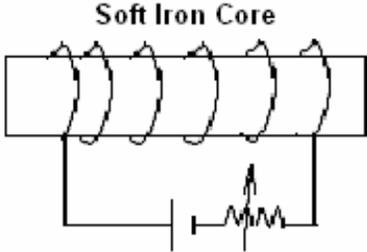
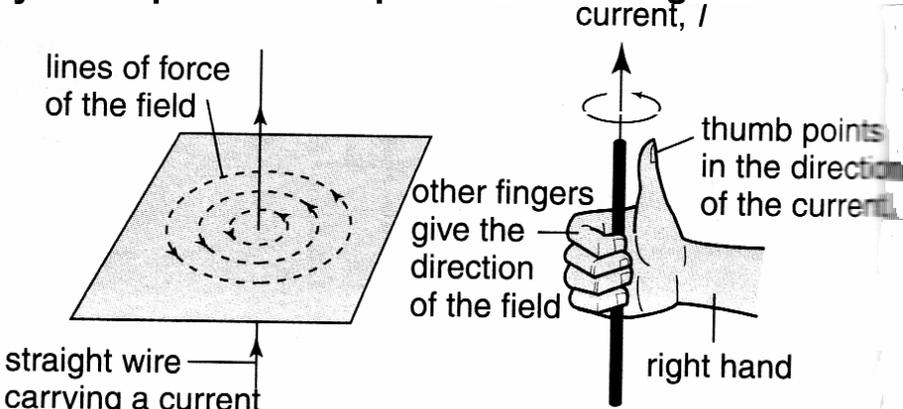
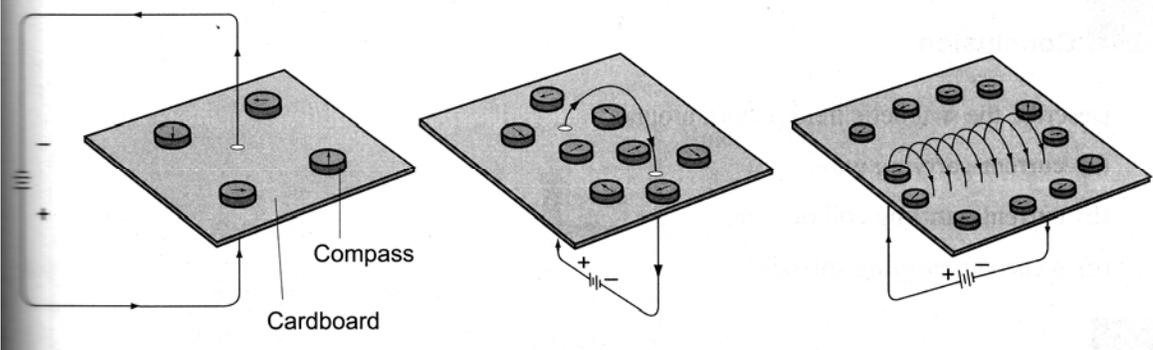
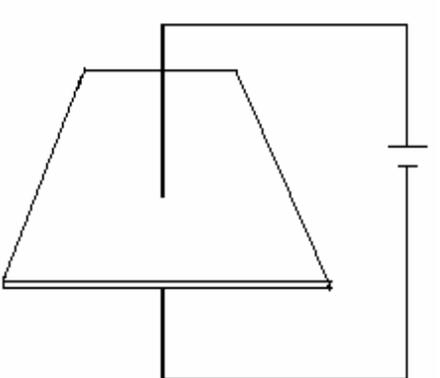
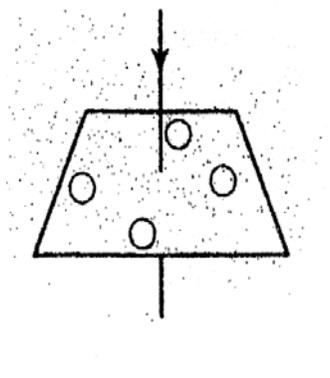
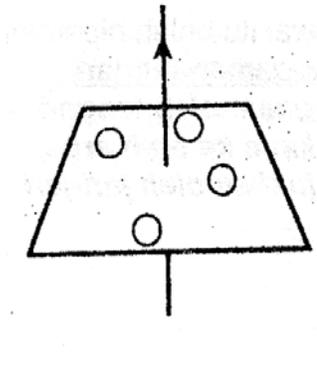
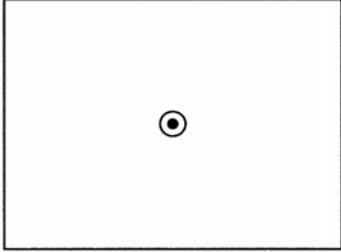


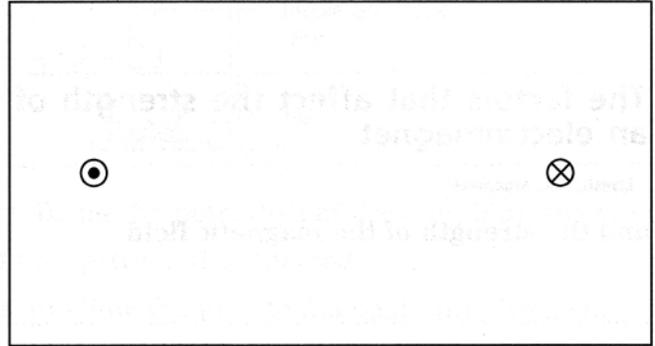
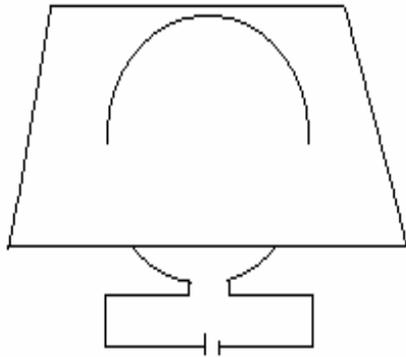
3.1 MAGNETIC EFFECT OF A CURRENT-CARRYING CONDUCTOR

<p>What is an electromagnet?</p>	<p>An electromagnet can be made by sending an electric current through a coil of wire wound around an iron core.</p>  <p>Soft Iron Core</p> <p>When a current flows through the coil, it produces a <u>magnetic field</u>. The soft iron core becomes temporarily magnetized when the current is switched on. When the current is switched off, it loses its magnetism.</p>
<p>What is a magnetic field pattern?</p>	<p>A magnetic field pattern can be represented by field lines that show the shape of the field. Magnetic field lines which are close together represent a strong field. The field direction is defined as the direction indicated by a compass needle placed in the magnetic field.</p>  <p>lines of force of the field</p> <p>straight wire carrying a current</p> <p>current, I</p> <p>thumb points in the direction of the current</p> <p>other fingers give the direction of the field</p> <p>right hand</p>
<p>Determine the direction of the magnetic field around a current-carrying wire</p>	<p><u>The Right-Hand Grip Rule</u> Grip the wire using the <u>right hand</u>, with your thumb pointing in the direction of the <u>current</u>. Your other fingers now point round the wire in the direction of the magnetic field. When the direction of the current is reversed, the magnetic field direction also is reversed.</p>

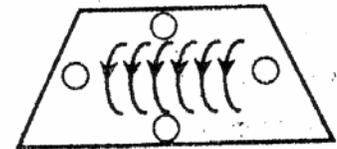
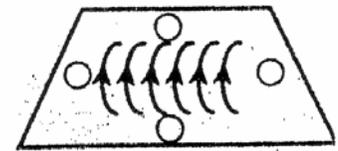
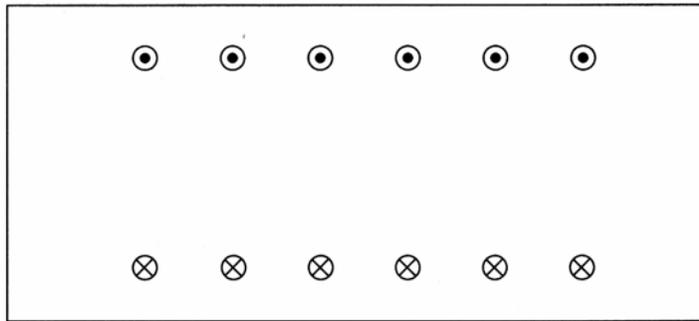
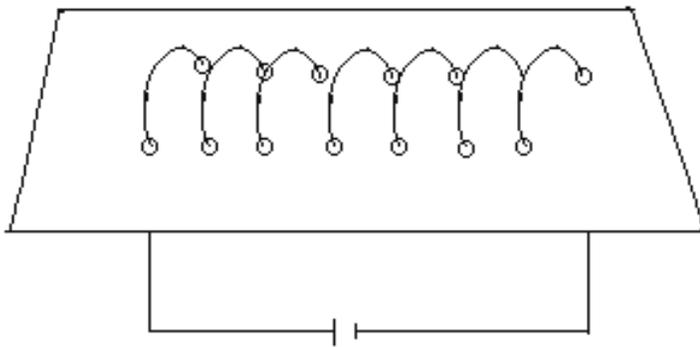
Activity 1

Aim	Draw the magnetic field pattern due to a current in a 1. straight wire, 2. coil 3. solenoid Determine the direction of the magnetic field.		
Procedure	 <ol style="list-style-type: none"> 1. Use small plotting compasses and place them on the cardboard to determine the direction of the magnetic field. 2. Observe and sketch the pattern produced. 3. Reverse the current supply connections to see its effect on the compass needle. 4. Remove the compasses and sprinkle iron filings onto the cardboards and tap the sheets gently with a pencil. Sketch your observation. 		
Straight Wire			
	 <p style="text-align: center;">Current into the paper</p>	 <p style="text-align: center;">Current out of the paper</p>	

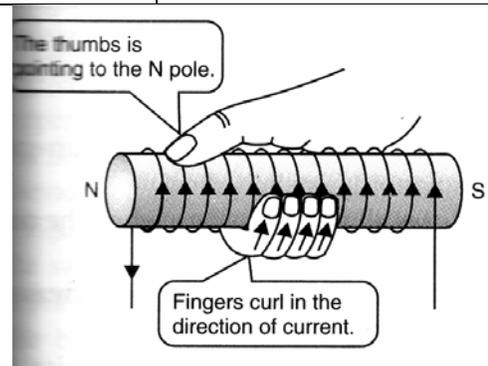
Coil



Solenoid



Note:
The right hand grip rule for a solenoid:
The thumb points towards north pole of the magnetic field while the other fingers indicate the direction of the current in the solenoid.

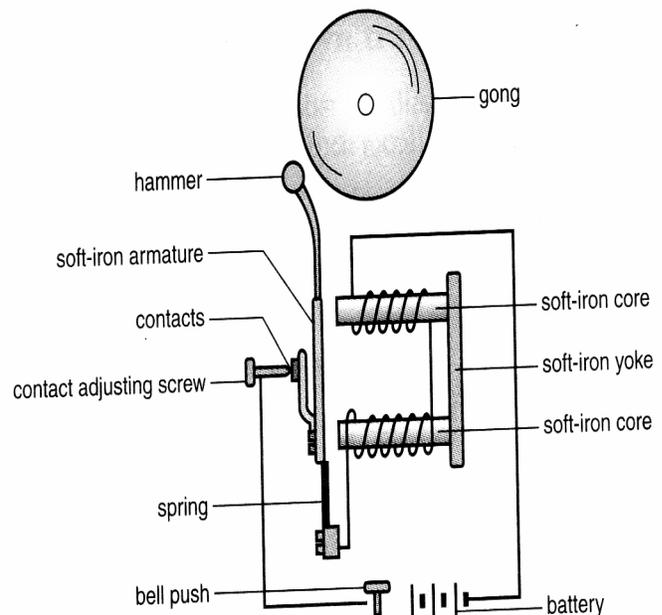


State the factors that affect the strength of the electromagnet.

Describe application of Electromagnet

Electric Bell

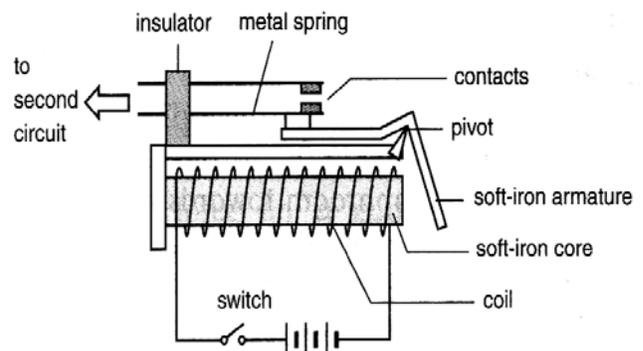
- When the bell push is pressed, a current flows in the coils of the electromagnet, causing it to be magnetized.
- The magnetized electromagnet attracts the soft-iron armature, causing the hammer to strike the gong.
- The movement of the armature breaks the contact and causes the electromagnet to lose its magnetism.
- The light spring pulls the armature back, remaking the contact and completing the circuit again.



- The cycle is repeated so long as the bell push is pressed and continuous ringing occurs.

Magnetic Relay

- A solenoid switch worked by an electromagnet. It is used in a circuit which controls the operation of another circuit, especially if the current is large in the second circuit.
- Circuit 1 requires only a small current.
- When the switch is closed, current flows in the coil,



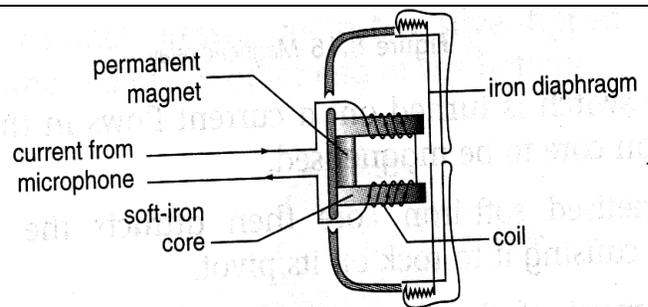
- causing the soft-iron core to be

- The movement of the iron armature closes the contacts in the second circuit. Circuit 2 is now switched on.
- Circuit 2 may have a large current flowing through it to operate powerful motors or very bright lights.

- magnetized and attracts the armature
- The advantage of using a relay is that a small current (circuit 1) can be used to switch on and off a circuit with a large current (circuit 2).
- This is useful for two reasons:
 - (b) circuit 1 may contain a component such as a light detecting resistor (LDR), which uses small currents.
 - (c) Only the circuit with a large current needs to be connected with thick wire.

Telephone Ear-piece

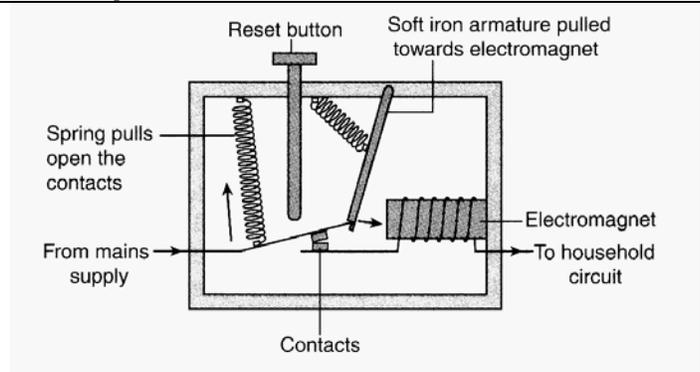
- The varying current from the microphone flows through the coils of an electromagnet in the earpiece.
- This pulls the iron diaphragm towards the electromagnet by a distance which depends on the current.



As a result, the diaphragm moves in and out and produces sound waves that are replicas of those that entered the microphone.

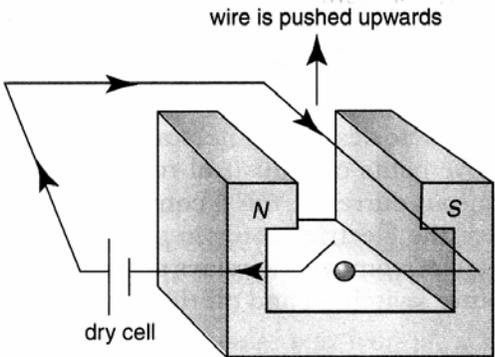
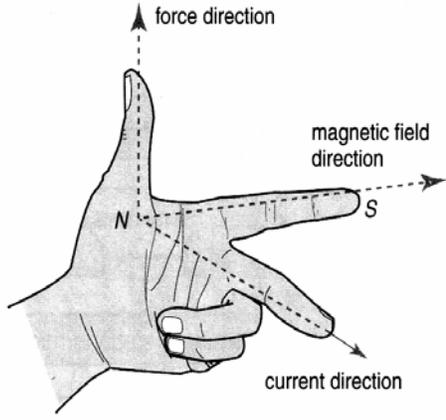
Circuit Breaker

- Acts as an automatic switch that breaks open a circuit when the current becomes too large.
- In a household circuit, the current may become excessive when there is a short circuit or an overload.
- The strength of the magnetic field of the electromagnet increases suddenly.
- The soft iron armature is pulled towards the electromagnet.



- This results in the spring pulling apart the contacts. The circuit is broken and the current flow stops immediately.
- After repairs have been made, the reset button is pushed to switch on the supply again.

3.2 THE FORCE ON A CURRENT-CARRYING CONDUCTOR IN A MAGNETIC FIELD

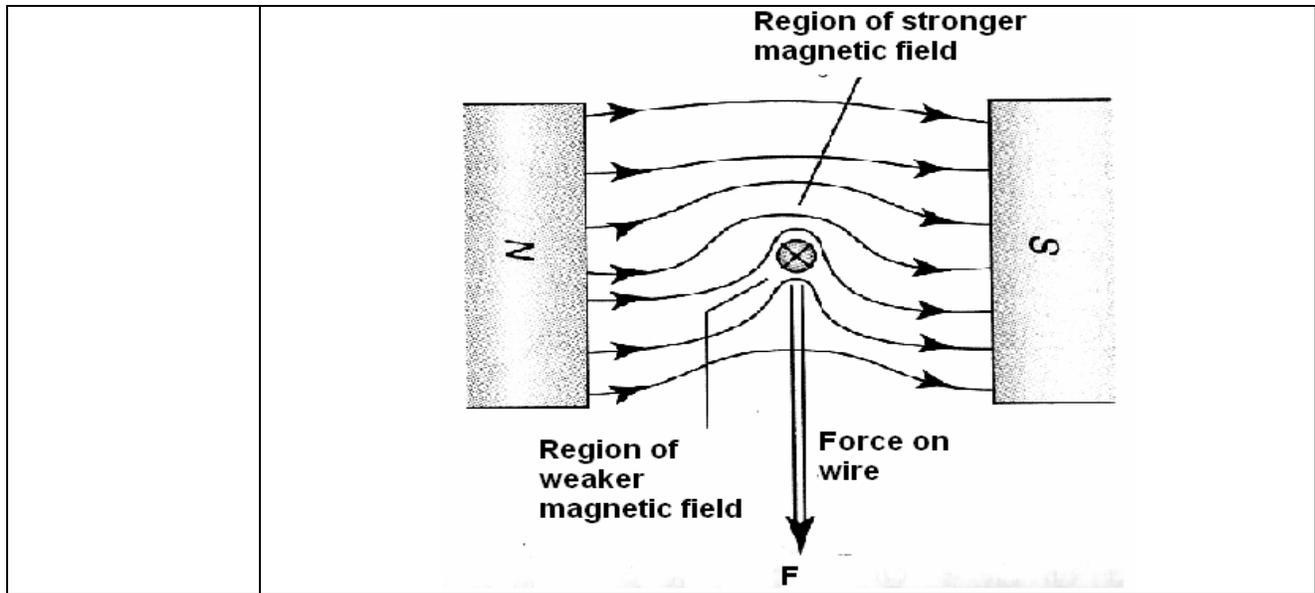
<p>Describe what happens to current-carrying conductor in a magnetic field</p>	<ul style="list-style-type: none"> • An electric current produces a magnetic field around it. • When a wire carries an electric current through another magnetic field, a <u>force</u> is exerted on the wire. • The <u>magnetic force</u> on a current-carrying conductor is in a magnetic field is due to the combination of the magnetic field due to the current in the conductor and the external magnetic field to produce a resultant magnetic field. • The direction of the magnetic force, F, acting on the wire can be determined by using Fleming's left-hand rule. 	
<p>What is Fleming's Left – Hand Rule</p>	<p>If the forefinger, second finger and the thumb of the left hand are extended at right angles to each other, with the <u>forefinger</u> in the direction of the <u>magnetic field</u>, the <u>second finger</u> in the direction of the <u>current</u>, then the <u>thumb</u> will point the direction of the <u>force, F</u> or motion.</p>	

To investigate the force on a current-carrying conductor in a magnetic field.

Procedure	<div style="text-align: center;"> </div> <ol style="list-style-type: none"> 1. Switch on the current and observe what happens to the short copper wire. 2. Reverse the connections of the voltage supply. Observe what happens to the copper wire. 3. Reverse the magnetic field and repeat step 2 and 3. 4. Align the magnetic field so that it is parallel with in the short copper wire.
Observation	<p>Indicated the flow of current using arrows. Show the direction of magnetic field and indicate the direction where the short copper wire will move. Prove the direction of the force using the Fleming's left-hand rule.</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>step 1</p> </div> <div style="text-align: center;"> <p>step 2</p> </div> <div style="text-align: center;"> <p>step 3</p> </div> </div>
	<p>Step 4</p> <div style="display: flex; align-items: center;"> <div style="margin-left: 20px;"> <p>The direction of magnetic field is parallel to the direction of current. <i>The short wire stays at rest.</i></p> </div> </div>

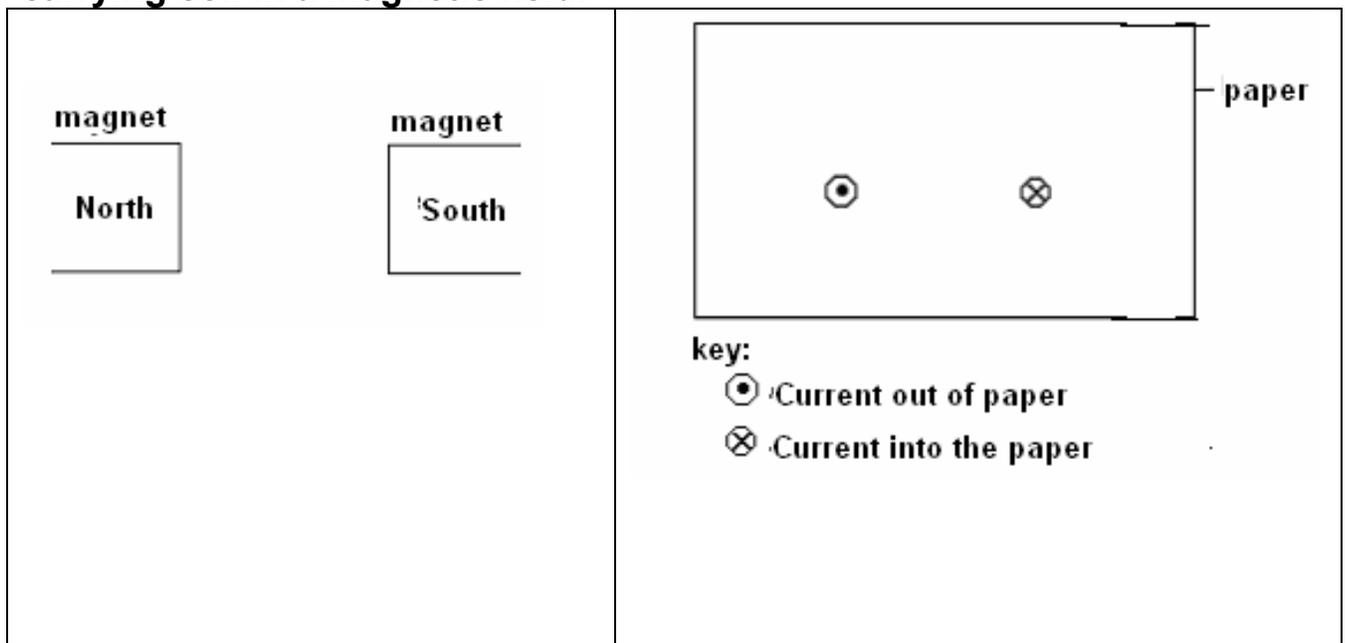
Conclusion	<ul style="list-style-type: none"> • <i>When a current-carrying conductor is in a magnetic field of a permanent magnet, the interaction between the two magnetic fields produce a force on the conductor.</i> • <i>The direction of the magnetic field, the current and the force acting on a conductor is perpendicular to each other.</i>
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<p>Describe how a current-carrying conductor in a magnetic field experiences a force.</p>	<ul style="list-style-type: none"> • The magnadur magnets produce a uniform, parallel magnetic field. • The current-carrying vertical wire produces a circular magnetic field around itself. • The two fields interact to produce a resultant magnetic field known as a <u>catapult field</u>. • Upward, the two fields are in the same direction and they produce a stronger combined field. • Downward, the two fields act in opposite directions and the combined field is weaker. • The wire carrying a current thus experiences a resultant force in the direction from the stronger to the weaker field, i.e from upward to downward. <div style="text-align: center; margin-top: 20px;"> <p style="text-align: center;">magnadur magnet permanent conductor-carrying current</p> </div>
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<p>Explain the factors that affect the magnitude of the force on a current-carrying conductor in a magnetic field.</p>	<p>The magnitude of the force on a current-carrying conductor in a magnetic field depends on:</p> <ol style="list-style-type: none"> 1. the size of the current in the conductor 2. the strength of the magnetic field
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Draw a pattern of resultant magnetic field or catapult field for a current-carrying coil in a magnetic field.



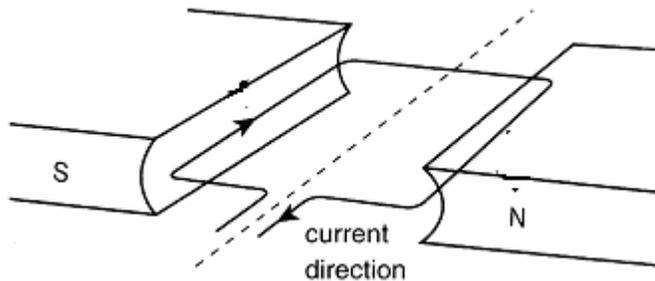


Key

⊙ Current out of paper

⊗ Current into paper

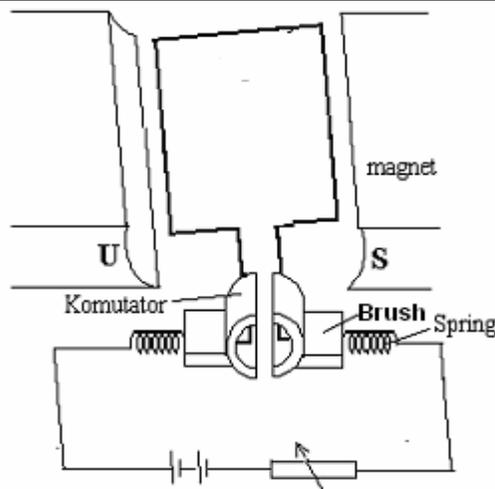
Show the direction of the resultant force, F.



What will happen to the coil?

The coil will rotate clockwise.

Describe how a direct current motor works

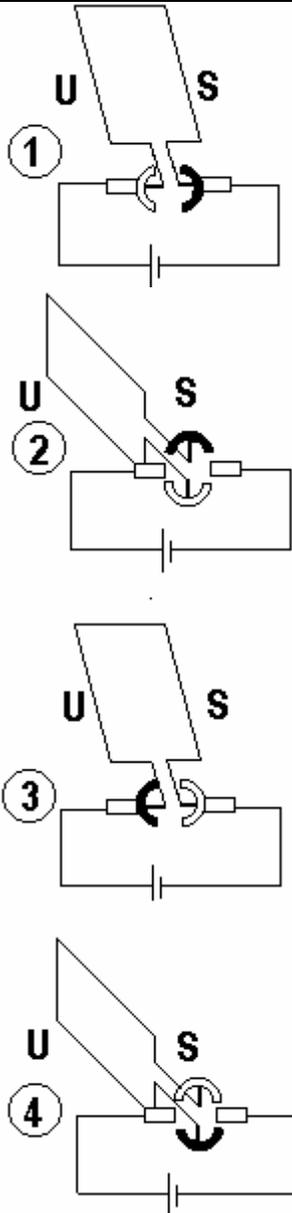


Commutator: reverse the direction of current in the coil every half rotation so that the coil continues to turn in same direction

Carbon Brush: to contact with the commutator so the current from the battery enters the coil.

Spring: push the brush so it will always contact with the commutator.

Show the direction of the two forces acted on the coil.



1. When current flows through the horizontal coil, magnetic field is produced around it. The interaction between the magnetic field of the current and the magnetic field of the permanent magnet produces a catapult field and 2 turning force. The direction of the force is determined by Fleming's left-hand rule. The two forces produce a couple which rotates the coil.

2. When the coil gets to the upright position, the contact between the carbon brushes with the commutator is broken. There is no turning force on it because no current flows in the coil. But the coil continues to rotate because of its inertia.

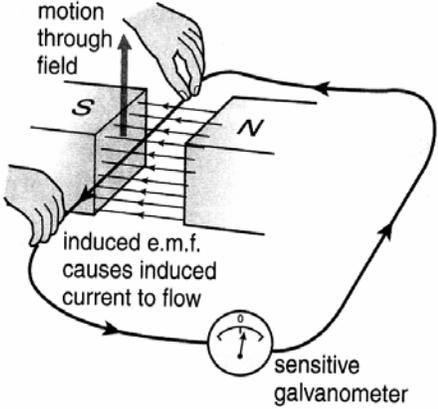
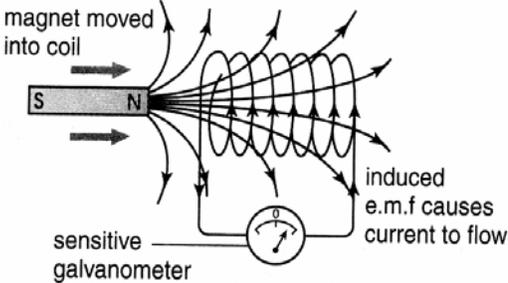
3. When the coil is in a horizontal position again, the sides of the coil change position. The commutator reverses the direction of the current in the coil to ensure that the forces on the coil turn the coil in one direction only. So the coil is still rotating in the same direction.

4. The above processes are repeated and the motor continues to rotate.

Factors which affect the speed of rotation of the motor

Factors	Speed of rotation of the motor
1. Increasing the size of the current	Increases
2. Increasing the strength of the magnetic field	Increases
3. increasing the number of turns	Increases
4. Increasing the area of the coil	Increases

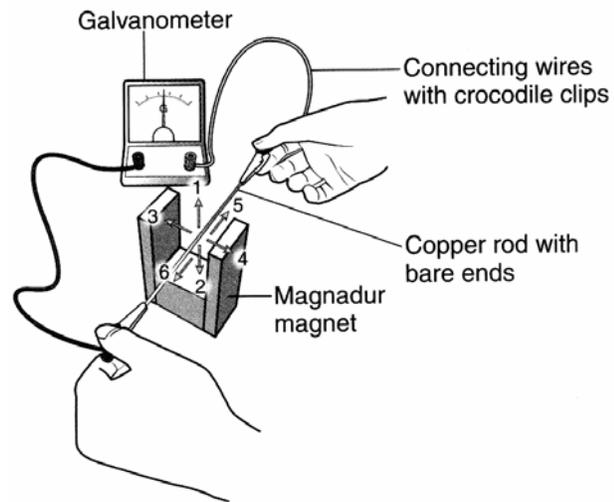
3.3 ELECTROMAGNETIC INDUCTION

<p>Describe electromagnet induction</p> <p>How induced current is produced?</p>	<p>Electromagnetic induction is the production of an <u>electric current</u> by a <u>changing magnetic field</u>.</p> <p>The induced current is produced only when there is relative motion between the conductor / coil and the magnetic field lines.</p> <p>The relative motion of a conductor across a magnetic field can be produced by: (a) moving a <u>straight wire</u> quickly across a magnetic field between <u>two flat magnets</u>.</p>  <p>(b) Moving a <u>permanent magnet</u> towards one end of a <u>solenoid</u>.</p>  <p>Each time the straight wire cuts across the magnetic field, or the permanent magnet moves towards the solenoid, a <u>current is induced</u> in the coil and a <u>deflection</u> is observed in the sensitive galvanometer.</p> <p>This current is called <u>induced current</u>. The electromotive force that is produced is called the <u>induced e.m.f.</u></p>
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A. Electromagnetic Induction in a straight wire.

Procedure:

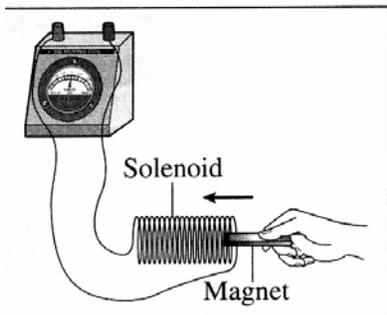
1. Hold the copper rod stationary between the poles of the magnet. Observe the reading of the galvanometer.
2. Move the rod quickly in Direction 1. Observe the deflection of the galvanometer.
3. Repeat step 2 for the other directions.



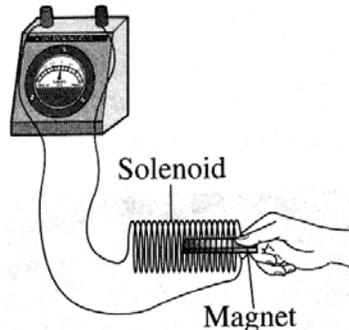
- If a galvanometer shows a deflection, it means there is an induced current produced
- Current is induced in a straight conductor when it moves and cuts the magnetic field lines.
- The motion of the copper rod must be perpendicular to the direction of the magnetic field lines so that an induced current will be produced.

B. Electromagnetic Induction in a solenoid.

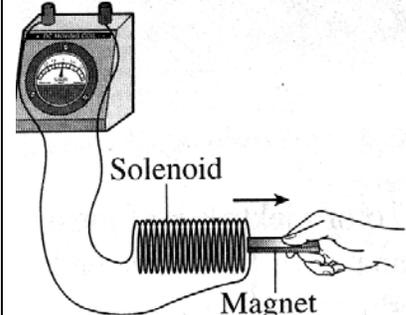
1. Push the bar magnet into the solenoid. Observe the deflection of the galvanometer.



2. Hold the bar magnet stationary in the solenoid. Note the reading of the galvanometer.



3. Now pull the bar magnet out of the solenoid. Observe the deflection of the galvanometer.



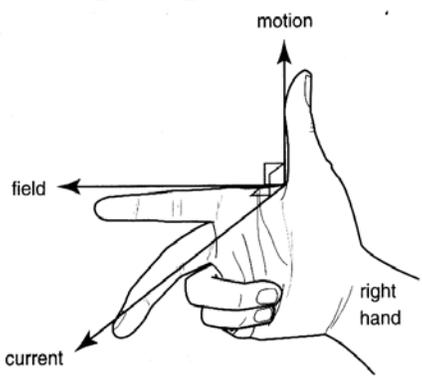
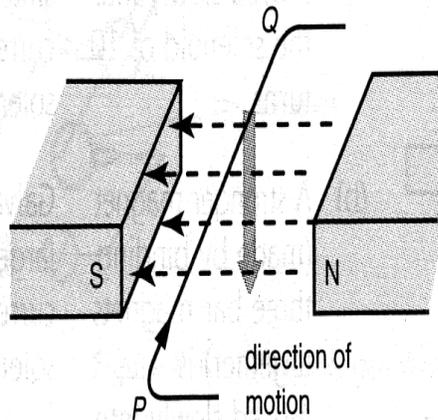
- *The galvanometer showed a positive reading when the bar magnet and solenoid were coming closer to each other. This shows that a current is produced in the solenoid in certain direction.*

- **The galvanometer showed a negative reading when the magnet and solenoid were moving further away from each other. This shows that a current is produced in the solenoid in the opposite directions.**
- **A current is induced in a solenoid when there is relative motion between the solenoid and a magnet.**

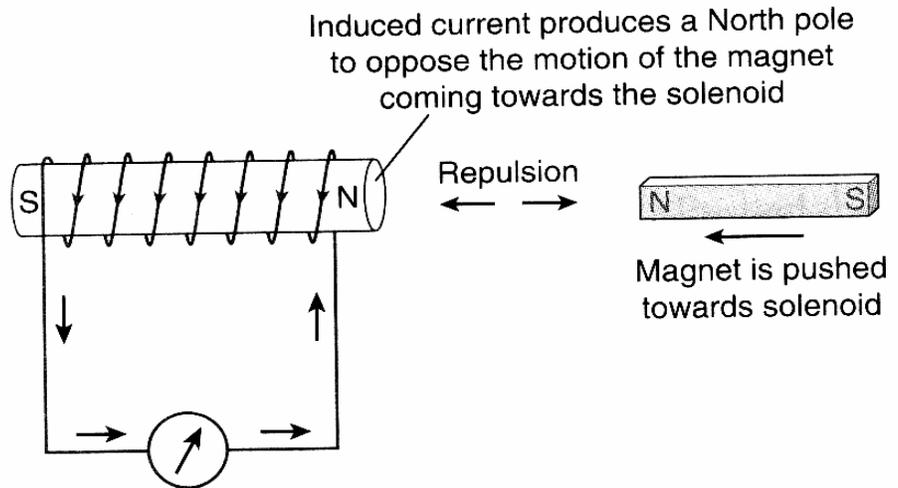
Conclusion

Current is induced in a straight conductor when it moves and cuts the magnetic field lines.

Current is induced in a solenoid when there is relative motion between the solenoid and a magnet.

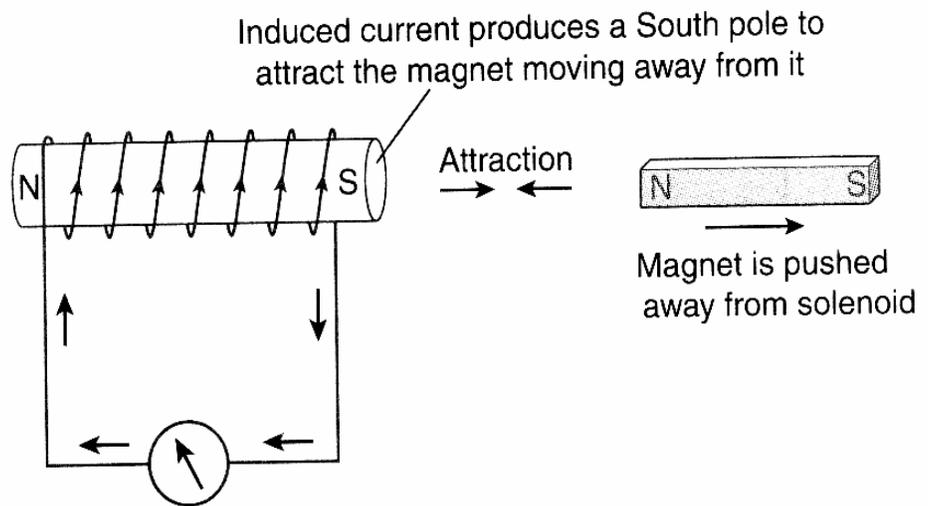
<p>Indicate the direction of the induced current in a straight wire</p>	<p>Fleming's right-hand rule:</p>  <p>If the thumb and the first two fingers on the right hand are held at right angles to each other with the <u>first finger</u> pointing in the <u>direction of the magnetic field</u> and the <u>thumb</u> in the <u>direction of the motion</u>, then the <u>second finger</u> points in the <u>direction of the induced current</u>.</p>	<p>A wire PQ is moved vertically downwards in a magnetic field. Applying Fleming's right-hand rule, the induced current will flow from P to Q.</p> 
<p>Indicate the direction of the induced current in a solenoid.</p>	<p>Lenz's Law: The direction of the induced current in a solenoid is such that its magnetic effect always oppose the change producing it.</p>	

Magnet is moved towards the solenoid



(a)

Magnet is moved away from the solenoid



(b)

Lenz's Law for solenoid

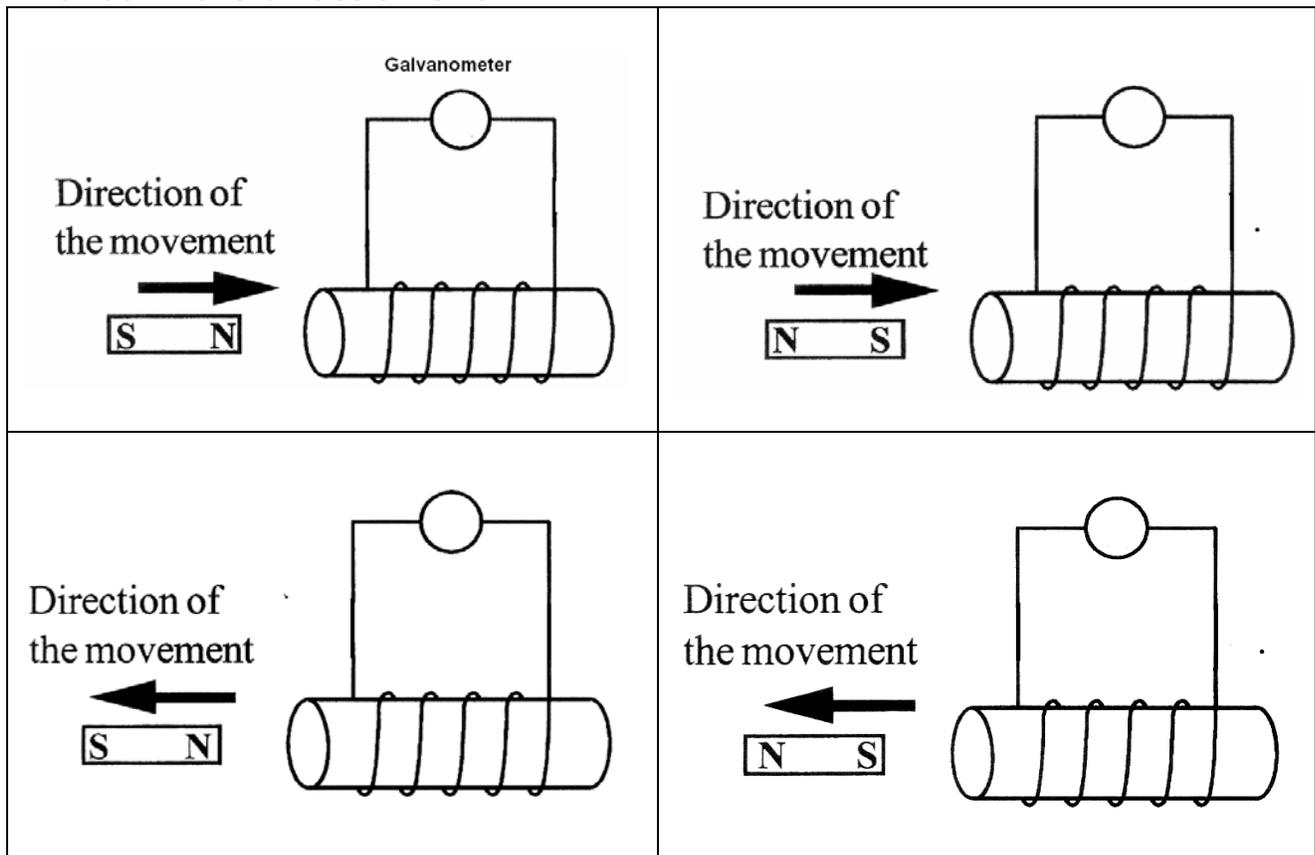
Relative motion between magnet and solenoid	Polarity at the end of the solenoid facing the magnet
Toward each other	Same polarity as the magnet
Away from each other	Opposite polarity as the magnet

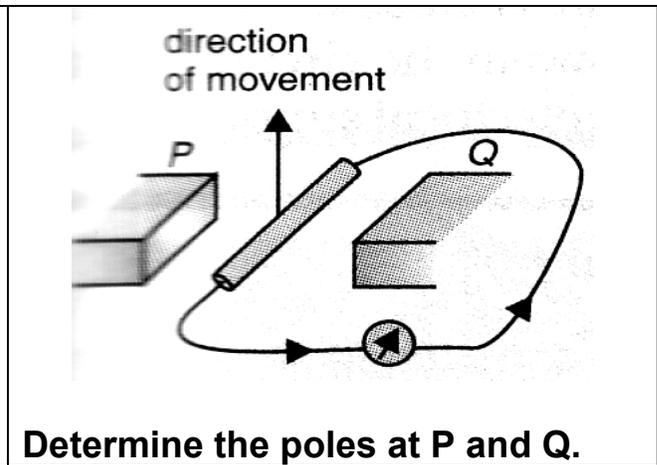
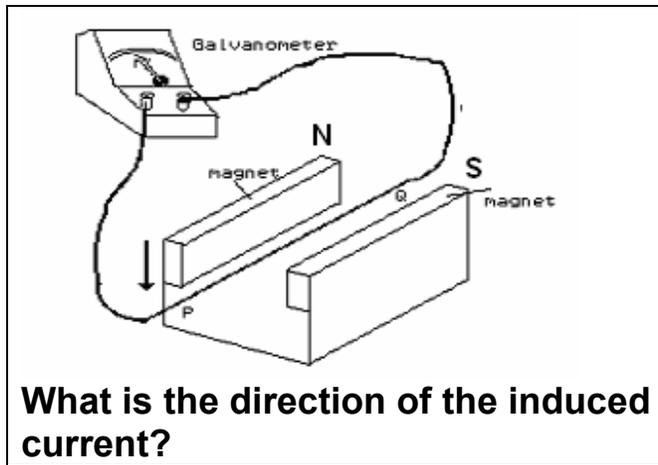
Principle of Conservation of Energy

Lenz's law is an example of the Principle of Conservation of Energy. When the magnet or solenoid is moved against the opposing force, work is done. Therefore mechanical energy is converted to electrical energy.

<p>Explain factors that affect the magnitude of the induced current.</p>	<p>Faraday's Law: The size of the induced e.m.f is directly proportional to the rate at which the conductor cuts through the magnetic field lines.</p> <p>The size of the induced e.m.f. and thus the induced current and be increased by:</p> <ol style="list-style-type: none"> 1. moving the magnet or the solenoid at a higher speed 2. increasing the number of turns on the solenoid 3. increasing the strength of the magnetic field through the use of a stronger magnet.
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Show the correct direction of the induced current when the magnet is moved in the direction shown.

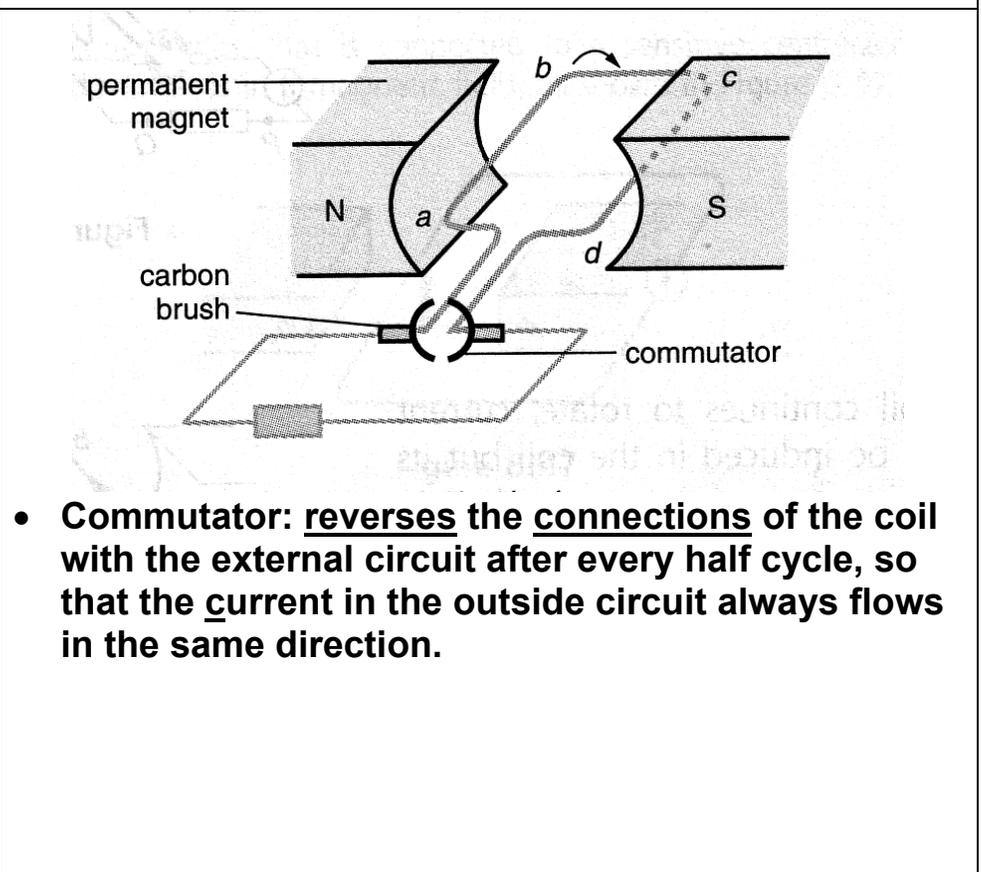




Describe applications of electromagnetic induction

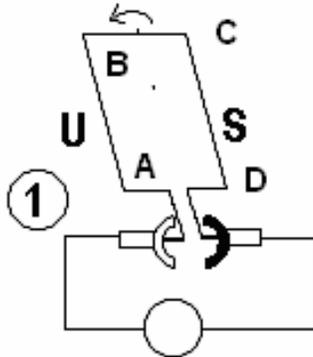
- Current Generator**
- **Current generator functions by converting mechanical energy to electrical energy.**
 - **Current generator works based on electromagnetic induction and uses the Fleming's Right hand rule.**
 - **Current generator is divided into: direct current generator and alternate current generator.**

Direct Current Generator

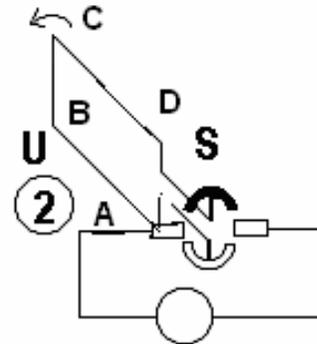


- **Commutator: reverses the connections of the coil with the external circuit after every half cycle, so that the current in the outside circuit always flows in the same direction.**

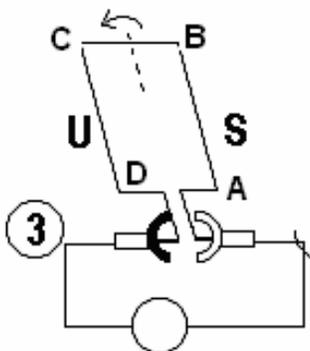
Describe how does a direct current generator work. Show the direction of movement of the coil AB and CD. Mark the direction of the induced current in the coil and the galvanometer.



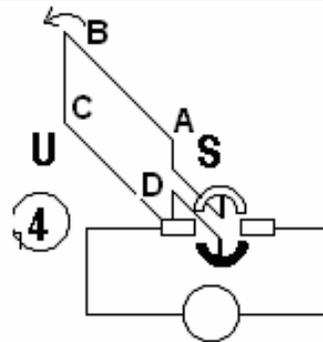
- Coil AB moves, coil CD moves.....
- When the coil rotates, its sides cut across the magnetic field lines and induced current flows in the coil from
- The galvanometer will deflect to



- The sides AB and CD are movingto the magnetic field and thus do notthe magnetic field lines.
- Nois produced at the instant.
- The galvanometer returns tomark.

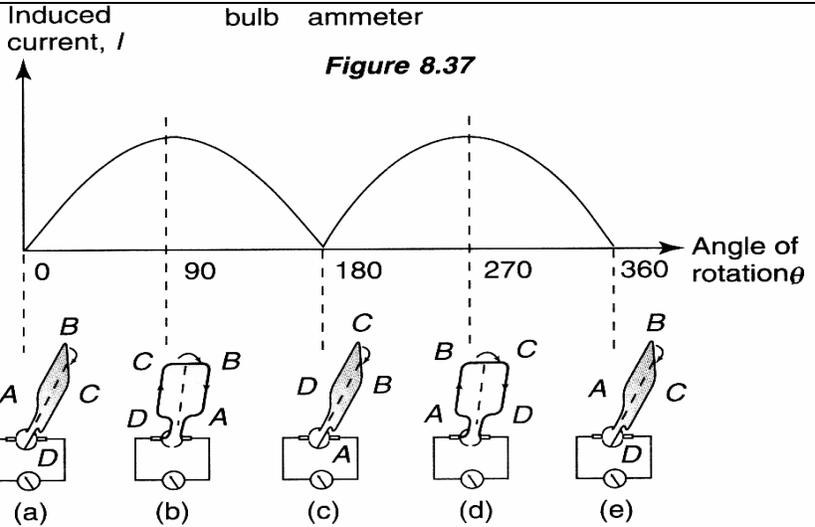


- As the coil continues to rotate, current will again be induced in the coil but its direction is now opposite to that in figure 1 which is from to and from to
- However, the direction of the current through the external circuit remains the same, so the galvanometer deflects to the

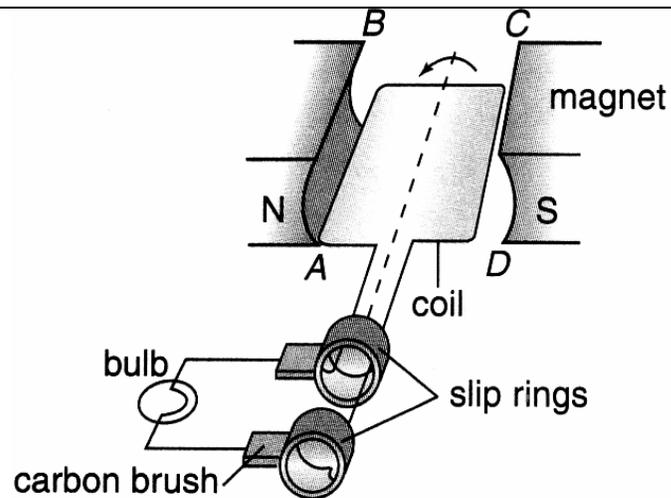


- The sides AB and CD are movingto the magnetic field and thus do notthe magnetic field lines.
- Nois produced at the instant.
- The galvanometer returns tomark.
- The process is

The induced current varies from a maximum to zero, it flows in one direction only. Hence, the induced current is called a direct current.

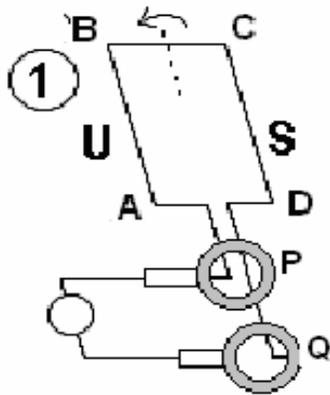


Alternating Current Generator

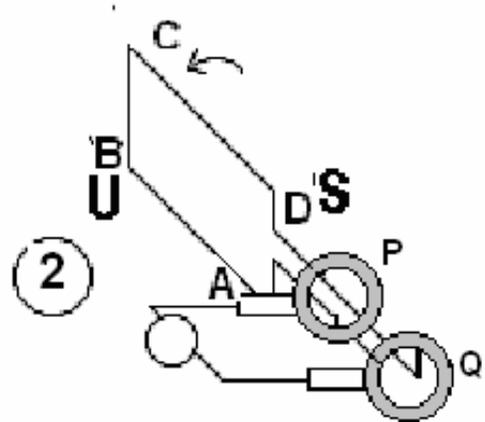


- The two ends of the coil are connected to two slip rings which rotate with the coil.
- Each slip ring is always in contact with the same carbon brush.

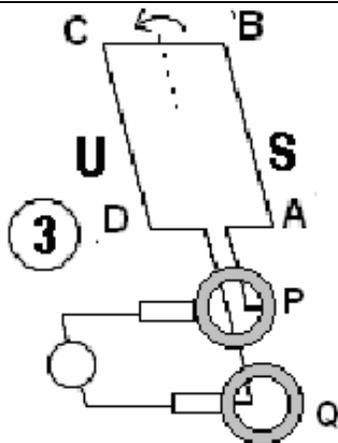
Describe how does an alternating current generator work. Show the direction of movement of the coil AB and CD. Mark the direction of the induced current in the coil and the galvanometer.



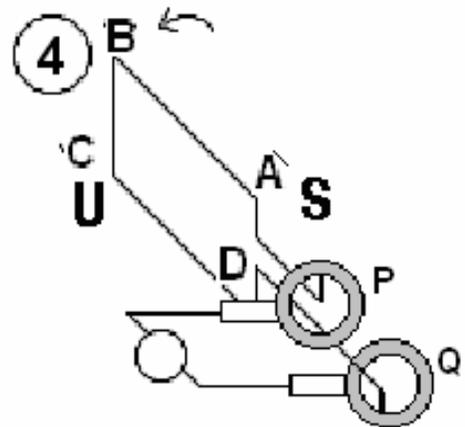
- Coil AB moves, coil CD moves.....
- When the coil rotates, its sides cut across the magnetic field lines and induced current flows in the coil from to and from to (using Fleming's right hand rule)
- In the external circuits, current flows from to



- The sides AB and CD are movingto the magnetic field and thus do notthe magnetic field lines.
- No is produced at the instant.
- The galvanometer returns tomark.

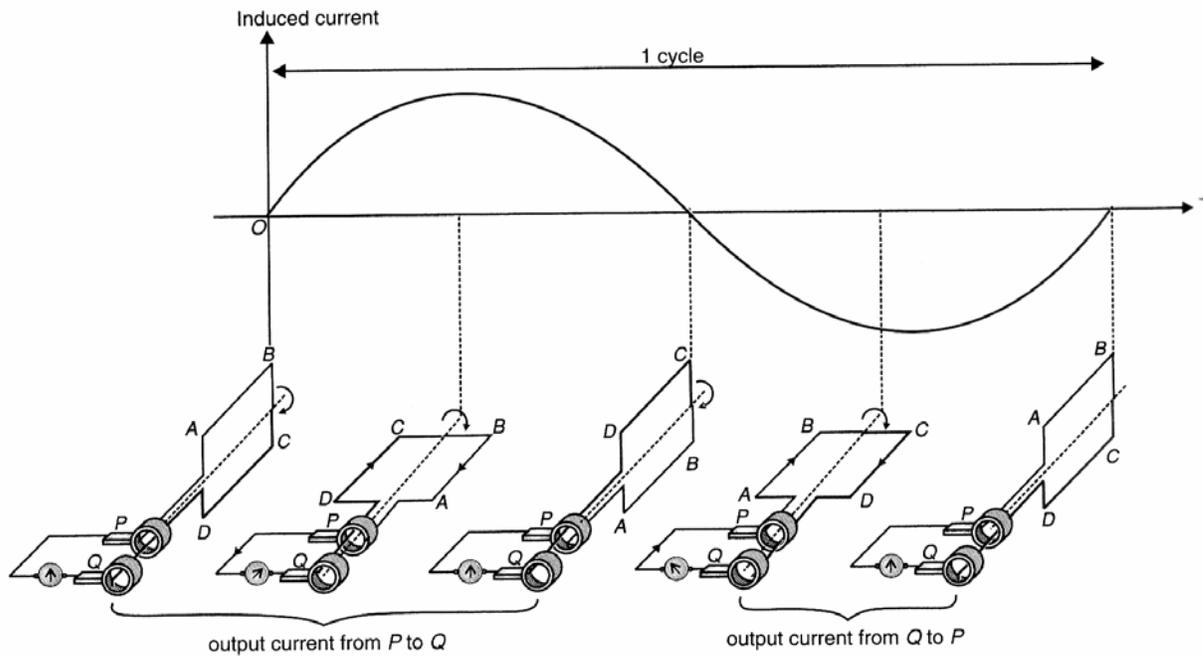


- After the vertical position, the current increases until it attains the maximum value when the coil is in a horizontal position.
- Coil CD moves, coil AB moves
- The direction of the induced current is from to and from to
- The direction of the current through the external circuit is from



- The sides AB and CD are movingto the magnetic field and thus do notthe magnetic field lines.
- No is produced at the instant.
- The galvanometer returns tomark.
- The process is

the brush to which is reversed.

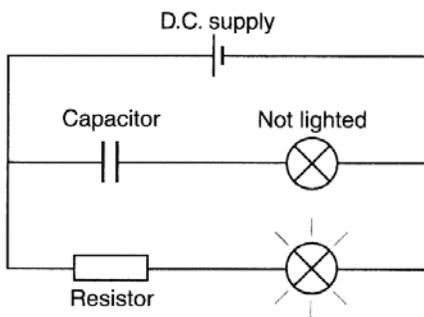
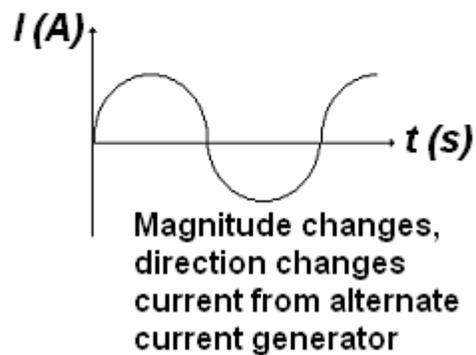
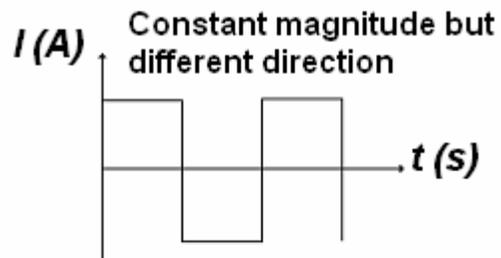
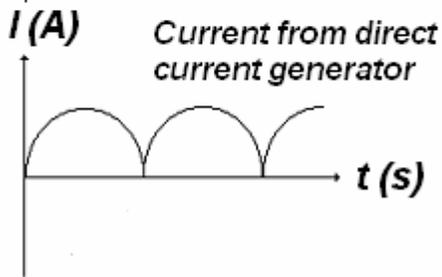
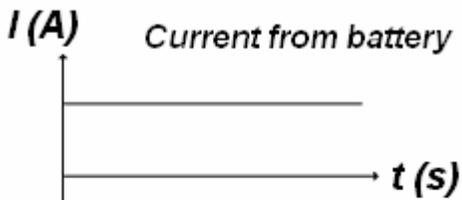


- The output current generated is an alternating current because the current changes direction in the external circuit each time the coil passes the vertical position.
- Assume the current flows from P to Q is positive and the current flows from Q to P is negative.
- The current changes magnitude and direction after every half rotation.

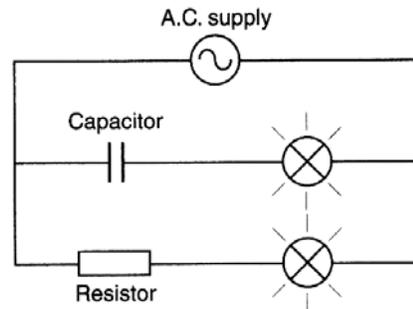
Compare direct current and alternating current.

1. A direct current is a current that flows in one direction only in a circuit.
2. The magnitude of a direct current may be:
 - (a) constant
 - (b) changes with time

1. An alternating current is a current which flows to and fro in two opposite directions in a circuit. It changes its direction periodically.

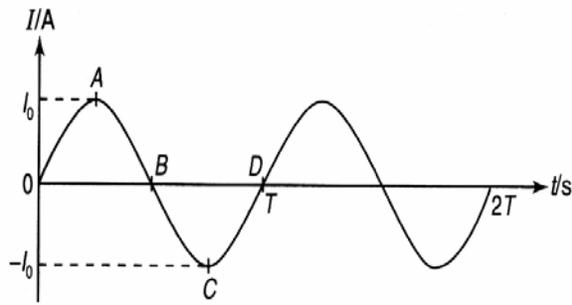


A direct current can flow through a resistor but cannot flow through a capacitor.

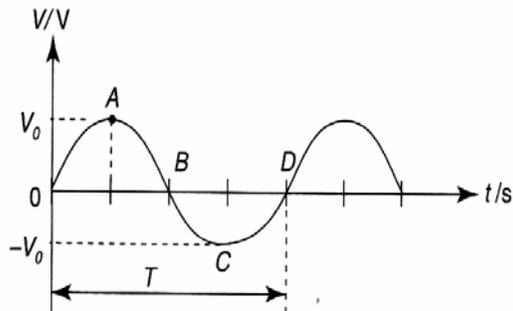


An alternating current can flow through both a resistor and a capacitor.

Both the direct current and alternating current have a heating effect on the filament of a bulb and can light up the bulb.



(a) Alternating current

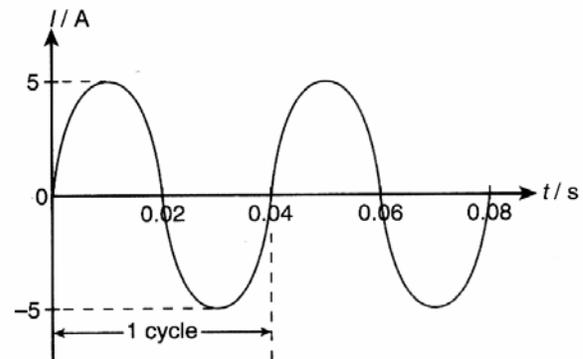


(b) Alternating voltage

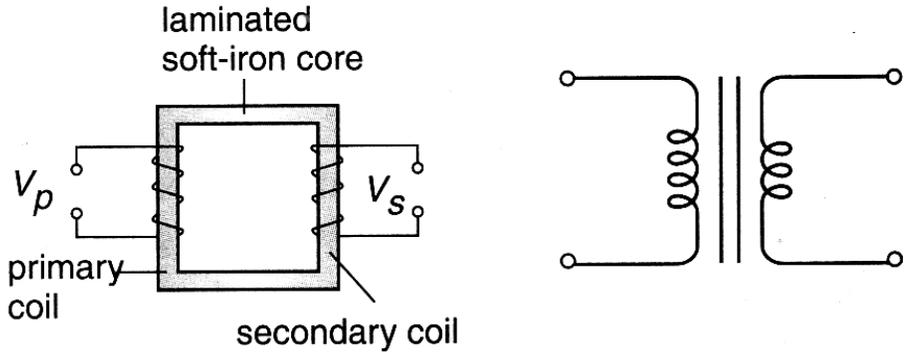
- The current increases from zero to a maximum value of $+I_0$ (at A), and back to zero at B. It then reverses direction and increases to $-I_0$ at C and back to zero again.
 I_0 = peak current,
 V_0 = peak voltage
- The time taken for a complete cycle from O to D is called one period, T.
- Frequency of the current is f where $f = 1/T$
- In Malaysia, the frequency of the a.c supply is 50 Hz.
 Hence, the period of the a.c is :
 $T = 1/50 = 0.02$ seconds.

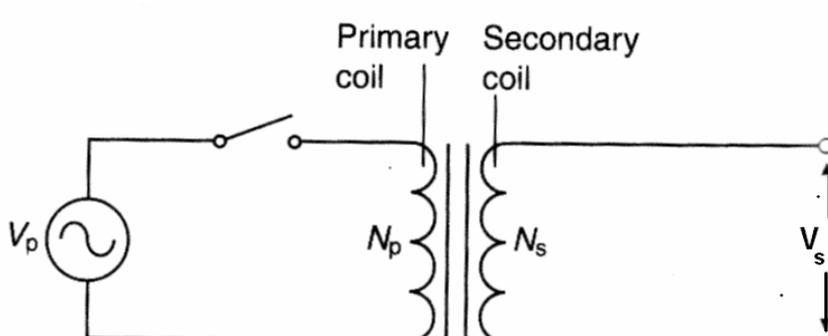
Figure shows an alternating current with a magnitude that changes with time.

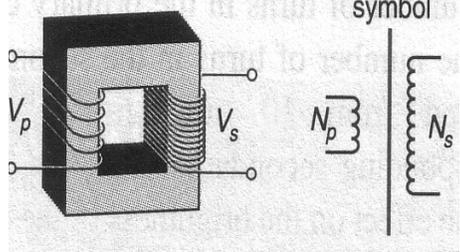
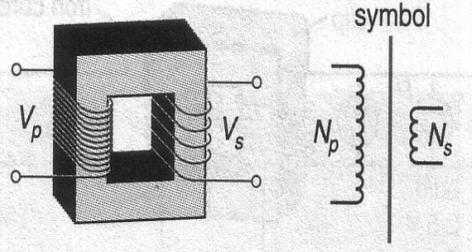
- What is the peak current?
- What is the period of the a.c. current?
- What is the frequency of the a.c current?



8.4 TRANSFORMERS

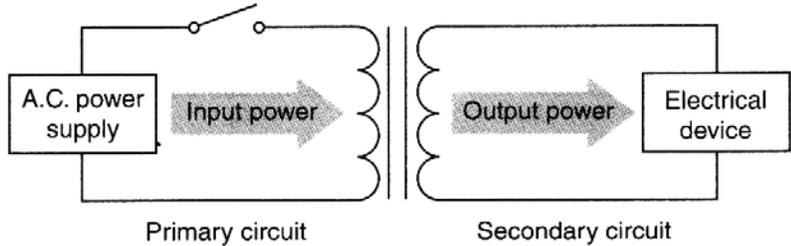
<p>What is a transformer?</p>	<p>A transformer is an electrical device which <u>increases</u> or <u>decreases</u> an alternating voltage based on the principle of electromagnetic induction.</p>
<p>Describe the structure of a simple transformer</p>	<div style="text-align: center;">  <p>(a) Structure of transformer (b) Symbol of a transformer</p> </div> <ul style="list-style-type: none"> • A transformer consists of two coils of wire wound round separately on a laminated soft-iron core. • The coil connected to the input voltage is called the <u>primary</u> coil. The coil connected to the output voltage is called the <u>secondary</u> coil. • The purpose of the common iron core is to provide a magnetic field linkage in the secondary coil.
<p>Describe the operating principle of a simple transformer</p>	<ul style="list-style-type: none"> • A transformer works on the principle of <u>electromagnetic induction</u>. • When a.c voltage, V_p, is applied to the primary coil of transformer, an alternating current flows through the coil. The soft-iron core is magnetized in one way and then the other. • This means that the magnetic flux linkage in the secondary coil is constantly changing. • An alternating e.m.f is induced across it to produce an a.c voltage, V_s in the secondary coil and a.c current flows through the second coil. • The frequency of the secondary voltage V_s is the same as that of the primary voltage, V_p. • The magnitude of the secondary voltage, V_s, depends on the ratio of the number of turns of the primary and secondary coils.

<p>Why does the transformer not work with a d.c power supply?</p>	<ul style="list-style-type: none"> • A current is induced in the secondary coil only when there is a changing magnetic flux due to a changing primary current. (changes direction and magnitude) • A d.c. power supply gives a constant current in the primary circuit • A constant direct current whose magnitude and direction is constant does not create a changing magnetic flux in the secondary coil. • Therefore electromagnetic induction does not take place.
<p>State the relationship between number of turns in coils with voltage in a transformer, (V_p, N_p, V_s and N_s)</p>	<ul style="list-style-type: none"> • According to Faraday's law: Voltage \propto number of turns in coils $V \propto N$ $V = kN \quad \therefore \frac{V_p}{N_p} = \frac{V_s}{N_s}$ $\frac{V}{N} = k$ <p> V_p = input (primary) voltage V_s = output (secondary) voltage N_p = number of turns in the primary coils N_s = number of turns in the secondary coils </p> 
<p>Compare and contrast a step-up transformer and a step-down transformer</p>	<p><u>Step-up transformer</u> If N_s is greater than N_p, then V_s is greater than V_p</p> <p><u>Step-down transformer</u> If N_s is lower than N_p, then V_s is lower than V_p</p>

Step-up transformer	Step-down transformer
	
$N_s > N_p$ $V_s > V_p$	$N_s < N_p$ $V_s < V_p$

What is the relationship between output power and input power of an ideal transformer?

- A transformer transfers electrical power from the primary circuit to the secondary circuit.
- The primary circuit of a transformer receives power at a certain voltage from the a.c power supply. The transformer delivers this power at another voltage to an electrical device connected to the secondary circuit.



- In an ideal transformer, there is no energy loss during the process of transforming the voltage.

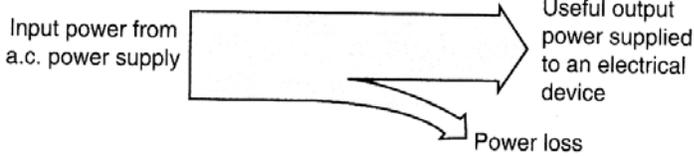
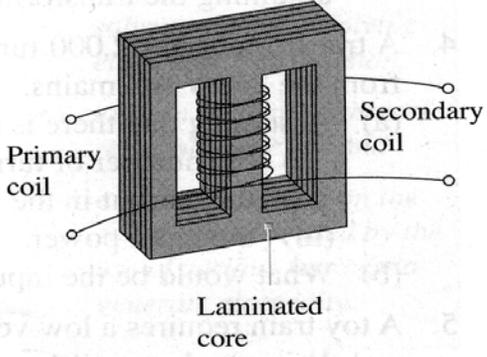
[Power supplied to = [Power used in the
the primary coil] secondary coil]

Input power = Output power

$$V_p I_p = V_s I_s$$

Describe the energy losses in a transformer

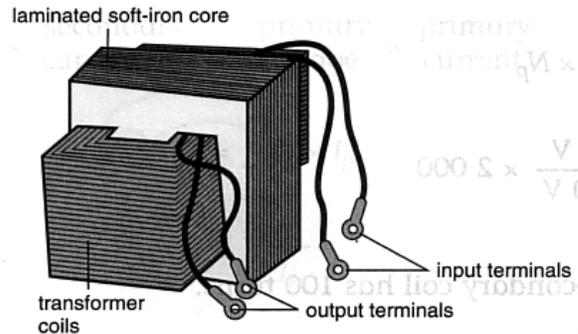
- In a real transformer, some energy is lost in the transformer especially in the form of heat.
- The output power is less than the input power.
- Therefore the efficiency of the transformer is less than 100%.

<p>Efficiency of a transformer</p>	<div style="text-align: center;">  </div> <ul style="list-style-type: none"> • Efficiency = $\frac{\text{output power}}{\text{Input power}} \times 100\%$ • The power loss is due to <ol style="list-style-type: none"> (a) heating of coils (b) eddy currents in the iron core (c) magnetization and demagnetization of core (d) leakage of magnetic flux. 	
<p style="text-align: center;">Causes of energy loss in transformers</p>	<p style="text-align: center;">Ways to improve the efficiency of a transformer</p>	
<p>Resistance of the coils</p> <ul style="list-style-type: none"> • all coils will have resistance • heat is produced when current flows through them 	<p>Use thick copper wires to make the coils</p> <p>The resistance will reduce as the wire is thicker.</p>	
<p>Eddy currents in the core</p> <ul style="list-style-type: none"> • the changing magnetic field will also induces current in the iron core • this induced current is called eddy current • cause heat to be produced in the iron cores. 	<p>Use laminated cores to reduce eddy currents</p> <div style="text-align: center;">  </div>	
<p>Magnetization and demagnetization of the core</p> <ul style="list-style-type: none"> • the alternating current flowing through the transformer continually magnetizes and demagnetizes the core • work has to be done to change the magnitude and direction of the magnetic field in the core which contributes to energy loss 	<p>Use cores made from soft-iron as soft-iron core can be easily magnetized and demagnetized.</p>	

Leakage of magnetic field

- electrical energy is lost when a fraction of the magnetic field produced by the primary coil does not link with the secondary coil.

Wind the secondary coil on top of the primary coil



Solve problems involving transformers

1. A transformer is required to step down the mains voltage of 240 V provide a 12 V supply for an electric toy. If the primary coil is wound with 1 000 turns of wire, calculate the number of turns required for the secondary coil.

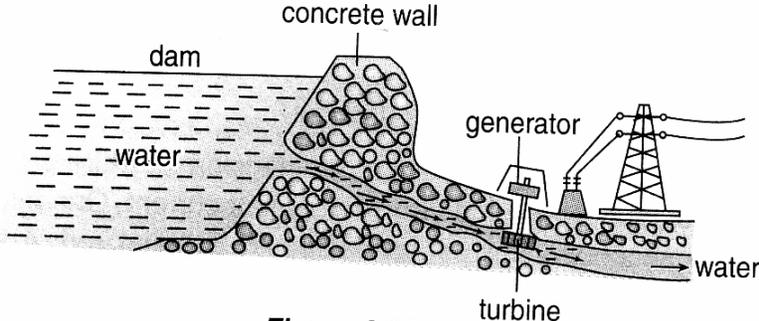
2. A step up transformer has 10 000 turns on its secondary coil and 100 turns on its primary coil. An alternating current of 5.0 A flows in the primary coil when it is connected to a 12 V a.c supply. Calculate:

- (a) the input power to the transformer
- (b) the e.m.f induced across the secondary coil.
- (c) What is the maximum current that could flow in a circuit connected to the secondary coil if the transformer is 100% efficient.

8.5 GENERATION AND TRANSMISSION OF ELECTRICITY

Electricity is *generated* in power stations, *transmitted* (sent) through long-distance cables, and then *distributed* to consumers.

<p>List sources of energy used to generate electricity</p>	<ul style="list-style-type: none"> • Renewable energy sources : an energy resource that is continually replaced and will not run out. • Non-renewable sources: an energy resource that <u>cannot be replaced</u> once it has been used. <table border="1" data-bbox="418 625 1312 932"> <thead> <tr> <th data-bbox="418 625 863 667">Renewable energy</th> <th data-bbox="870 625 1312 667">Non-renewable energy</th> </tr> </thead> <tbody> <tr><td> </td><td> </td></tr> </tbody> </table>	Renewable energy	Non-renewable energy												
Renewable energy	Non-renewable energy														
<p>Describe the various ways of generating electricity</p> <p>Coal-fired power station</p> <p>Gas-fired power station</p>	<ul style="list-style-type: none"> • Electricity is produced using generators • A generator has a huge magnet that is turned by a turbine. • As the magnet turns inside a coil of wire, electricity is produced by <u>electromagnetic induction</u>. • Many sources of energy are used to turn these turbines. <ol style="list-style-type: none"> 1. Coal is burned and the heat energy is used to produce high pressure steam. 2. The steam produced is used to drive the generators to produce electricity. 3. The energy changes: chemical energy to heat energy to kinetic energy to electric energy <ol style="list-style-type: none"> 1. The burning of natural gas produces high pressure steam that is used to drive turbines. 2. The energy changes: chemical energy to heat energy to kinetic energy to electric energy 														

<p>Hydro-electric power station</p>	<ol style="list-style-type: none"> 1. A huge dam is built across rivers to contain water. 2. When the water in the dam is allowed to flow down to a lower level, the kinetic energy of the moving water is used to drive water turbines, which in turn drive the generators to produce electricity.  <p>The diagram illustrates a hydroelectric power station. On the left, a reservoir of water is held behind a dam. The dam consists of a concrete wall and a spillway. Water is shown flowing down the spillway. At the base of the spillway, a turbine is positioned. The turbine is connected to a generator, which is shown with electrical lines extending from it. Labels include 'dam', 'water', 'concrete wall', 'generator', 'turbine', and 'water' with an arrow indicating flow direction.</p> <ol style="list-style-type: none"> 3. The energy changes: potential energy to kinetic energy to electric energy
<p>Nuclear power station</p>	<ol style="list-style-type: none"> 1. Energy from nuclear fission (splitting of uranium 235 atoms) is used to produce high pressure steam to drive turbines 2. The energy changes: nuclear energy to heat energy to kinetic energy to electric energy
<p>Biomass</p>	<ol style="list-style-type: none"> 1. Biomass includes rotting plants and agricultural wastes such as oil palm kernels and household sewage that are used to produce methane gas and alcohol. 2. Heat energy from the burning of biomass is used to generate electricity
<p>Solar</p>	<ol style="list-style-type: none"> 1. Solar energy originates from the sun 2. Solar cells use sun energy to generate small electrical energy to power calculators. 3. Solar panels use sun energy to generate heat energy to heat water at home.
<p>Wind generator</p>	<ol style="list-style-type: none"> 1. High speed wind can be used to turn the blades of large windmills which will in turn drive generators to produce electricity.

<p>Describe the transmission of electricity</p>	<ul style="list-style-type: none"> • Electrical energy is transmitted from power station to the consumer using long transmission cables or power lines. • Electrical energy is transmitted at a high voltage and use alternating current. • A step-up transformer which increases the voltage to as high as 110,000 or 132, 000 V. • Step-down transformers are used to decrease the voltage before being delivered to the consumers. • The long tick cables used as transmission lines are made of copper or aluminium
<p>Describe the energy loss in electricity transmission cables deduce the advantage of high voltage transmission</p>	<ul style="list-style-type: none"> • The heating effect due to the resistance of the cables causes loss of electrical energy as heat energy. • When a current flows in a cable, the power loss, P through heating is $P = I^2 R$ where R is the resistance of the cable. • The power loss can be reduced by <ul style="list-style-type: none"> (a) reducing the resistance of the cables (b) reducing the current in the cables • In order to reduce resistance of the cables, a thick cable is used eg copper or aluminium. But thick cables are very expensive to install and will be too heavy to be supported securely. • The loss of power in the transmissions of electricity is reduced by reducing the current in the cables. • The power to be transmitted by the cables is $P = VI$ where I = current in the cables, V = voltage of the cables. • The current in the cables: $I = \frac{P}{V}$ • This means that the current in the cables is inversely proportional to the voltage of the cables for a certain value of power transmission. • When power is transmitted at lower voltage, the current in the cables is large. • The greater the current in the cables, the greater the power loss.

Activity 1: Solve problems involving electricity transmission

1. Find the power loss in a transmission cable when 20 kW is transmitted through a cable of 1.5Ω
(i) at a voltage of 200 V
(ii) at a voltage of 10 kV.

What is the effect of the energy losses in case (i) and (ii)?

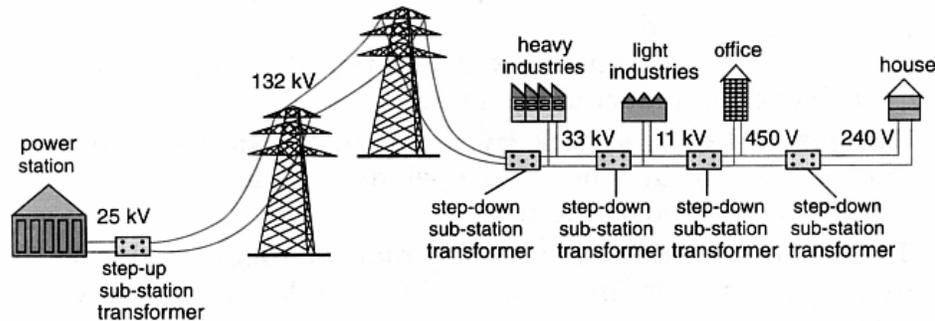
2. Electric power is transmitted from a power station to a town by a transmission cables with a total resistance of 50Ω . If the power station generates 8 MW of power, calculate the power loss in the cables if power is transmitted
(a) at 80 kV
(b) at 400 kV

What is the National Grid Network

- **National Grid Network is a network system of high voltages cables which connects all the power stations in the country to the consumers.**
- **Electricity is generated at 25 kV at the power station. It is then stepped up in a transformer to 132 kV before it is sent to the grid network.**
- **The purpose of increasing the voltage to 132 kV is to lower the current flowing through the grid, and this reducing power loss during transmission.**
- **The high voltage in the grid is subsequently reduced by sub station transformers for distribution to local users.**
- **Heavy industries will be supplied with power at 33 kV. Light industries will be supplied with power at 11 kV.**

State the importance of the National Grid Network

Offices will be supplied with power at 415 V while domestic users will be supplied with power at 240 V.



- **Cost of generation of electricity is reduced because high voltage transmission reduces the current flowing through the cables and hence reduces power loss in the cables.**
- **Power stations in areas where the demand is low can supply electricity to areas where the demand is high.**
- **If a particular station breaks down or is shut down for maintenance work, the other stations can supply electrical energy to the affected area.**
- **The grid network also enables less efficient stations to be shut down at off-peak period, thereby reducing the overall cost of generation and transmission.**
- **Power stations can be located outside city limits so that air and environmental pollution can be reduced.**

Transmission issues

<p>Alternating current, a.c</p>	<ul style="list-style-type: none"> • An alternating current is used in the transmission of electrical energy at a high voltage because its voltage can be easily increased or decreased with transformers. • A transformer cannot function with a direct current.
<p>High voltage or low voltage?</p>	<p>Electrical power is transmitted at a high voltage so that</p> <ul style="list-style-type: none"> • The current in the cables is smaller • The loss of power due to heating of the cables is minimized.

Overhead or underground?	<ul style="list-style-type: none"> • High voltage cables are the cheapest way of sending power over long distances. • However, to prevent sparking, the only effective way of insulating the cables is to keep huge air spaces around them • The cable have to be suspended from pylons.
Cost of cables	<ul style="list-style-type: none"> • Copper cables have low resistance but are of high cost • Aluminium cables are usually used as they are light, have low resistance and cost less.
Charge leakage between the cables and the earth	<ul style="list-style-type: none"> • To prevent charge leakage, the aluminium cables are supported by high metal pylons. • The metal support of the pylon is earthed so that it is safe to workers and the public who come into contact with them.
Danger of being struck by lightning	<ul style="list-style-type: none"> • The pylons carry lightning conductors that are properly fixed into the ground • The cables are properly fixed with porcelain support so that the cables do not touch the pylons.
Danger of being struck by light aircraft	<ul style="list-style-type: none"> • Lights and special markers must be attached to the pylons.
Theft	<ul style="list-style-type: none"> • Stricter laws should be enforced to deter thieves from stealing the aluminium cables.

Explain the importance of renewable energy	<ul style="list-style-type: none"> • Non-renewable sources of energy such as crude oil, coal and natural gases are fast depleting. Alternatives must be found to replace such sources to ensure continuous supply of power in the future. • Renewable energy sources are those which originate from the sun or the earth and will last as long as the Solar System itself. • From the sun: solar panels, solar cells, biomass, wind and wave energy, hydroelectric power • From the earth: geothermal energy, energy from the tides. • Renewable sources of energy do not pollute the environment.
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- For renewable sources of energy to be widely used, many hurdles must be overcome, especially those related to the economical production and distribution of power generated from such sources.

Explain the effects on the environment caused by the use of various sources to generate electricity.

Energy resource	Advantages	Disadvantages
Hydro	<ul style="list-style-type: none"> • Renewable energy • Water is freely available in large quantities • Clean and does not pollute the environment • Water stored in dams can be used to irrigate farms • Dams can be used to control floods • Dams can be promoted as recreational centre 	<ul style="list-style-type: none"> • Building of dams can upset the balance of the ecosystem • Not suitable in areas where natural disasters such as earthquakes may occur • Not suitable in flat and dry regions.
Oil and natural gas	<ul style="list-style-type: none"> • At present it is still available in large quantities • Can be transported to the location where it is to be used 	<ul style="list-style-type: none"> • Non-renewable energy • Discharges harmful gases that can pollute the environment • High cost
Solar	<ul style="list-style-type: none"> • Renewable energy • Freely available • Clean and no pollution 	<ul style="list-style-type: none"> • Requires very large space to collect sufficient energy • Lower efficiency in the generation of electricity • Intensity of sunlight is dependent of seasonal changes, climate and latitude of the region. • High cost

Coal	<ul style="list-style-type: none"> • Plenty of resources available for up to 200 years • Can be transported to the location where it is to be used 	<ul style="list-style-type: none"> • Non-renewable energy • Discharges harmful gases that can pollute the environment
Nuclear	<ul style="list-style-type: none"> • A small amount uranium can release a large quantity of energy • Minimum discharge of carbon dioxide • Reactor in nuclear power stations can be used to produce useful radioisotopes to be used in industry, medicine and agriculture 	<ul style="list-style-type: none"> • High cost of building • Waste in the form of used fuel rods which are very hot and highly radioactive • Hot water discharged causes thermal pollution to the environment • Risk of accidents which may lead to the leakage of large amounts of radioactive substances to the environment.
Biomass	<ul style="list-style-type: none"> • Renewable energy • Reduces problem of disposal of organic waste 	<ul style="list-style-type: none"> • Requires large storage space far from human population if the biomass is animal dung or sewage.
Wind	<ul style="list-style-type: none"> • Renewable energy • Clean and does not pollute environment 	<ul style="list-style-type: none"> • Requires many windmills which cover a larger area • Generates high level of noise