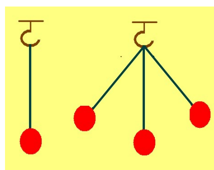
PHYS 418 - 2018-2019

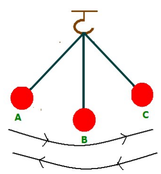
MATERIAL ADAPTATION AND DEVELOPMENT IN PHYSICS EDUCATION

a. Pendulum
    a. Calculation of period

A string with a mass at the end which is free to swing is called a pendulum.



The motion of the mass from its extreme position A to C and back to A is called an oscillation. The time taken to complete one oscillation is called the periodic time of the simple pendulum. It is sometimes also called its period and is denoted by T.



The Period of the pendulum T is related to the length L by the relation

$$T = 2\Pi\sqrt{\frac{L}{g}}$$

UNITS:

***T* in seconds**

Question: Take g=10 m/s^2 and Pi: 3, calculate the period of a pendulum with length 1.6 m.

b. Calculation of frequency

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

UNITS:

***T* in seconds**

***f* in Hz (s^{-1})**

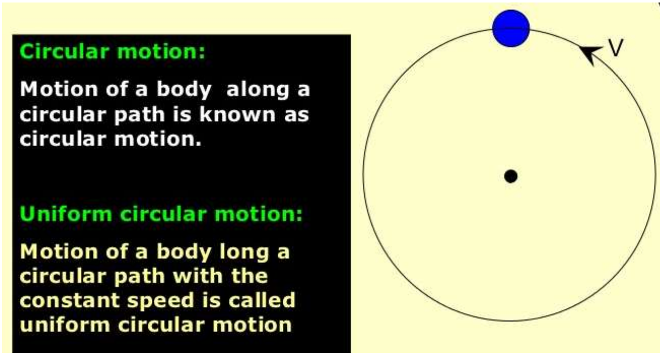
Question: Calculate frequency of a motion which has a period of 4 seconds.

Activities with BICYCLE

b. Circular motion

Question: How can use bicycle to teach circular motion? Explain.

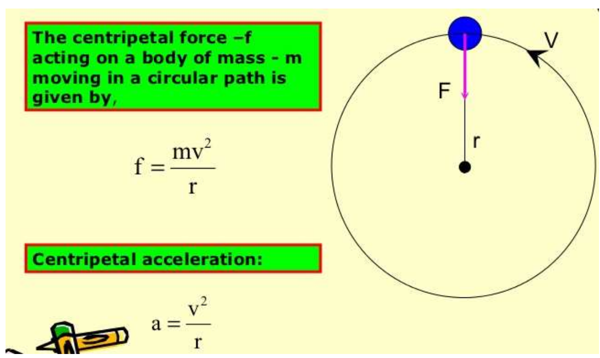
Calculation of circular velocity



Question: Explain circular motion and uniform circular motion.

Circular acceleration

a. Calculation of circular acceleration



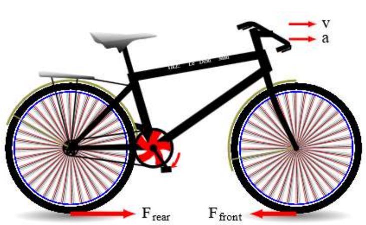
Question: If an object has a velocity of 5 m/s^2 and a radius of 2 m making circular motion,

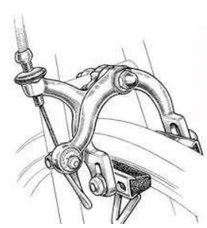
i. calculate its centripetal acceleration
ii. If the mass of the object is 5 kg, calculate its centripetal force.

i. Friction

Question : How can you use bicycle to teach friction force? In which parts of bicycle there are frictions?

a. Direction of friction between tires and ground

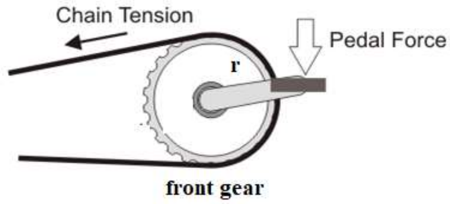




Brakes

j. Torque

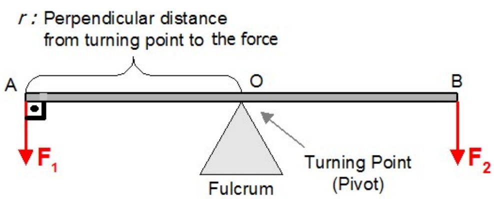
When you apply force on the pedal you produce torque on the front gear. This



a. Calculation of torque

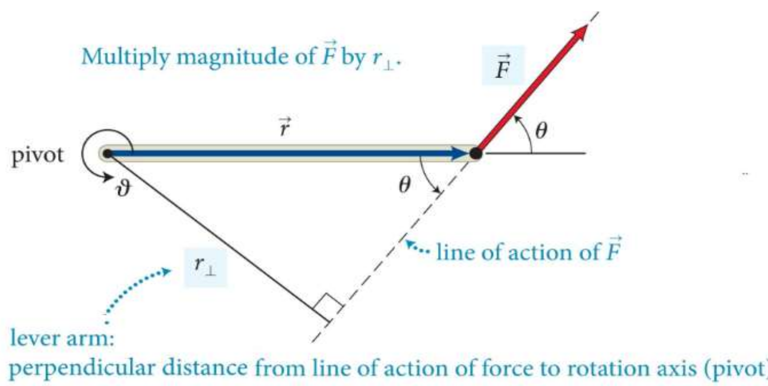
Torque (τ, Greek letter, tau) is the turning effect of a force. It depends on the magnitude of the force, F, and the perpendicular distance between the point of rotation and the line of action of the force, r.

$$\vec{\tau} = \vec{F} \times \vec{r}$$



If the angle formed between the line joining the point of rotation to the point of application of the force and the line of action of the force is θ, then r may be expressed in terms of this angle and the distance, r, between the point of rotation and the point of application of force as $r_{perpendicular} = r \sin \theta$. Therefore we may also write the following expression for the torque:

$$\vec{\tau} = \vec{F} \times \vec{r} sin(\theta)$$



Problem

The length of a bicycle pedal arm is $r = 0.152$ m, and a downward force of $F = 111$ N is applied by the foot.

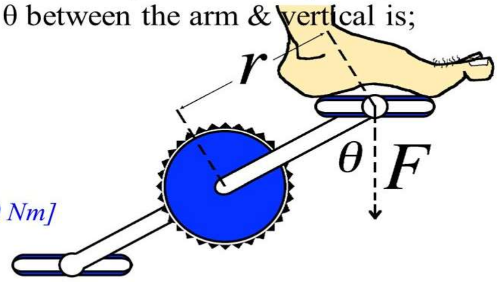
What is the magnitude of torque about the pivot point when the angle θ between the arm & vertical is;

30.0°?

90.0°?

180.0°?

[8.44 Nm, 16.9 Nm, 0.00 Nm]



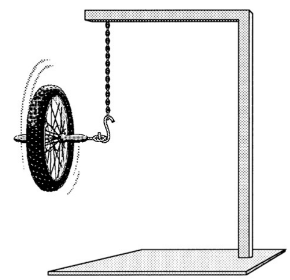
Question: Show on the picture: where are the friction forces?

a.Gravitational force
b.Normal forces
c.Torque
d. Frictional forces
tension force

k. Angular momentum with bicycle

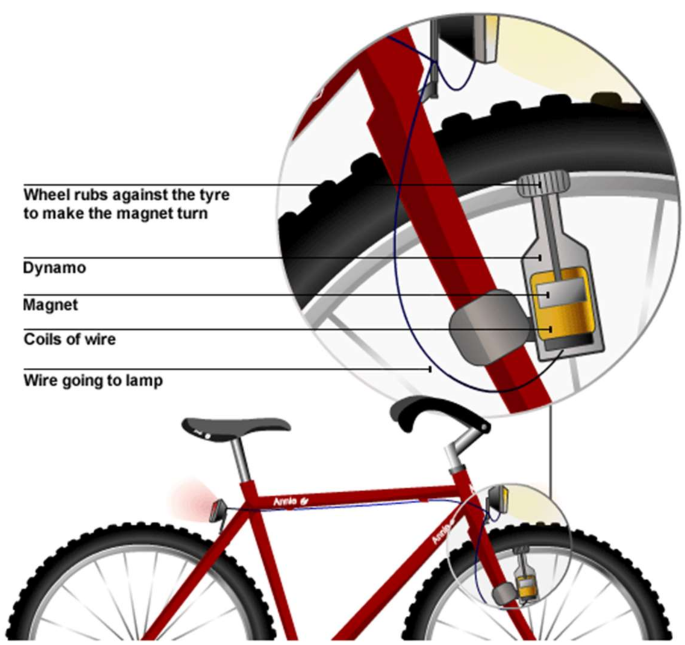
Question : How can you use bicycle to explain angular momentum?

Get the wheel spinning, then hang the wheel from the axle with a rope. Hold the wheel so that the axle is horizontal, then release it. The axle will remain more or less horizontal while it moves slowly in a circle. A rotating bicycle wheel has angular momentum, which is a property involving the speed of rotation, the mass of the wheel.



l. Electricity production from bicycle dynamo

Question: How can you produce with a bicycle?



m. Colour disc

White light is composed of all the spectral colors, when rotating the colours on a disc, all the colors will be observed in white color.

Question: How can you use a bicycle for getting white colour from the mixture of seven colours?

n. Newton's laws

Question: State the Newton's three laws. How can you explain newton`s laws by a bicycle?

First Law
Objects at rest remain at rest and objects in motion remain in motion in a straight line unless acted upon by an unbalanced force.

Second Law
Force equals mass times acceleration (or f = ma).

Third Law
For every action there is an equal and opposite reaction.

Activities with an EGG

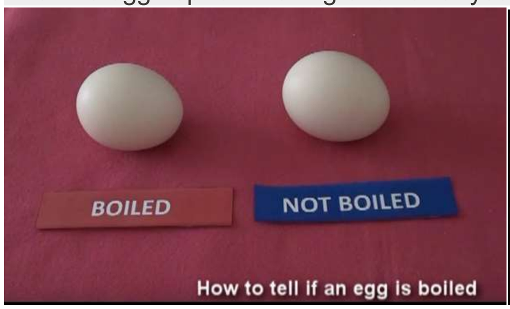
Question: How can you explain:

a. Newton's 1st law with eggs?

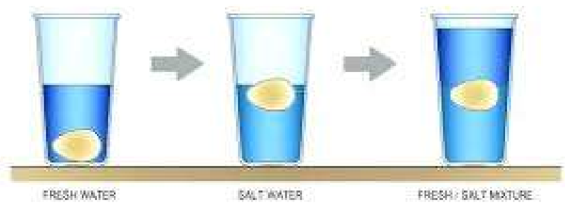
1.Place the egg on a flat surface and spin it. 2. Gently and briefly place your finger on the top center of the egg.

1.What happened to the egg after you try to stop it from spinning? 2.What do you think is the reason why the egg kept on moving after you try to stop it?

Ans: the egg kept on moving even after you try to stop it, is because of INERTIA



b. Density and floating?



Activities with magnets and iron filings

a. Magnetic field lines around a bar magnet

g. Making a magnet

Magnetic materials such as iron, nickel, cobalt and alnico can be turned into magnets by the methods of stroking, contact, induction and electrification. Magnets produced by these methods are called *artificial magnets*.

Figure 2.99

Figure 2.100 Unlike poles attract each other.

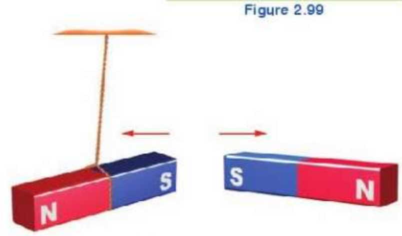


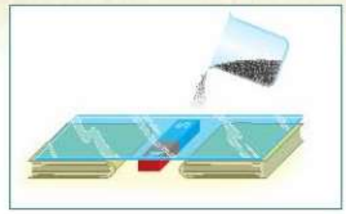
Figure 2.101 Like poles repel each other.

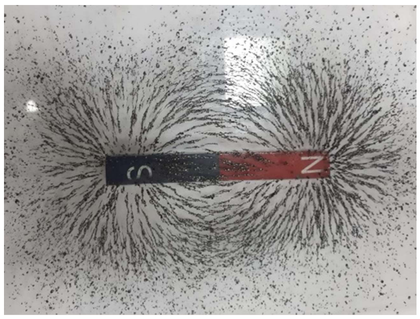
activity — Observing magnetic field lines

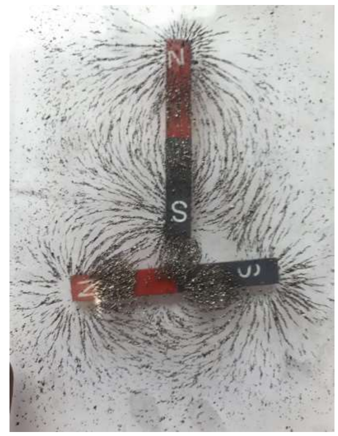
Materials: A bar magnet, a sheet of clear glass, two similar books and iron filings.

Procedure: Place a bar magnet under the glass. Use the books to support the glass as shown. Sprinkle iron filings over the glass and tap it gently. The iron filings arrange themselves along the magnetic field lines.

Sketch this pattern on a sheet of paper. Do the magnetic field lines cross each other? Where do the filings concentrate most?







Magnetic field lines between like and unlike poles

When two unlike poles are placed face to face, they attract each other. The magnetic field lines follow the paths from the N pole of one magnet to the S pole of the other as shown in the figure 2. 106.a and 2. 107.a.

However, when two like poles face each other, a repulsive force occurs between the magnets. At the midpoint between the poles of the magnets, magnetic forces are equal but act in opposite directions, so they cancel each other out. This is shown in figures 2. 106.b-c and 2. 107.b-c.

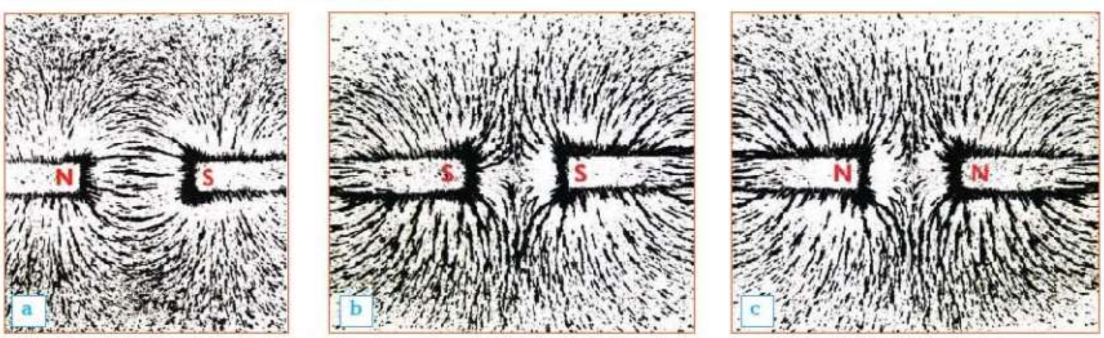


Figure 2.106 The pattern of magnetic field lines between two magnets obtained using iron filings.

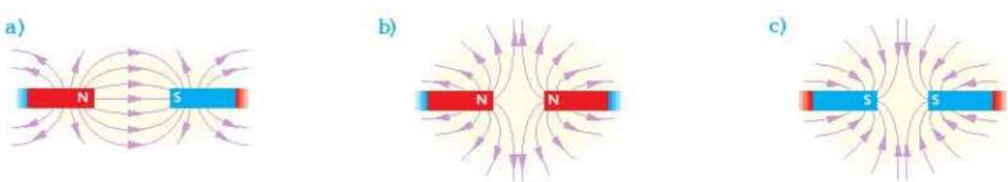


Figure 2.107 Illustration of magnetic field lines between the poles of two bar magnets.

e. Compass

A compass is a device which indicates direction. It has been used for thousands of years by travellers.

A compass mainly consists of a magnetised piece of steel, called a needle, and a scale indicating directions. The needle is supported by a pin through its centre so that it can turn freely. A compass is shown in figure 2.110.

Figure 2.109

Making a compass from a needle

Question: How can you make a needle a magnet?

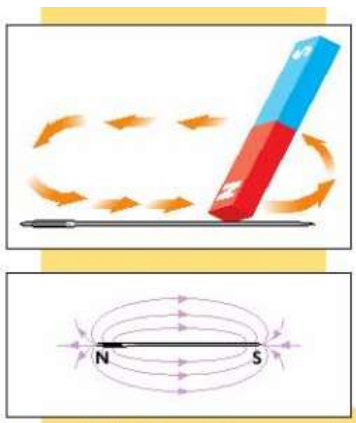


Figure 2.116 Magnetising a needle using the stroking method

activity

Water compass

Materials: A sewing needle, a magnet, a cork, a container full of water.

Procedure: Magnetise the sewing needle by stroking it many times with the magnet.

Place it on top of the cork on the water as shown in the figure. The needle points roughly in the north-south direction. This is a simple water compass.

Question:

How can you show that magnetic field can pass from air, glass, water, wood, glass and oil?

Does magnetism pass through everything?

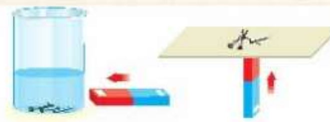
The magnetic field lines can pass through materials such as air, plastic, glass, wood, concrete, paper, water and so on. Carry out the following activity to observe this fact.

activity — **Magnetic field**

Materials: A bar magnet, a sheet of cardboard (or wood), a glass of water, pins.

Procedure: Scatter the pins on the cardboard and bring the magnet close to them from under the cardboard. Do the pins move towards the magnet?

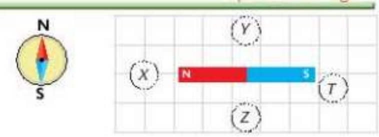
Now put the pins in the glass filled with water. Bring the magnet close to the pins outside the glass. Move the magnet up and down. Do the pins move towards the magnet?



Question:

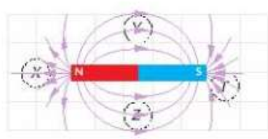
Example 2.10 — Speed of light

If we put a compass at the points X, Y, Z and T, what will the position of the compass' needle be?

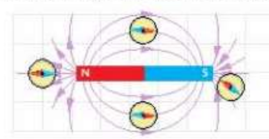


Solution

First we should draw the magnetic field lines around the magnet.



Like poles repel each other so the magnets' N pole repels the N pole of the compass. The compass' needle aligns itself in the direction of the magnetic field lines as shown below.



Magnetic field lines around a U magnet

Question:

Why do we use U magnet?

U magnet

If a bar magnet is bent as shown, a U shaped magnet can be obtained. The magnetic field between the arms of a U-magnet is uniform, its field lines are arranged in straight lines as shown in Figure 2.115.

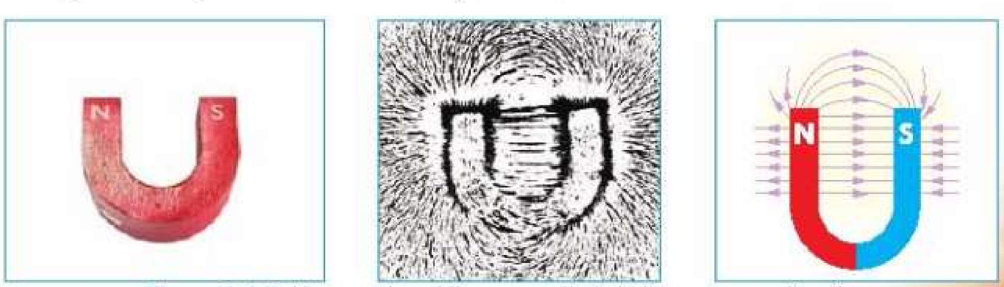
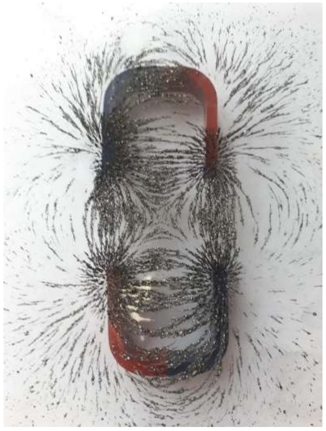
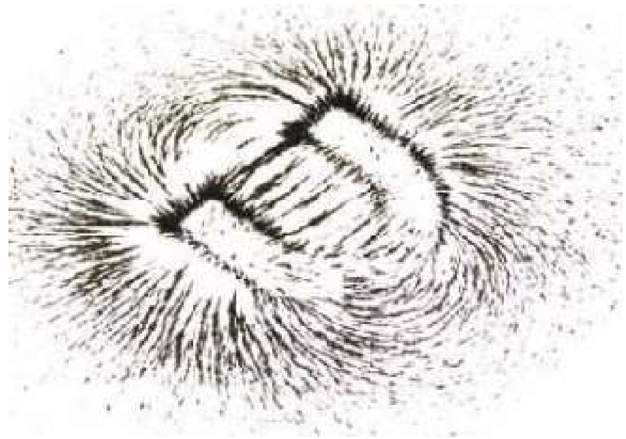


Figure 2.115 U magnet and the magnetic field lines surrounding it.





Questions

Answer the test questions

1. Which of the following is a magnetic material?

   A) sewing needle B) glass

   C) copper D) wood

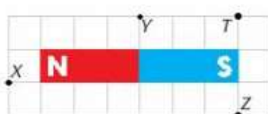
2. Which one of the statements below is incorrect?

   A) Like poles repel each other.

   B) Unlike poles repel each other.

   C) A magnet has two poles.

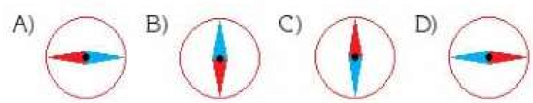
   D) Magnetic force is stronger at the poles.

3. 

   At which point around the magnet is the magnetic force the lowest?

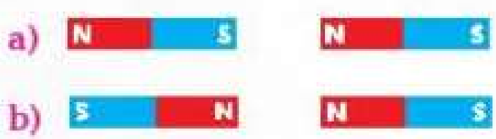
   A) X B) Z C) Y D) T

4. What will the direction of the compass needle be if it is placed between the arms of the **U**-magnet in the figure?



5. Which of the following figures cannot be obtained with bar magnets?

8. Draw the magnetic field lines between the magnets when they are placed as shown below



Activities with a thin wire-telephone wire

a. Magnetic field around a wire

Aim: To observe the magnetic effect of electricity

Materials: A switch, conducting wires, a compass, a battery

Procedure: Set up a circuit including a switch, conducting wires and a battery as shown in the figure. Let the compass line up in the north–south direction. Place the wire on the compass parallel to the compass needle as shown. Now press the switch for 3 to 5 seconds. What do you observe when the current is on?

Discussion: Does the deflection depend on the amount of current?

2.6 ELECTROMAGNETISM

a. How can we obtain magnetism from electricity?

Before the 19 th century electricity and magnetism were thought to be different phenomena. In 1819 a Danish physics teacher named Oersted, observed that the needle of a compass placed near an electric wire deflected when a current flowed through it. After some experiments, Oersted concluded that an electric current passing through a wire produces a magnetic field in the space around it. Let's carry out the experiment Oersted first performed.

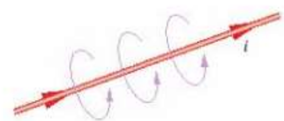
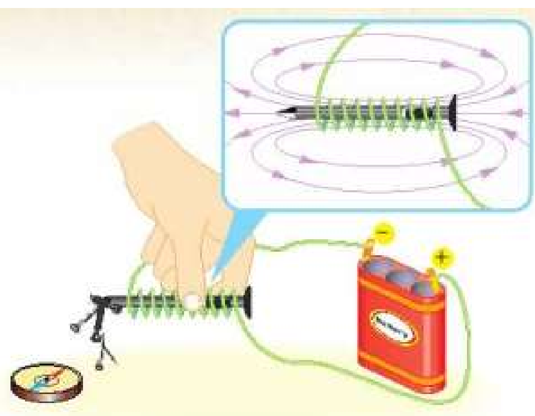


Figure 1.26 Illustration of magnetic field lines around a current carrying wire

b. Making an electromagnet

What is an electromagnet?

An iron bar cannot display magnetism. But if a piece of insulated wire is wound around it and the wire is connected to a battery, it displays magnetism. N and S poles form at its ends as in a magnet. This is illustrated in figure 2.127. It can attract all magnetic materials such as iron filings and needles. It can also deflect the needle of a compass. This kind of magnet produced by electricity is called an *electromagnet*, and this method of producing magnetism using electricity is called *electromagnetism*.



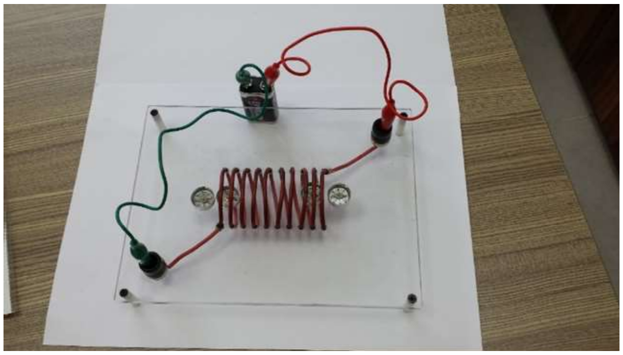
Materials: Some insulated wire, an iron nail, a battery, pins, a compass

Procedure: Wind the wire many times around the nail. Connect the ends of the wire to the battery as shown in the figure. Now, you have an electromagnet, try to pick pins and iron nails up with it. Bring a compass near the ends of the nail and determine the poles of your magnet. Now, remove the battery and add more turns to the nail. Connect the wire to the battery.

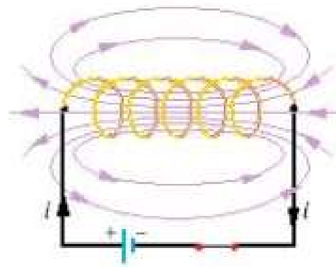
Discussion: What happens when the current is off, does it attract the pins? What happens to the magnet when you add more turns?

c. Making a solenoid

A solenoid is a coil of wire as in the picture below. When you sent a current through the wire you get a concentrated and almost uniform magnetic field inside the coil. Outside the solenoid the magnetic field is not strong as inside.

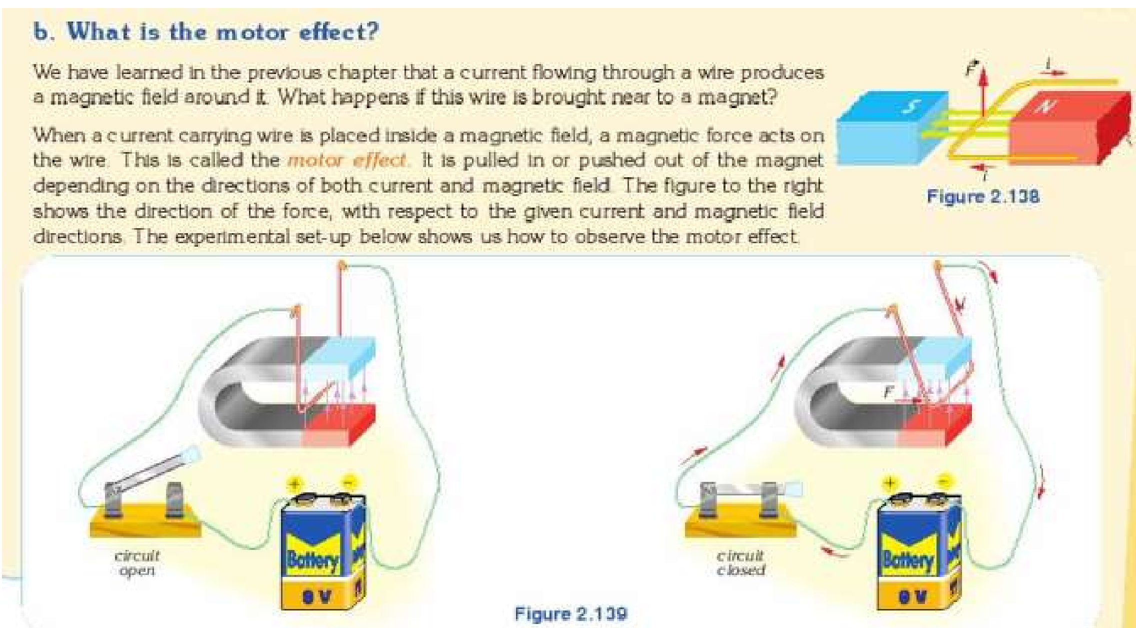


d. Electromagnetic field inside a solenoid



An activity with an insulated copper wire

a. Making an electric motor



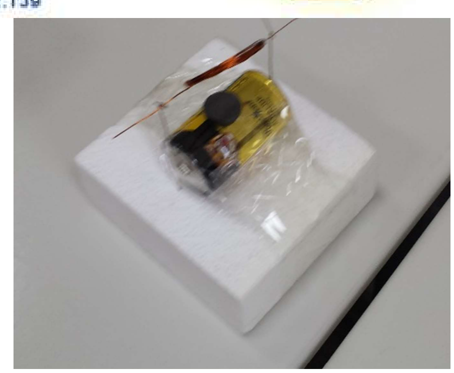
b. What is the motor effect?

We have learned in the previous chapter that a current flowing through a wire produces a magnetic field around it. What happens if this wire is brought near to a magnet?

When a current carrying wire is placed inside a magnetic field, a magnetic force acts on the wire. This is called the *motor effect*. It is pulled in or pushed out of the magnet depending on the directions of both current and magnetic field. The figure to the right shows the direction of the force, with respect to the given current and magnetic field directions. The experimental set-up below shows us how to observe the motor effect.

Figure 2.138

Figure 2.139



Turning effect on a coil: Electric motors

A coil of wire is placed within a magnetic field and a current is sent around the coil. Each side of the coil experiences a motor effect. The direction of current on each side of the coil flows in the opposite direction therefore an upward force acts on one side and a downward force acts on the other side of the coil as shown in figure 2.142. Two forces acting in this configuration is called a 'couple' and it causes rotation by acting upon the coil. Thus, the couple causes the coil to rotate.

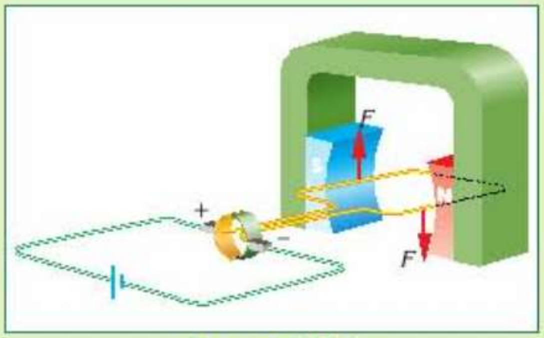


Figure 2.142

Electricity production with an electric generator

What is a generator?

A *generator* is a device which produces electricity. Figures 2.142-144 show some examples of generators. Electricity generators are divided into two groups: A.C. generators and D.C. generators.

A.C. Generator

An A.C. generator includes a rotating coil between opposite poles of a magnet as shown in Figure 2.155. Two slip–rings are connected to the ends of the coil and two carbon brushes are in contact with the rings. An alternating current is induced across the ends of the coil due to rotation. An A.C. generator is also known as an *alternator*.

Figure 2.152 An antique generator and lamp

Figure 2.153 A car alternator

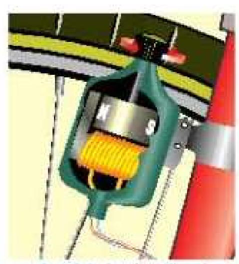


Figure 2.154 A bicycle dynamo

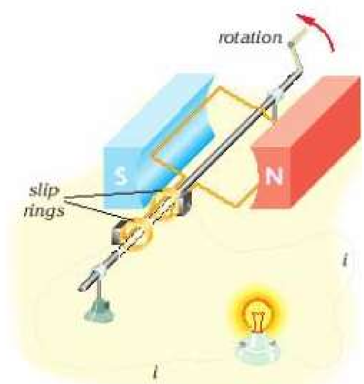


Figure 2.155 A model of an alternating generator

Questions:

1. Which one of the statements below is correct?

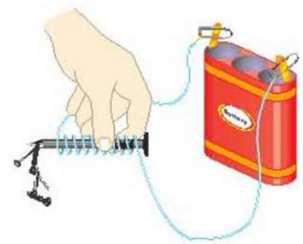
A) An electric current passing through a wire produces a magnetic field.

B) A soft iron core attracts magnetic materials when a current is applied to it.

C) A magnet is a source of electricity.

D) An electromagnet has only one pole.

2.



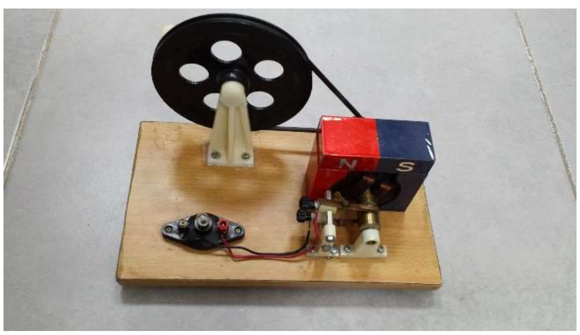
Which one of the statements below is not correct with respect to the electromagnet above.

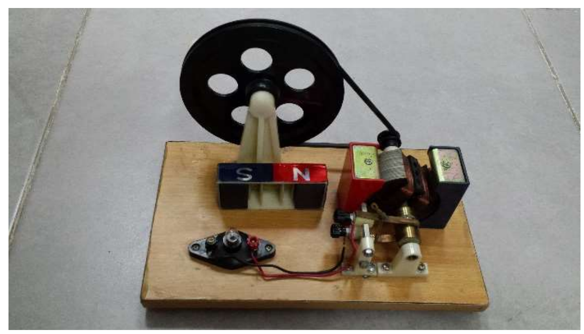
A) It is a permanent magnet.

B) The iron produces a magnetic field in the space around it.

C) One end of the nail becomes a north pole.

D) Direct current flows through the circuit.





Activities with resistance wires (Electric heater wire)

a. Resistance of a wire depends on length

1. Resistance and length of a conductor

The resistance of a conductor is directly proportional to its length *(L)*. So we can write

$$R \sim L$$

Longer wires provide a longer path for electrons to travel in causing many more collisions and hence a greater resistance as shown in Figure 2.62

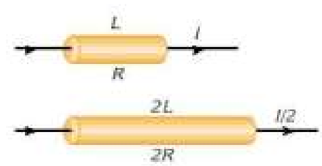


Figure 2.62 Longer wires have higher resistance.

PROJECT TIME

MAKING A SIMPLE RHEOSTAT

Materials: A battery, a lamp, connecting wires, a piece of nichrome resistance wire (which is used as a heating element in electric lines).

Procedure: Connect the elements as shown in the figure.

Move the wire over the heating element to the right and to the left, does the brightness of the lamp change?

Can you name some electrical devices which work with a rheostat?

b. What is a Rheostat?

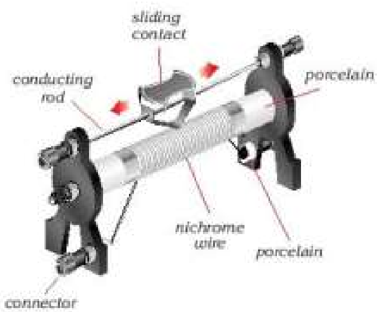


Figure 2.66 Rheostat

Rheostat

A rheostat is a variable resistor. It is used to change the current in a circuit. A rheostat consists of a long nichrome wire wound on an insulating material (porcelain). It has a sliding contact on the coil. The sliding contact moves along a brass rod as shown in Figure 2.66.

A rheostat is connected in series with a circuit. The current entering the rheostat from one terminal flows through the wire and the sliding contact, and then leaves the rheostat at the other terminal as shown below.

Figure 2.67

activity

Using a rheostat

Materials: A rheostat, a battery, a lamp, an ammeter, conducting wires.

Procedure: Set up a simple circuit with an ammeter as shown. Connect the clips to the terminals of the rheostat. Move the slide back and forth slowly. Note the changes in the brightness of the lamp and ammeter reading. In which position of the slide does the lamp glow the brightest?

a. Resistance of a wire depends on thickness

2. The resistance and thickness of a conductor

The cross-sectional area of a conductor affects the resistance. Thick wires provide low resistance because they have more space for electrons to move in, hence less collisions occur. However thin wires of the same substance provide higher resistance because they offer less space for the electrons to move around in. This is illustrated in figure 2.64. Resistance and cross-sectional area (*A*) (thickness) are inversely proportional:

$$R \sim \frac{1}{A}$$

An increase in cross-sectional area causes a decrease in resistance. The experiment below shows the relationship between thickness and resistance of a conductor.

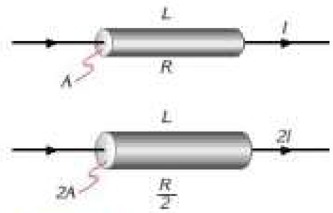


Figure 2.64 Thick wires offer less resistance

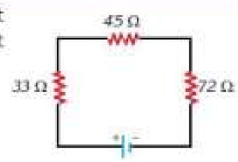
$$R = \rho \frac{L}{A}$$

Questions:

Example 2.4

Series combinations

What is the equivalent resistance of the circuit shown in the figure?



Solution

Resistors are connected in series. So we add resistances to find the equivalent resistance.

$R_{eq} = 33 + 45 + 72$

$R_{eq} = 150\ \Omega$

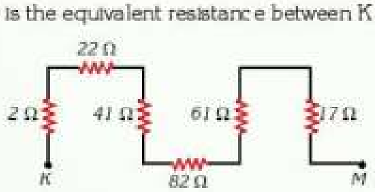
Exercise (2.2)

Series combinations

If the applied voltage is 6 V in the circuit given above, calculate the current flowing in the circuit. **Ans:** 0.04 A

Questions:

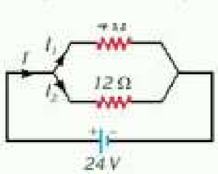
What is the equivalent resistance between K and M



3. What is the current I in the circuit?

A) 3.3 A B) 2.6 A C) 2.1 A D) 1.9 A

the circuit

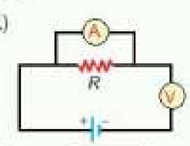


1. What is the resistance R in the circuit?

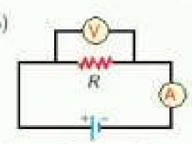
A) 25 Ω B) 18 Ω C) 13 Ω D) 8 Ω

2. A student wants to measure the resistance of a resistor. Which circuit diagram should the student use?

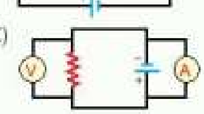
A)



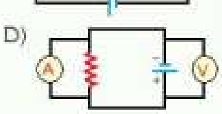
B)



C)



D)



Activities with aluminum foil, glass and a wire: Electroscope

a. What is electrostatics?

Interactions between charges

Charges attract or repel each other according to the kind of charge they have. This is illustrated in figure 2.4. The interactions between charges are governed by a simple rule:

Like charges repel each other, unlike charges attract each other.

The force between charged particles is called an *electrostatic force*. The electrostatic force keeps an electron in its orbit around the nucleus, like the earth orbiting the sun (Figure 2.5).

> Like charges repel each other.
>
> Unlike charges attract each other.

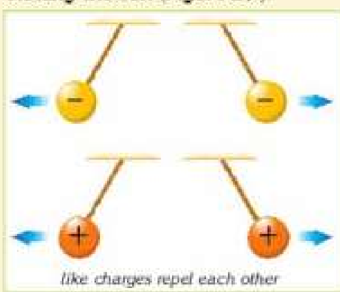


Figure 2.4 Attraction and repulsion between charges.

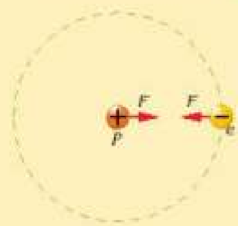


Figure 2.5 The electrostatic force keeps an electron in an orbit around the nucleus.

b. What is static electricity?

The word static means not moving or stationary, therefore static electricity means stationary electric charges. Static electricity causes an object to attract and repel other objects.

c. What is a conductor? What is an insulator?

Materials which allow electrons to pass through them are called *conductors*. Some electrons far away from the nucleus in the atoms of conductors are so weakly bound to the nucleus that they can move freely between neighbouring atoms. These electrons are called *free electrons* (Figure 2.6). These free electrons are the electrons which make metals conductors of electricity. Metals such as copper, silver and aluminum are called good conductors (Figure 2.7). Some materials conduct electricity poorly, therefore they are called *poor conductors* examples are the earth and the human body. Good and poor conductors are listed in Table 2.2.

Materials which don't conduct electricity are called *insulators*. Their electrons are tightly bound to the nucleus and can't move freely. Examples of insulators are plastic, air, wood, nylon and porcelain (Figure 2.7).

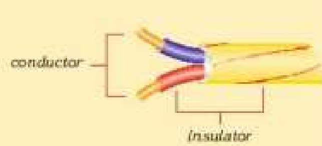


Figure 2.7 A piece of cable with conducting wire inside the insulating cover.

Question:

d. How can you build-up charge on objects?

There are different ways of building up charge on objects: Charging by rubbing (friction), charging by contact and charging by induction.

activity — **A Comb and pieces of paper**

Materials: A plastic comb, some pieces of paper, a balloon, a woollen cloth

Procedure: Pull a plastic comb through your hair (it also should be dry and free of oil).

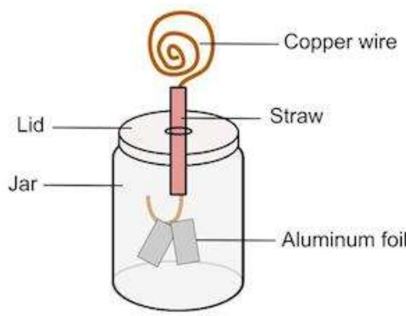
Then hold the comb near some tiny pieces of paper. What do you observe?

Now hold the other end of the comb near the pieces. Do they stick to the comb?

(A plastic pen can also be used instead of a comb.)

Question: What is an electroscope? Why do we use it?

An electroscope is a device used to understand if there are charges on an object and to learn the type of charge if the object has.



Question:

How can you make an electroscope?

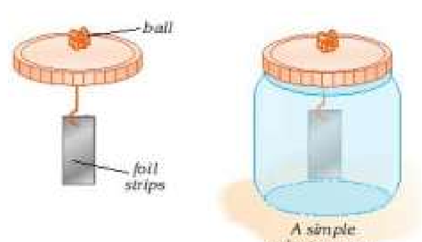
PROJECT TIME — **MAKING A SIMPLE ELECTROSCOPE**

Materials: A glass jar with a plastic lid, a copper wire about 20 cm long, a piece of aluminum foil (or an aluminum chocolate wrapper), a plastic pen.

Procedure: Make a hole in the plastic lid, and insert the wire tightly through. Bend the top end of the wire into a ball and bend its bottom into a hook. Cut out two 2×1cm aluminum foil strips and make a small hole at the top of each.

Hang the strips on the hook and check if they can move freely. Place the lid over the mouth of the jar.

Now rub the pen on a woollen cloth and check your electroscope. Does it work? Repeat this with a comb.



A simple electroscope

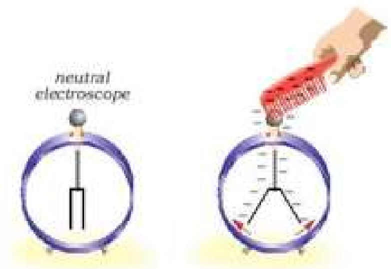


Figure 2.16 Charging an electroscope by contact

Charging an electroscope by contact

A neutral electroscope becomes charged when its cap (knob) is in contact with a charged object. For example if a charged comb is made to touch the cap of a neutral electroscope as in the figure 2.16, some electrons on the comb move to all metal parts of the electroscope. The negative charges collected on the leaves repel each other causing them to open.

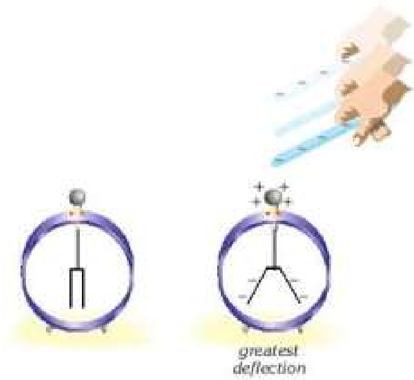


Figure 2.17 Charging an electroscope by induction

Charging an electroscope by induction

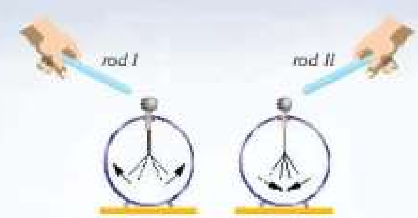
When a negatively charged object is brought close to the cap of a neutral electroscope, the charges on the object repel some electrons from the cap towards the leaves. Thus, the knob becomes positively charged and the leaves negatively charged. The leaves repel each other and open, thus the electroscope becomes charged by induction as in figure 2.17.

If the charged object is pulled away from the electroscope, the negative charges on the leaves return to the knob again and the leaves close.

Questions:

1. When an object is charged, which of the following changes?
   A) the number of protons
   B) the number of electrons
   C) the number of neutrons
   D) the number of protons and electrons

2. When you walk on a rug and then touch a conducting object, you often get an electric shock due to an electric discharge. Because
   A) Electricity is produced due to friction between the rug and your body
   B) Your body produces electricity.
   C) The rug produces electricity.
   D) The conducting object produces electricity.

7. 

When rod (I) is brought close to the knob of a negatively charged electroscope, the leaves rise up, when rod (II) is brought close, the leaves drop down. What can be said about the charges on the rods?

	Rod I	Rod II
A)	–	–
B)	+	–
C)	–	+
D)	+	+

8. When a comb is rubbed through hair, it gains charge. What are the charges on the hair and the comb?
   A) hair (–), comb (–)
   B) hair (+), comb (+)
   C) hair (–), comb (+)
   D) hair (+), comb (–)