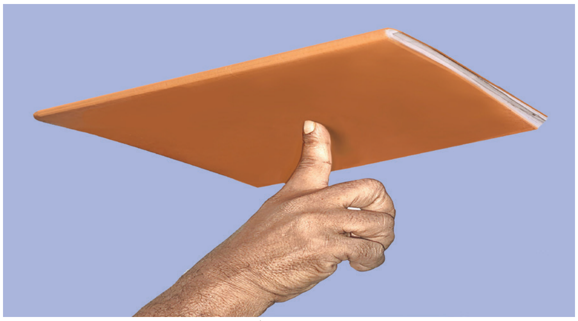


Fig. 7.9

You can balance a book on the tip of your finger (Fig. 7.9). A book can be balanced when it is pivoted on the perpendicular line passing through its centre of gravity.

Centre of Gravity

Centre of gravity is the point at which the entire weight of an object is considered to act.

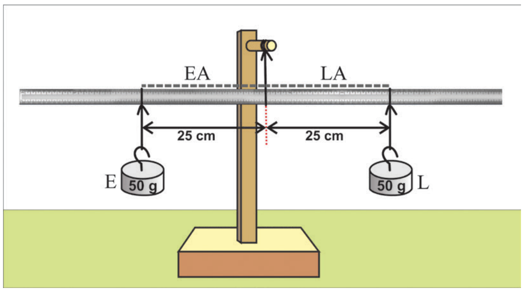


Fig. 7.10

As shown in figure 7.10, suspend a mass of 50 g at a distance of 25 cm from the balancing point on one side of a meter scale. Suspend another mass of 50 g on the other side of the meter scale to balance it.

The weight suspended first is considered as the load. The perpendicular distance from the load to the fulcrum is the load arm.

- What is the load arm here?

The weight suspended or the force applied to produce equilibrium in the rod is the effort.

- What is the perpendicular distance from the effort to the fulcrum known as?
- How much is the effort arm here?

Next, suspend a load of mass 70 g instead of 50 g at 25 cm. Find out at what reading on the other side of the meter scale you can suspend a mass of 50 g to balance it.

Change the loads and their positions and use appropriate efforts to bring the meter scale to equilibrium. Complete the table with the data obtained in each case.

Sl no	Load **(L) gwt**	Effort **(E) gwt**	Load arm **(LA) cm**	Effort arm **(EA) cm**	Load × Load arm **(L × L A)**	Effort × Effort arm **(E × EA)**
1	50	50	25	25	1250	1250
2	60	50	25	30	1500	1500
3	70	50	30			
4		70	35	50		
5						

Table 7.1

- What inference can you arrive at from these activities?

When a lever is in equilibrium,

Load × Load arm = Effort × Effort arm. This is the principle of a lever.

How can we calculate the mechanical advantage of a lever?

We know that Mechanical advantage $= \dfrac{\text{Load}}{\text{Effort}}$

Similarly, according to the principle of the lever, Load × Load arm = Effort × Effort arm.

So,

$$\frac{\text{Load}}{\text{Effort}} = \frac{\text{Effort arm}}{\text{Load arm}}$$

Hence, the Mechanical advantage of levers will be $= \dfrac{\text{Effort arm}}{\text{Load arm}}$.

You are given a meter scale, weights, a stand, a thread, and a mango. Find out and present how to determine the mass of the mango.

Is the fulcrum in a lever always between the load and the effort?

Levers can be classified into three types based on the relative positions of the fulcrum, effort, and load.

- First Order Lever
- Second Order Lever
- Third Order Lever

First Order Lever

Observe figure 7.11 (a). What is the position of the fulcrum?

If the fulcrum is in between the load and the effort, it is a first order lever.

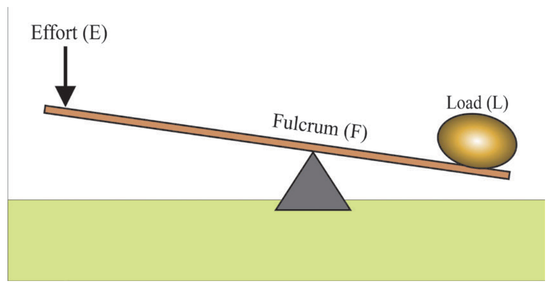
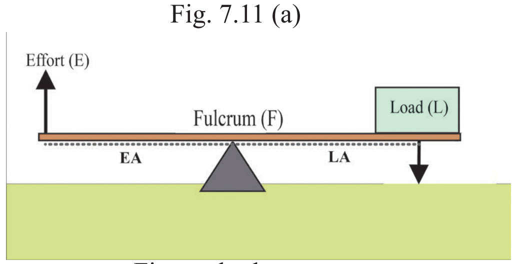


Fig. 7.11 (a)

Examples : common balance, scissors, seesaw.

- In a common balance, the effort arm and the load arm are
  (equal / not equal).

Hence the load and the effort will be equal.



First order lever
Fig. 7.11 (b)

Fig. 7.12

- What about while using scissors?
- While using a crowbar to move a stone, as shown in figure 7.11 (a), should you increase the effort arm or the load arm to enhance the mechanical advantage?
- What is the mechanical advantage in this case?

  (greater than one, one, less than one)
- If the length of the load arm is increased more than the length of the effort arm, what will the mechanical advantage be?

  (greater than one, one, less than one)

Complete table 7.2 with the appropriate terms from the brackets.

(load is more than the effort, load and effort are equal, load is less than the effort)

If the mechanical advantage is less than one.	
If the mechanical advantage is one.	
If the mechanical advantage is greater than one.	

Table 7.2

Write down examples for first order levers from daily life situations.

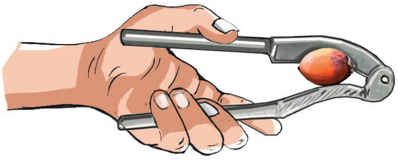
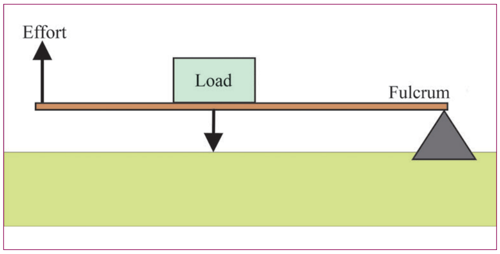


Fig. 7.13

Second Order Lever

Observe figure 7.13.

- Mark the position of the load, fulcrum, and effort in the figure.
- Where is the position of the load in the figure?



Second Order Lever
Fig. 7.14

If the load comes in between the effort and the fulcrum, it is a second order lever.

Mark the load, fulcrum, and effort in the pictures given below.

Fig. 7.15 (a)

Fig. 7.15 (b)

- Where will the fulcrum in a second order lever be?
- What about the position of the load?

- Which of the following is correct in a second order lever?

  (effort arm and load arm are equal, effort arm is longer than the load arm, effort arm is shorter than the load arm)

- Then the mechanical advantage of second order levers will always be ....

  (less than one, one, greater than one)

Write down more examples for second order lever from daily life situations.

Third Order Lever

Observe figure 7.16 and mark the load, effort, and fulcrum.

Tongs

Fig. 7.16

If the effort comes in between the load and the fulcrum, it is a third order lever.

Haven't you seen tools used to pick sweets in bakeries? You have also seen forceps. These are third order levers.

- In third order levers, which arm is longer?

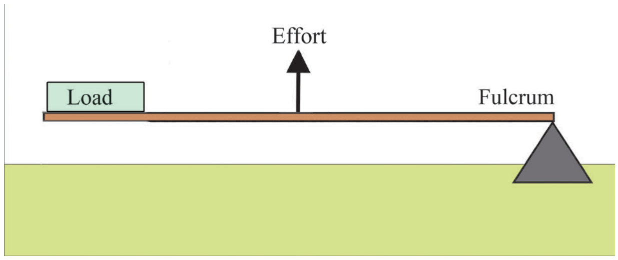
  (load arm, effort arm)

- What will be the mechanical advantage of a third order lever?

  (less than one, one, greater than one)

- Write down more examples for third order levers from daily life situations.

  - Fishing pole
  -

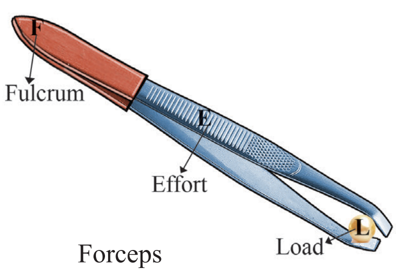


Third Order Lever

Fig. 7.17

- The effort is greater than the load in a third order lever. If so, what is the advantage of using a third order lever?

The advantage is that it helps to handle objects safely with ease.



Forceps

Fig. 7.18

Fig. 7.19

Complete the table.

Order of a lever	Relative position of fulcrum, load and effort	Mechanical advantage
First order	Fulcrum is in between the load and the effort	Greater than one /equal to one/less than one
Second order		
Third order		

Table 7.3

Pulley is another simple machine. It is of two types:

1. Fixed pulley 2. Movable pulley

Fixed Pulley

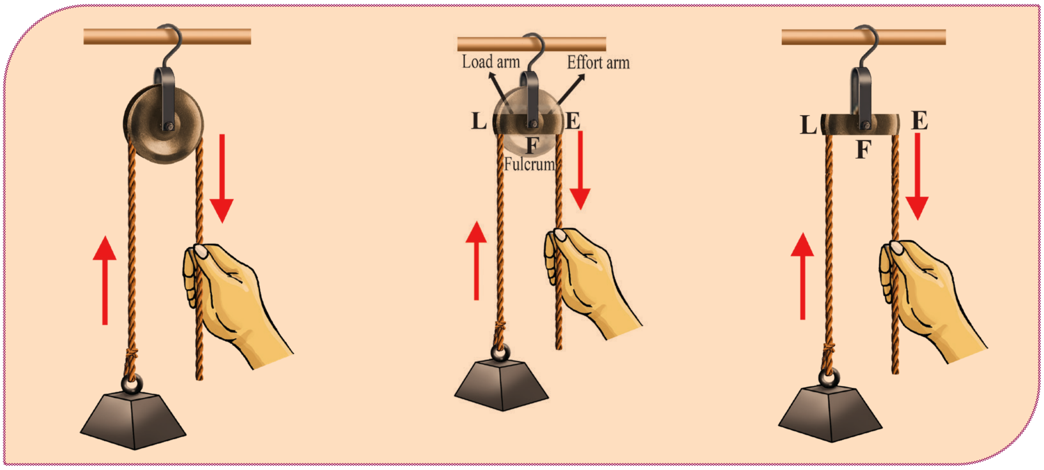


Fig. 7.20 (a) Fig. 7.20 (b) Fig. 7.20 (c)

Fig. 7.20

Fixed pulleys are pulleys that rotate around a stationary axle. A fixed pulley can be imagined as many spokes rotating around a central pivot named fulcrum. In these spokes, the position where the load is experienced is marked as L and the position where the effort is applied is marked as E. A fixed pulley is similar to a first order lever. In this, the effort arm and the load arm are the radii of the pulley.

- If so, what will be the relation between the load arm and the effort arm of the pulley?

  (load arm is longer, effort arm is longer, effort arm and load arm are equal)

- When we consider a fixed pulley without friction, we have to apply ....

  (more effort than the load, less effort than the load, an effort equal to load)

- What will be the mechanical advantage of a fixed pulley?

  (less than one, one, greater than one)

- What is the advantage of using friction less fixed pulley to lift objects? Choose the correct option from those given below.

  (can reduce the magnitude of the applied force / can change the direction of the applied force)

Movable Pulley

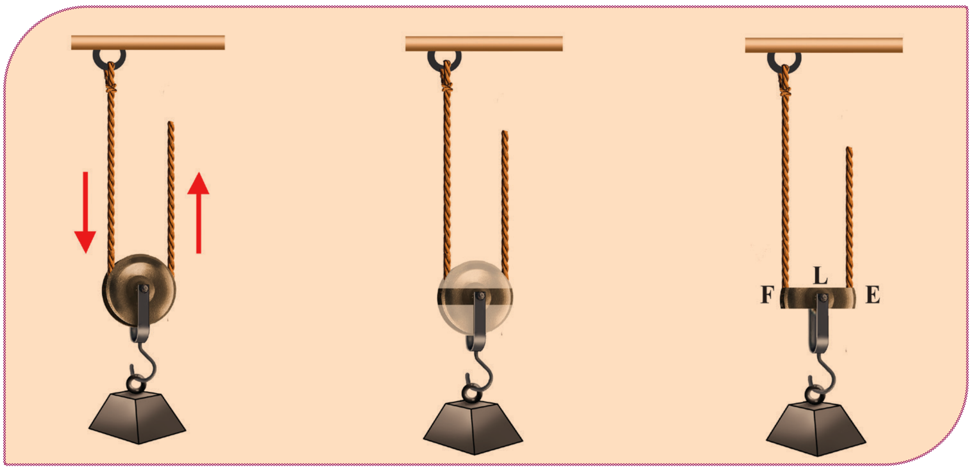


Fig. 7.21 (a) Fig. 7.21 (b) Fig. 7.21 (c)

Fig. 7.21

When effort is applied on a movable pulley, the pulley and the load will be lifted upwards along the other side of the rope. This lifting is caused by the rotation of the pulley along the rope.

- In a movable pulley the effort and the fulcrum are at either ends and the load is at the middle. Which is the order of this lever?
- Which is the load arm and effort arm?

  Load arm = Radius of the pulley

  Effort arm = ...

- What is the mechanical advantage of a movable pulley?

  $$\text{Mechanical advantage} = \frac{\text{Effort arm}}{\text{Load arm}}$$

$$= \frac{\text{Diameter of the pulley (2r)}}{\text{Radius of the pulley (r)}}$$

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

- The mechanical advantage of a single movable pulley is 2. If so, how many times of the load to be lifted should the applied effort be?

Is there a gain in work when the applied effort is halved? Let's see.

System of pulleys is a combination of many pulleys

First system of pulleys

The load (L) is distributed equally on each segment of the rope of the first pulley. Each segment of rope on the first pulley experiences half the weight of the object.

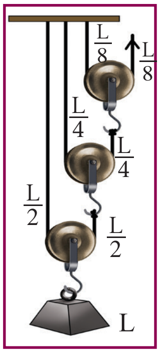


Fig. 7.22

In the case of the second movable pulley of the system, this half weight is divided into two segments as $\frac{1}{4}$ parts. Then, for the third movable pulley, it becomes $\frac{1}{8}$ part and so on.

- Here, the mechanical advantage of the first movable pulley = 2, i.e., 2^1 (one is the number of pulleys).
- If two movable pulleys are used, the mechanical advantage = 4 i.e., 2^2.
- If three movable pulleys are used, the mechanical advantage = 8, i.e., 2^3
- Therefore, on using a system of n movable pulleys, the mechanical advantage is 2^n.

Second system of pulleys

Here, a combination of two sets of three pulleys each is shown in figure 7.23. The number of pulleys in each set can be varied.

In the second system of pulleys the pulleys in the first set and those in the second set are

- The rope is pulled 2 m by applying effort. How much will the load rise?

The load rises only one metre, doesn't it?

We know that work, W = Fs.

What should be the displacement of the rope, when the effort applied raises the load by 1 m? (1 m, 2 m, 0 m)

Here, when the effort is reduced by half, the displacement produced by it is doubled. That is, $W = \frac{F}{2} \times 2s = Fs$. Is there a change in the quantity of work done? Note down your inference.

A movable pulley is used to lift 600 N load. When the rope is pulled 8 m by applying a force of 300 N then the load raises by 4 m.

Prove that there is no gain in the work even though there is a gain in the effort applied,

The displacement of the object, $s = 4$ m

Weight of the object, $F = 600$ N

Work done on the object $= F \times s$

$= 600 \times 4$ J $= 2400$ J

The displacement of the rope on applying 300 N force, $s_1 = 8$ m

$F_1 = 300$ N

The work done by the force we applied $= F_1 s_1$

$$= 300 \times 8 \text{ J} = 2400 \text{ J}$$

Haven't you understood that the work done on the object and the work done by the effort are equal? Hence we can conclude that no gain in work is achieved while using a movable pulley.

There is no gain in work by using simple machines

Wheel and Axle

There were instances when modern machines failed to lift train bogies that had fallen into a lake. But they were brought ashore using a wheel and axle.

In such systems, the wheel is rotated by applying force (Effort) to it. When the wheel is rotated once, the axle also rotates once. If the radius of the wheel is R and the radius of the axle is r, and when the wheel is rotated once, the distance moved by a point on the wheel's circumference would be $2\pi R$. Wouldn't it? What will be the distance moved by the object tied to the rope attached to the axle? ($2\pi R$ / $2\pi r$).

- Isn't the distance moved by the point on the wheel when it is rotated once due to the effort applied (E) $2\pi R$? Isn't the distance moved by the load $2\pi r$? Here, the work done by the effort and the work done by the load are equal.

Work done by the effort = Work done by the load.

$$\text{Work done} = Fs$$

$$E \times 2\pi R = L \times 2\pi r$$

$$\frac{L}{E} = \frac{R}{r}$$

Since the radius of the wheel is larger and the radius of the axle is smaller, the mechanical advantage will be greater than one. As the radius of the wheel increases, the mechanical advantage also increases. The train bogies were slowly lifted by turning the wheel using long levers.

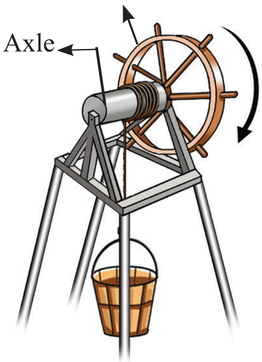


Fig. 7.24

connected by passing a single rope through each pulley as shown in fig.7.23. The pulleys are arranged here in two groups, one above and the other below.

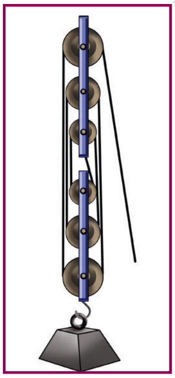


Fig. 7.23

Isn't the rope seen as six segments between the first set and the second set of pulleys? Since each segment supports the load equally, the mechanical advantage will be 6.

- What will be the mechanical advantage in the second system of pulleys, if there are a total of 12 pulleys? Isn't it 12?

In the second system of pulleys, the number of pulleys in the two sets need not be equal. In such cases, the mechanical advantage is considered as the total number of pulleys or the number of segments of the rope supporting the load.

Gear

Why are gears used in some bicycles?

Fig. 7.25

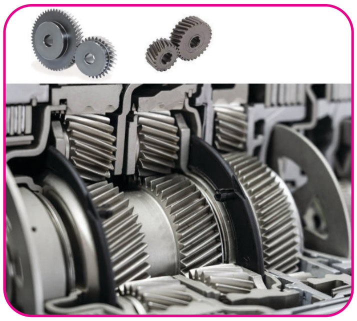


Fig. 7.26

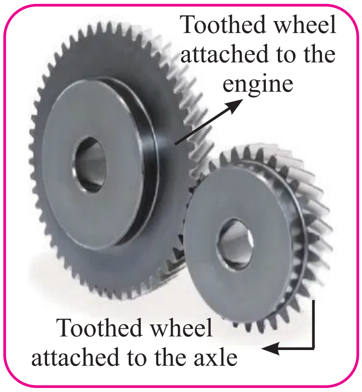


Fig. 7.27

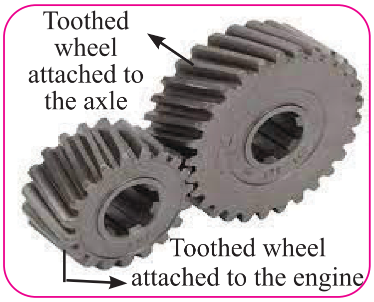


Fig. 7.28

Have you seen gears in some bicycles?

- What are the uses of these gears?

Let's see how the gears in large vehicles function. A gear is a mechanical device used in machines. They are used to transfer motion or force from one part of the machine to another. The main part is a system of two interlocking toothed wheels.

In gears, energy is transferred from a large toothed wheel to a small toothed wheel or from a small toothed wheel to a large toothed wheel.

- When the large toothed wheel rotates once, how many times will the small toothed wheel rotate?

  (once, more than once, less than once)

- What changes will this cause in the speed of the second toothed wheel?

A toothed wheel is attached to the engine of most of the vehicles. This toothed wheel is connected to a system of wheels of different sizes attached to the axle which transfers motion to the tyres.

It is understood that to increase the speed of the vehicle, the toothed wheel attached to the engine must be connected to the small toothed wheel that helps to turn the tyre of the vehicle (Fig. 7.27)

- Which wheel is connected to the toothed wheel attached to the engine while going uphill?

  (small / large)

When connected to a large toothed wheel, the speed of the vehicle decreases, but its efficiency to rotate increases.

- What happens to the speed of the large toothed wheel when energy is transferred from the small toothed wheel to the large toothed wheel?

  (Increases / decreases)

Do you know of other instances where mechanical advantage is gained? Haven't you seen an inclined plane being used to load large logs, machine parts, etc., onto a lorry?

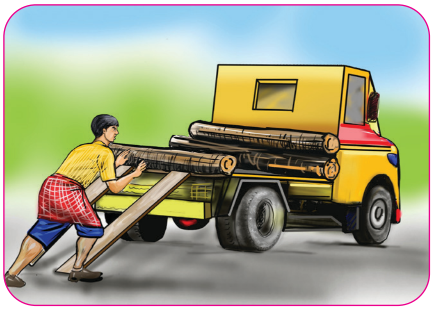


Fig. 7.29

Is there a mechanical advantage while using an inclined plane?

- Try lifting the same object to the same height using inclined planes of different lengths. When did it feel easier?

An object is to be lifted to a height h metre by pushing along an inclined plane of length ℓ metre.

- Here, what is the work done by the effort?

If the effort is E and the load is L then the work done by the effort E to move it over a distance ℓ (Fs) = $E\ell$

Work done by the load L to lift to a height h is

Work = Force × Displacement i.e., Weight × height = Lh

Here $E\ell = Lh$

Mechanical advantage $= \frac{L}{E} = \frac{\ell}{h}$

$$\frac{L}{E} = \frac{\text{Force required to lift (Weight)}}{\text{Force applied (Effort)}}$$

$$\frac{\ell}{h} = \frac{\text{Length of inclined plane}}{\text{Height of inclined plane}}$$

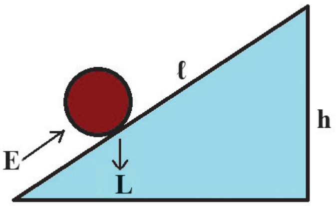


Fig. 7.30

Does using a longer inclined plane or a shorter inclined plane provide more mechanical advantage?

Inclined planes are often used in situations where objects are to be lifted.

a) What is the work done to lift a 600 N load by 3 m?

b) The force applied was 200 N along an inclined plane to lift this load. Displacement of the load was 9 m. What is the work done?

c) Is there a gain in the work done?

a) Force, F = 600 N

Displacement, s = 3 m

Work done, W = Fs

= 600 N × 3 m

= 1800 Nm

= 1800 J

b) Force, F = 200 N

Displacement, s = 9 m

Work done, W = Fs

= 200 N × 9 m

= 1800 Nm

= 1800 J

c) There is no gain in work done.

- What are the ways to increase the mechanical advantage of an inclined plane?

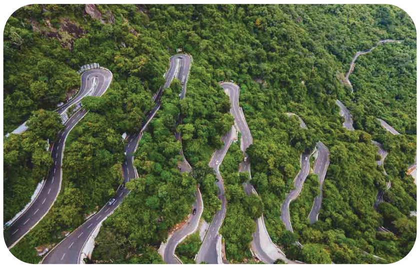


Fig. 7.31 (a)

Have you seen hairpin roads on ghats and other places? Why are long roads built inclined in such places? Isn't it to reach uphill easily by moving along an inclined plane rather than climbing directly? Isn't the concept of mechanical advantage of inclined plane utilised here? Do you know that vehicles have to travel a longer distance to reach the uphill along the roads built as inclined planes? After each hairpin bend, we can see the height reached on gazing down.

But what about the distance we travelled? Don't we have to increase the length of the inclined plane to lift heavy load? This concept is used to construct inclined roads.


Fig.7.31 (b)

It is understood that large heavy stones were taken up to build the pyramids using inclined roads.

Wedge

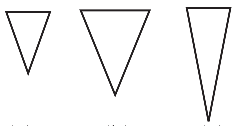
Observe the wedges of different length and thickness.

Which of these is easier to use? Why?

Household tools like knife, axe, and work tools like chisel are variants of wedges.

Mechanical advantage of a wedge = $\frac{L}{E}$

$$= \frac{\text{length of the inclined plane of the wedge } (\ell)}{\text{thickness of the wedge } (h)}$$


(a) (b) (c)
Fig. 7.32

A wedge is a double inclined plane. If it is made longer and thinner, it will be easier to use.

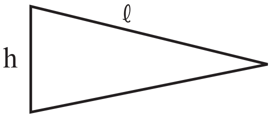
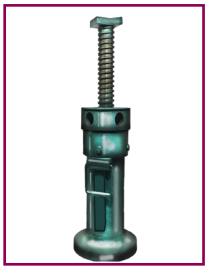


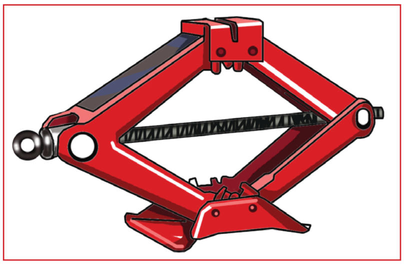
Fig. 7.33

The wedge in figure 7.32 (c) has less thickness and more length. So, its mechanical advantage is greater than that of others.

Screw Jack

Have you seen a screw jack being used to lift vehicles to change a tyre or for minor repairs?


(a)


(b)


(c)

Fig. 7.34

How does a screw jack lift a vehicle when its threads are turned?

Let's do a simple activity.

Cut a paper in the shape of an inclined plane [Fig.7.35(a)]. Colour its slanting edge. Wrap this paper around a cylindrical pencil as shown in figure 7.35 (b).

Fig. 7.35 (a)

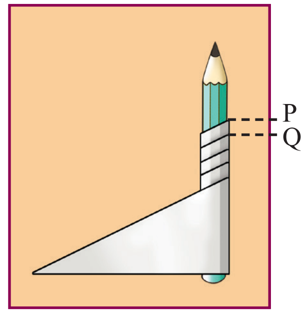


Fig.7.35 (b)

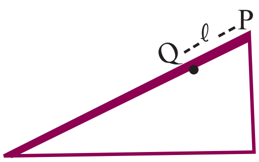


Fig. 7.35 (c)

The vertical distance from the beginning of the slanting edge of the paper (P) to where one full turn is completed (Q) is the pitch (h) [Fig.7.35 (b)].

That is, the distance between two consecutive threads is the pitch.

Unwrap the paper and straighten it. Measure the distance from P to Q [Fig. 7.35 (c)]. This distance is the length of the thread PQ (ℓ).

Don't the coloured lines that appear as rings on the pencil look like a screw? So, a screw can be considered as an inclined plane.

$$\text{Here, the mechanical advantage of a screw} = \frac{\text{length of the inclined plane } (\ell)}{\text{height of the inclined plane (h)}}$$

$$\text{That is, Mechanical advantage} = \frac{\text{length of one thread } (\ell)}{\text{pitch (h)}}$$

A 600 kgwt load is lifted by 4 m along an inclined plane of length 8 m. Calculate the mechanical advantage. What force must be applied along the inclined plane?

$$\textbf{Mechanical advantage of an inclined plane} = \frac{\textbf{length of the inclined plane}}{\textbf{height of the inclined plane}}$$

$$= \frac{8\text{ m}}{4\text{ m}}$$

$$= 2$$

$$\textbf{So, Mechanical advantage} = \frac{\text{Load}}{\text{Effort}} = \frac{600\text{ kgwt}}{\text{Effort}}$$

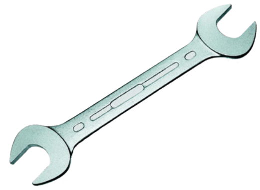
$$= 2$$

$$\textbf{Effort} = \frac{600\text{ kgwt}}{2}$$

$$= 300\text{ kgwt}$$

Axe
(a)

Vellikol
(an old weighing device)
(b)



Spanner
(c)

Screw driver
(d)

Chisel
(e)

Pickaxe
(f)

Fig.7.36

The bicycles and sewing machines we use today are often said to be the simplest machines. But do you know that they are a combination of many types of the simple machines mentioned above?

Let's Assess

1. Write down an example of a lever where the load arm and effort arm are equal. What is its mechanical advantage?

2. In which order of lever is the load arm longer than the effort arm? Write down an example. Which may be the possible mechanical advantage? Choose from the brackets.

   (less than one / one / more than one)

3. As shown in the figure, an object is suspended from one end of a meter scale. When 400 gwt is suspended from the midpoint of the other side, the scale is balanced. What is the mass of the object? What is the weight of the object?

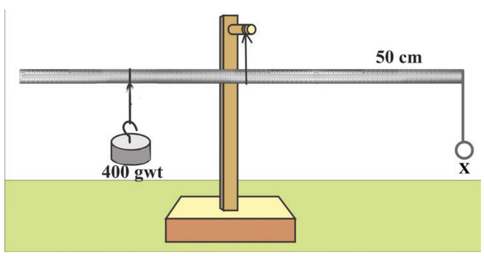


Fig. 7.37

4. In which type of lever is the mechanical advantage always greater than one?
5. Draw a schematic diagram of a second order lever. Mark the fulcrum, load, and effort. Explain why the mechanical advantage of this is neither one nor less than one.
6. A log weighing 5000 kgwt is lifted through a height of 2 m on to a lorry using an inclined plane. A force of 2000 N was applied. What is the length of the inclined plane used to lift the log? What is the mechanical advantage in this situation? (Consider $g = 10\ m/s^2$)
7. How will you calculate the mechanical advantage of a screw? Describe an experiment to prove that a screw is an inclined plane.
8. A load of 1600 kgwt is suspended from an axle with a diameter of 6 cm. What should be the force applied in newton, to turn a 3 m long lever on one side of the axle, to lift this load? (Consider $g = 10\ m/s^2$)
9. Explain the necessity of gears in vehicles.
10. Match appropriately.

Lever	A	B	C
First order	Load is always more than the effort	Fulcrum comes in between effort and load	Mechanical advantage is always less than one
Second order	Load can be equal to, lesser or greater than the effort	Effort comes in between fulcrum and load	Mechanical advantage is always more than one
Third order	Load is always less than the effort	Load comes in between effort and fulcrum	Mechanical advantage is always equal to one or greater than one or lesser than one.

Extended activities

1. Plan a project to find the density of a meter scale.
2. Observe a bicycle and list the simple machines that forms a part of it.

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.

CHILDREN'S RIGHTS

Dear Children,

Wouldn't you like to know about your rights? Awareness about your rights will inspire and motivate you to ensure your protection and participation, thereby making social justice a reality. You may know that a commission for child rights is functioning in our state called the ***Kerala State Commission for Protection of Child Rights.***

Let's see what your rights are:

- Right to freedom of speech and expression.
- Right to life and liberty.
- Right to maximum survival and development.
- Right to be respected and accepted regardless of caste, creed and colour.
- Right to protection and care against physical, mental and sexual abuse.
- Right to participation.
- Protection from child labour and hazardous work.
- Protection against child marriage.
- Right to know one's culture and live accordingly.
- Protection against neglect.
- Right to free and compulsory education.
- Right to learn, rest and leisure.
- Right to parental and societal care, and protection.

Major Responsibilities

- Protect school and public facilities.
- Observe punctuality in learning and activities of the school.
- Accept and respect school authorities, teachers, parents and fellow students.
- Readiness to accept and respect others regardless of caste, creed or colour.

Contact Address:

Kerala State Commission for Protection of Child Rights
'Sree Ganesh', T. C. 14/2036, Vanross Junction
Kerala University P. O., Thiruvananthapuram - 34, Phone : 0471 - 2326603
Email: childrights.cpcr@kerala.gov.in, rte.cpcr@kerala.gov.in
Website : www.kescpcr.kerala.gov.in

Child Helpline - 1098, Crime Stopper - 1090, Nirbhaya - 1800 425 1400

Kerala Police Helpline - 0471 - 3243000/44000/45000

Online ***R. T. E Monitoring : www.nireekshana.org.in***