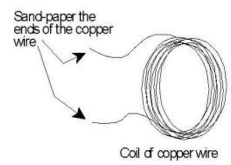
EXPERIMENT 21 – THE STRONGEST OF THEM ALL!
CSEC OBJECTIVE (S): Section D – Objectives 7.1-7.3

Grade Level - 10

What you need
your micro-electricity kit, steel nail or steel paper clips, small steel pins or iron filings, prestik/plasticine



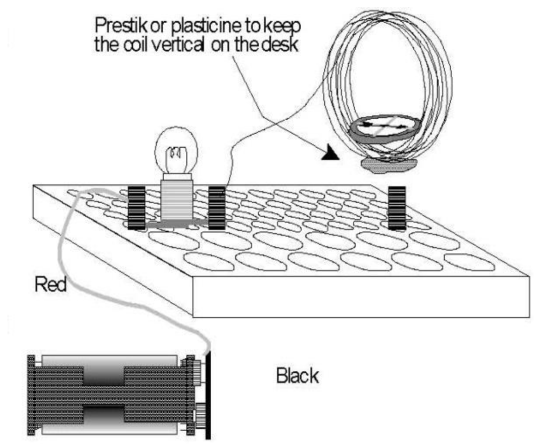
What to do
Note: In your micro-electricity kit you will find a coil of copper wire. This copper wire is coated. You must remove the coating from both ends of the wire. You do this by rubbing the ends with the sand paper.

1. Prepare the set up shown in the diagram on the right. Stand the coil vertically on the desk. Place the compass inside the coil.

a) Where does the pointer of the compass point to?

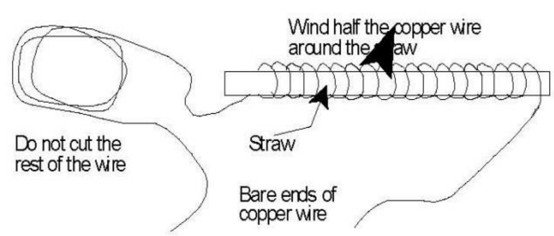
b) Connect the free end of the coil, to the right (as in diagram) spring.
Where does the pointer of the compass point to this time?

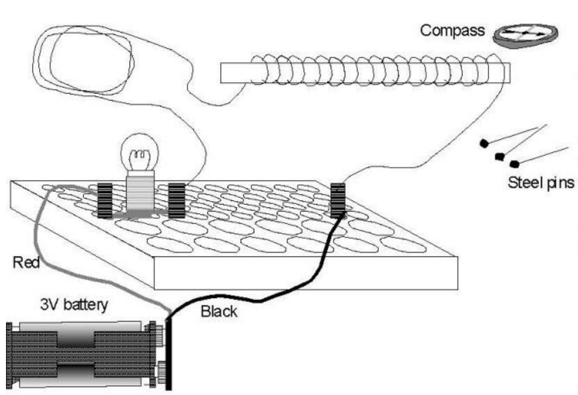
c) Disconnect the ends of the coil from the springs, and connect them the other way round. Where does the pointer of the compass point to this time?



2. In your micro-electricity kit, you have a piece of plastic straw. Wind about half the length of the copper wire around the straw.
Do not cut the rest of the copper wire! Lie the straw on your desk.

Note: The windings must be in the same direction!



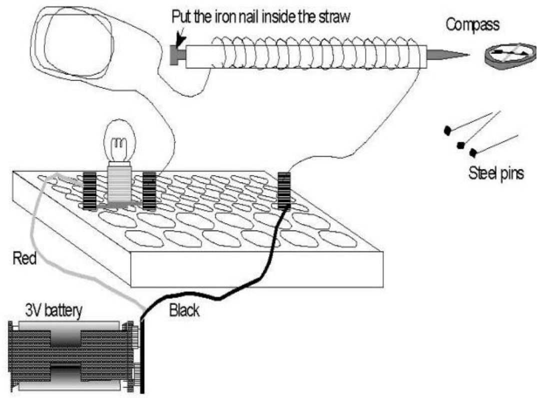


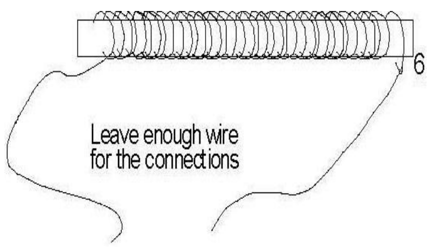
3. Connect the ends of the copper wire to your circuit, as in the diagram on the left.

a) Bring the compass close to the straw at different positions.
What happens?

b) Move one the end of the straw close to the pins. What happens?

4. Now, insert the iron nail inside the straw, as shown in the diagram on the right.
a) Bring the compass close to the straw. What happens?
b) Move one end of the straw close to the pins. What happens?
5. Disconnect the copper wire from the springs. Wind some more wire around the straw. Repeat steps 3 and 4.



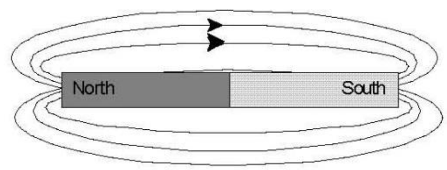


6. Replace the iron nail with the steel nail or straightened paper clips.
Repeat steps 3 and 4. If you have steel paper clips, straighten up two of them and insert them in the straw. You may also try the same thing with some of the strips in your kit. Record your observations in a table.

What to discuss

A coil of wire, like the copper wire wound around an empty straw, is called a **solenoid**. The word "solenoid" is a Greek word meaning "hollow pipe". If you put an iron bar inside the solenoid, you have an **electromagnet**.

1. In this Activity, you inserted an iron nail inside your solenoid. The solenoid with the nail is an electromagnet.
a) Do you think this name is suitable? Explain.
b) Does a solenoid connected to a battery produce a magnetic field around it? Explain.
c) In this Activity, how did you make a stronger electromagnet?
2. If you were to use the 9 V battery instead of the 3 V battery you used in this Activity, how do you think this change would affect your electromagnet?
3. Sibongile reads in her text book : "**An electromagnet is similar to a bar magnet.**"
Sibongile asks: "Then where is the south and north pole of the electromagnet?"
a) Explain to Sibongile how to find the north and south pole of an electromagnet.
b) How can you change the north and south poles of your electromagnet?
4. Diagram A, shows the magnetic field lines around a bar magnet. Their direction outside the magnet, is always due south.
With the help of diagram A, find the north and south poles of the electromagnet shown in the diagram B. (Hint: Use the right hand rule).



5. In conclusion, which factors affect the strength of your electromagnet?

EXPERIMENT 22 – AMMETER, TO BE AND NOT TO BE

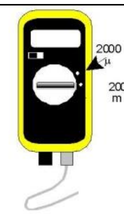
CSEC OBJECTIVE (S): Section D – Objective 4.6

Grade Level - 10

What you need

micro-electricity kit, multimeter

YOUR MULTIMETER - MAKE GOOD USE OF IT!



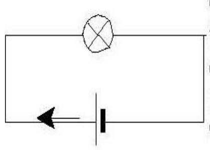
1. The diagram on the right shows roughly what your multimeter looks like. The multimeter becomes an ammeter, when the pointer points at either of the two dots shown in the diagram.

i. In the diagram, the pointer points at the dot marked 200 m. It stands for 200 milli-amperes (or mA). At this position, you can measure currents up to 200 mA.

ii. The dot marked 2000 m, stands for 2000 micro-amperes (or mA). When the pointer points at this dot, you can measure currents up to 2000 mA.

SOME MATHS NOW

2. What is “milli-” and what is “micro-”?
   a) Surely you have heard of millilitres (ml). You have also heard of millimetres (mm). What then is a milli-ampere (mA)?
   b) When do we use the prefix “micro”?
   c) The micro-ampere (mA) is a millionth of an ampere. How many mA make an ampere? How many mA make 1 mA?
3. You want to know the current in your circuit, so you must connect an ammeter in the circuit.



On the one hand, you want the charge to pass through the ammeter, so that it can measure the current.

ii. On the other hand, you do not want the ammeter to interfere in anyway with the current.

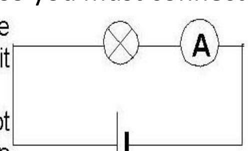


Diagram (a)

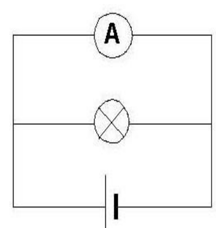
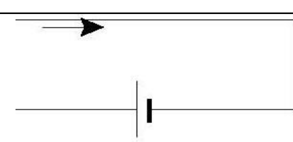


Diagram (b)

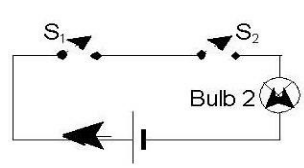
a How does one deal with these two points?

b You want to measure the current in the diagram on the left. Which diagram on the right shows the correct way to connect the ammeter and why?

MAKE SOME PREDICTIONS

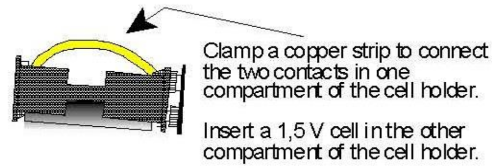


4. You connect an ammeter at point B of the circuit on the right. The ammeter reads 130 mA. What will the ammeter read if you connect it at:
   a) point C?
   b) point D?
   c) Compare the current at points C and D with the current at point B.



5. The diagram on the right shows a circuit with two identical bulbs and two switches S1 and S2 connected as shown.
   a) a Which switch/es must you close to make bulb 2 glow?

b) b If you close switch S1 while S2 stays open, what will happen to bulb 1?

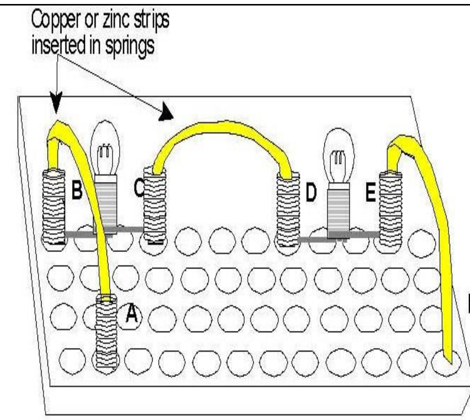


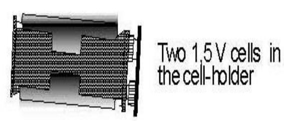
TEST YOUR PREDICTIONS

A USEFUL TIP: The cell holder is designed to hold two 1,5 V cells. If you want to use one cell only, you can still use the cell holder. The diagram on the right shows one way.

Of course you may have better ideas....

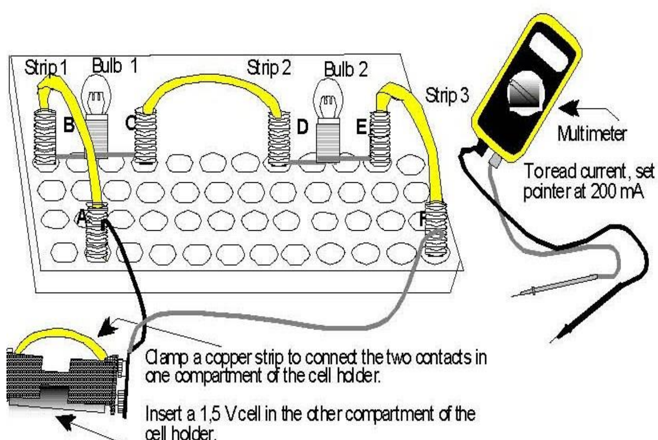
6. In question 4, you compared the current at points C and D with the current at point B. Test this prediction using components from the micro-electricity kit. Use only one 1,5 V cell.
7. Use components from your microelectricity kit to prepare the circuit shown in the diagram on the right.





a) Use this circuit to test your predictions in question 5. How will you simulate the action of the switches S1 and S2?
b) Compare your observations with your predictions. If there is conflict, explain.
c) Remove one bulb (or just unscrew it) from the circuit. What happens to the other bulb? Explain.

8 Work with the circuit you have just made, but use only one 1,5 V cell.



a Use the multimeter to measure the current:

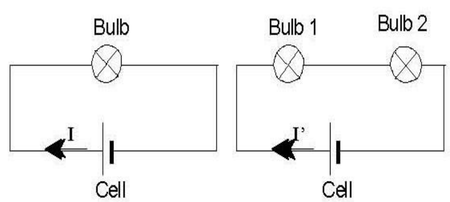
i on the left of bulb 1
ii between bulbs 1 and 2
iii on the right of bulb 2

In between measurements switch the ammeter off.
Record your measurements in a table.
When you finish, don't forget to disconnect the cell.

b Compare the three currents you have just measured. What is your conclusion?

9 The diagrams on the right, represent the circuits you set up in question 6 and in question 8 respectively.

Compare these two circuits. Compare what you have measured and observed. What conclusions can you draw from the information?



EXPERIMENT 23 – ELECTRIC MOTOR 1

CSEC OBJECTIVE (S): Section D – Objective 7.8

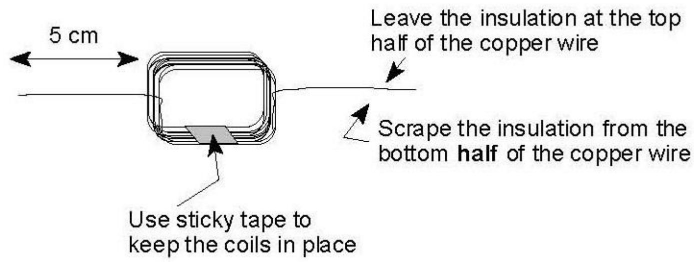
Grade Level - 10

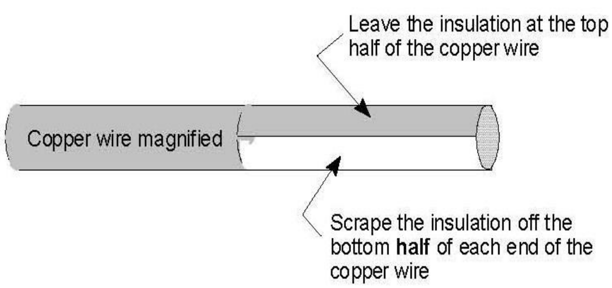
What you need

micro-electricity kit, two magnadur magnets, sticky tape, a pair of scissors

What to do

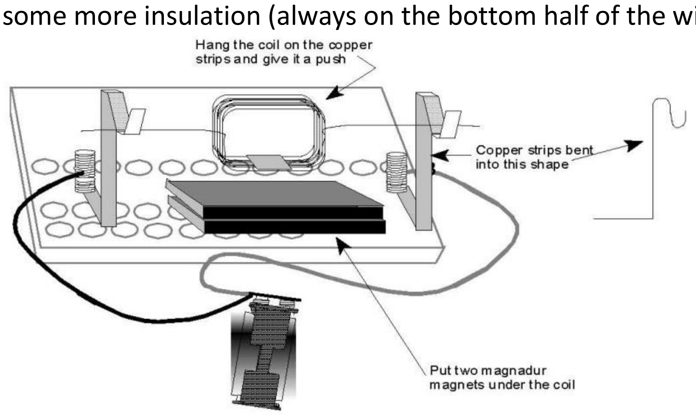
1. Use wire from the copper coil in the micro-electricity kit. Use this wire to make a coil of about 10 to 15 windings. You may use the 9 V batteries and wind the wire around it to make a coil. Leave about 5 cm wire free from both ends of the coil.





2. Scrape the insulation from only the bottom half of both the ends of the wire. See diagrams.
3. The diagram below, shows how to set up the coil and the magnets on the c omboplate.
   Connect the cell only when you are ready to test your motor.

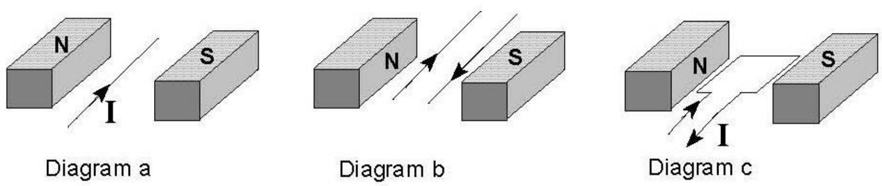
The ends of the coil where you scrapped off the insulation, must touch the copper strips.
When your motor is ready and the cells connected, give the coil an initial push with your finger to get it started. If the coil does not turn, check that the contacts between copper strips and coil are good. You may have to scrape off some more insulation (always on the bottom half of the wire).



4. This is the complete motor. You must be prepared to identify the direction of the current in the coil and the polarity of the magnets. You must give the initial push in the right direction!
5. You must also be prepared to explain to the other learners in your group, why you only scrape the insulation from the bottom half of the wire. What would happen if you were to scrape the insulation off all around the wire?

What to discuss

1. List five things that run with a motor. Things you can find at home or at school. Why do these things need a motor? (Which part of each device does the motor turn?)
   For example: The electric fan has a motor. The motor turns the blades.
2. In the following figure, what happens to each straight current carrying wire



a) in diagram a?
b) in diagram b?
c) in diagram c?
d) On all three diagrams draw any forces acting on the wires.

YOUR MOTOR

3. Study the motor you made in this Activity and briefly explain how it works. Mention the following:

a) is the magnetic field produced by a permanent magnet or by an electromagnet?
b) the direction of current in the coils, does the current alternate?
c) are there any commutators and brushes?
d) does the motor turn continuously in one direction? What keeps the motor turning in the same direction?
e) ways to make the motor “stronger”.

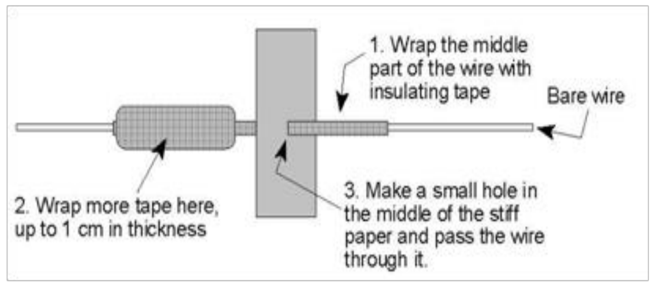
EXPERIMENT 24 – ELECTRIC MOTOR 2
CSEC OBJECTIVE (S): Section D – Objective 7.8

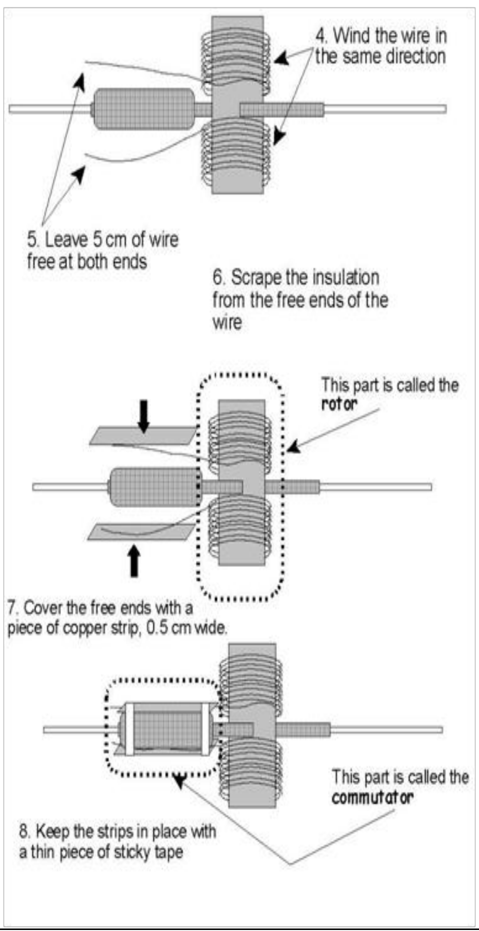
Grade Level – 10

What you need
a micro-electricity kit, straight wire about 15 cm long (eg. a large paper clip), two magnadur magnets, sticky tape, like insulating tape, a pair of scissors, a piece of stiff paper or other light material (eg. polystyrene), 4 cm x 1 cm.

What to do

1. Make this motor, following the steps in the diagrams.
2. To make the windings of this motor, use the wire from the copper coil in the micro-electricity kit. If you need two coils, remember to scrape the insulation from both the ends to be connected.

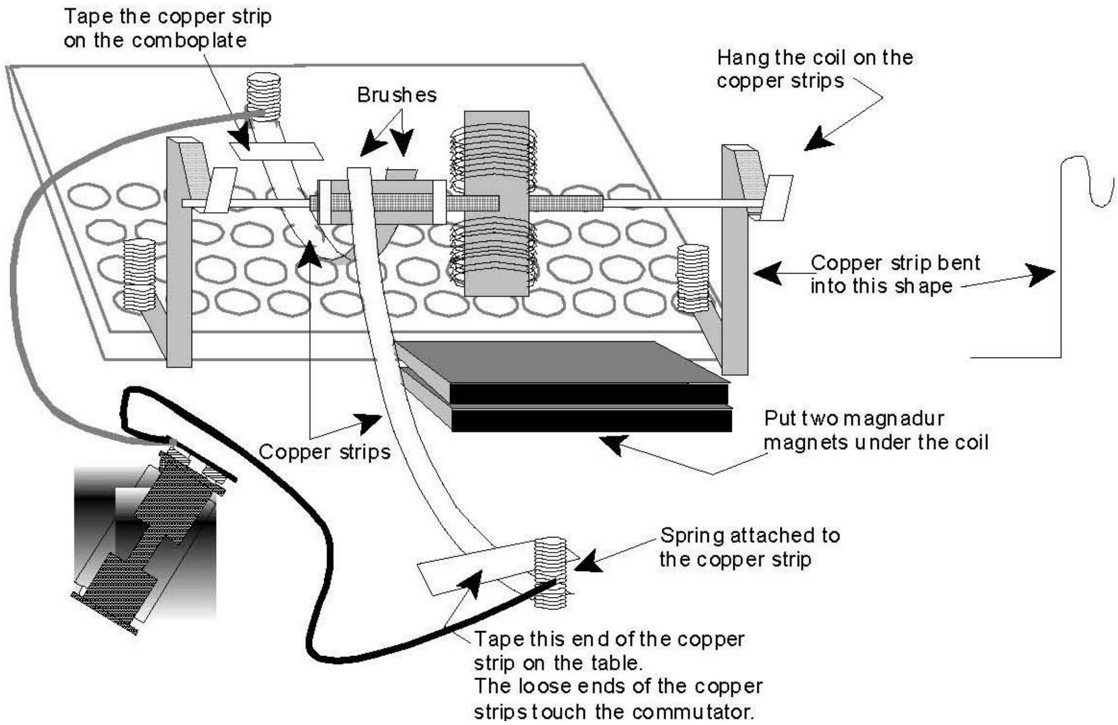




Leave 5 cm of wire free and start winding the rest onto the piece of stiff paper. *Start at the centre and wind evenly towards one end of the paper, in a clockwise direction. When you reach the end, work back towards the centre. **Without** breaking the wire, do the same thing on the other side of the stiff paper.
Repeat from the asterisk until you wind all the wire.
At the end leave a 5 cm piece of wire free.

Be careful that the windings are made in the same direction and be careful to wind the same number of layers on both sides of the stiff paper.

3. The diagram on the next page shows what to do next. The long copper strips that touch the commutator (see diagram), are called "brushes". Make sure that the brushes touch the conducting parts of the commutator at the same time. The motor is ready!



What to discuss

YOUR OWN MOTORS

1. Compare the motors in Activities 5 and 6. Briefly explain how each one works. Mention the following:

a) how the magnetic field is produced, by a permanent magnet or by an electromagnet?

b) the direction of current in the coils, does the current alternate?

c) are there any commutators and brushes?

d) does the motor turn continuously in one direction, and if so, what keeps the motor turning in the same direction?

e) ways to make the motors "stronger".

2. Explain the major difference in the way the two motors work.

AND THERE IS MORE!

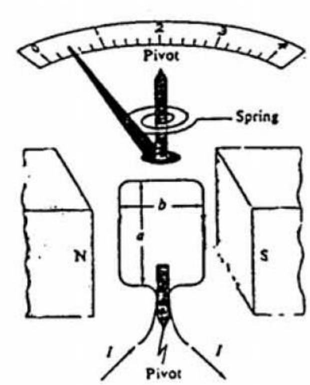
There are more important and practical devices, which also take advantage of the force between a current and a magnetic field, other than the motors! Such devices are the galvanometers, the loudspeakers, the chart recorders, and many more!

3. The diagram shows the principle workings of a galvanometer, the basic component of many meters (ammeters, voltmeters, ohmmeters.....)

a) Use the hand rule to find the force acting on each side of the rectangular loop.

b) Briefly explain how the pointer moves.

4. What energy transformations take place in an electric motor?



EXPERIMENT 25 – CAN MAGNETISM PRODUCE ELECTRICITY?

CSEC OBJECTIVE (S): Section D – Objective 7.4

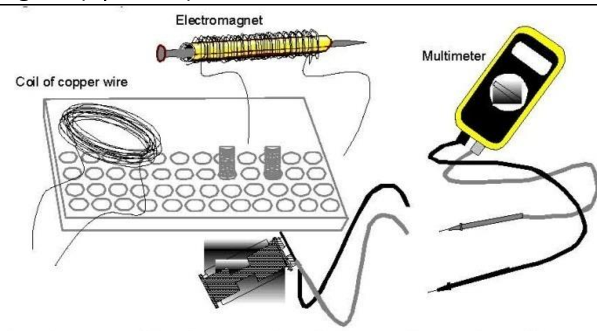
Grade Level – 10

Electricity produces magnetism. An electric current produces a magnetic field. Is the opposite true? Can magnetism produce electricity? Can a magnetic field produce an electric current?

What you need

micro-electricity kit, multimeter, magnadur magnet (optional)

To discuss before you start



Rashay, Nicolas and Alex are all grade 10 learners. In their group they discuss the question: **Can magnetism produce electricity?**

Rashay all excited, says: "If electricity produces magnetism, then I am absolutely certain that magnetism can produce electricity. In nature, everything happens in pairs .... positive and negative, north and south, action and reaction.... you name it!"

Nicolas is even more excited. He says: "And what is even better, having a strong magnet at home, will produce all the electricity we need! No more electricity bills! Electrical energy for free with a magnet!"

Alex is not very excited! He says: "Nicolas, I wonder why nobody has thought of this before! We also know that we can't get something out of nothing! Can a magnet, even a strong one, provide us with free energy?

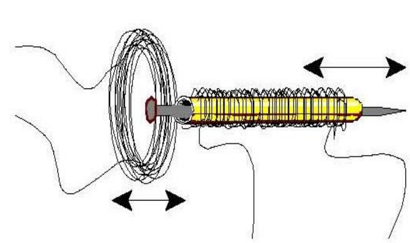
I find it hard to believe, it is against the laws of nature!"

So what do you think the answer is? Discuss the above comments with your group and add your own views. You can discuss this question again at the end of the Activity.

What to do

THE INVESTIGATION

1. Use a coil, an electromagnet (or a magnadur magnet), your multimeter, and any other component from your micro-electricity kit which you might think would be of some use. Your task is to investigate if there is a way to produce (induce) an electric current in the coil.

   Hint: Compare what happens when:
   - the electromagnet is stationary inside the coil
   - the electromagnet moves inside the coil
   - the coil moves along the length of the electromagnet

   Explain how you will produce a magnetic field.
   Explain how you will know if a current is induced in the coil.
   Something to consider in your group: If you manage to induce a current in the coil, do you expect this current to be large or small? On which scale would you set your multimeter?
   Try your plan out using your components.
2. If you do not have a multimeter, is there any other way to test if a current is induced in the coil? (using equipment from your micro-electricity kit.) If you think yes, test this new way.

3. Summarise your conclusions and prepare a report back. In your report, mention ways (and test these ways if possible), to increase the induced current in the coil.
4. It took more than 10 years after Oersted's discovery, before two other scientists eventually succeeded to induce an electric current this way. These scientists were the American Joseph Henry and the Englishman Michael Faraday. Working independently, they both found that it was possible to produce an electric current from a magnetic field.
   This phenomenon is called electromagnetic induction.
   Why do you think it took them so long?
5. When Henry and Faraday made this discovery, many people were not impressed! "So what!" they said.
   Today, our electricity supply relies on electromagnetic induction!
   Most of the electricity we use at home, comes to us in wires. We know by the monthly bill we pay, that there is an electrical company at the other end of the wires. How does the electric company produce electricity? With "giant batteries"? Surely not! Electricity is produced in power stations.

a) From which power station does your community get its electrical supply of energy?
b) Discuss in your group, how electrical energy comes from the power station to your homes or school? (As far as you know).

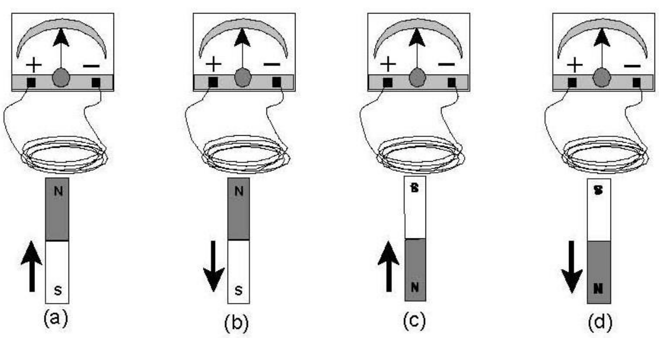
THE CHALLENGE!

How do we find the direction of the induced current in the coil?

Lenz's law: The induced current in a coil has such a direction, so that its magnetic field opposes the change brought about by the external magnetic field.

The diagrams below, show a coil connected to a galvanometer and a bar magnet in the vicinity of the coil. The bar magnet moves, its movement is indicated by an arrow.

A galvanometer is an instrument that detects small currents and their direction. When the needle is in the middle, it means that there is no current in the circuit.



Use Lenz's law to find the direction of the induced current in each diagram.

a) What will be the deflection of the galvanometer in each diagram?
b) What does this indicate?
c) Explain how you find the direction of the induced current.

EXPERIMENT 26 – ON, OFF-OFF, ON

CSEC OBJECTIVE (S): Section D – Objectives 4.1-4.5

Grade Level – 10

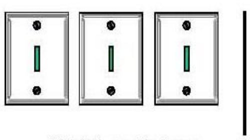
This Activity is to refresh your memories about electrical circuits. You will think about the differences between light bulbs when they joined in series and when they are joined in parallel. You will also use circuit diagrams to represent light bulbs in series and in parallel.

What you need

a basic micro-electricity kit

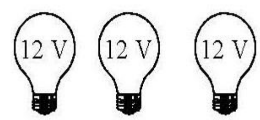
MR DHLAMINI'S ON, OFF - OFF, ON PROBLEM

Mr Dhlamini is quite an impatient man. He has been waiting for two years for electricity to be brought to his community, as promised by the government. He finally decides to try and light up his home on his own. He wants lights in three rooms of his house. He knows that the headlights of a car run off a car battery so he decides to use a 12 V car battery as his energy source. He buys three wall switches, three light fittings, three 12 V light globes and metres and metres of single stranded electrical wire.

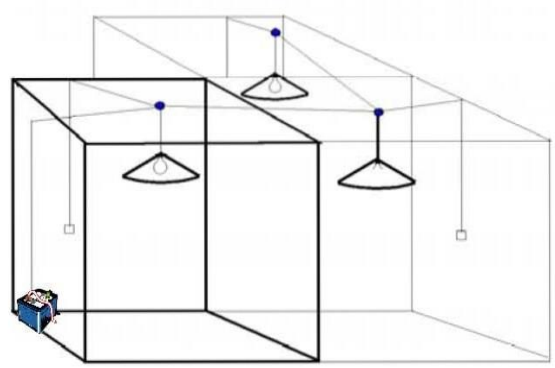


`light switches

12 V battery



light bulbs



He very proudly connects up the lights and switches in the three rooms to the car battery, as shown in the figure. However, he is so disappointed when none of them work. He finally discovers that only when the three switches are 'on' do his lights work. He is unable to turn any one of the lights on or off individually. They either all stay on or all go off. To say that he is disappointed is an understatement. He knows very little about electrical circuits and does not know how to solve this problem. How can you help him?

Note: The figure does not accurately show how the lights are connected.

PART A

What to do

1. Chose someone from your group to reads Mr Dhlamini's problem out aloud.
2. As a group you will discuss what Mr Dhlamini did wrong, and why he was unable to switch the lights on and off separately.
3. Each of you will sketch a circuit diagram of Mr Dhlamini's lights set up. You will then compare and discuss your circuits.
4. Select one of the circuit diagrams to use for the next step.
5. Use the chosen circuit diagram and the micro-electricity kit to build a model of the circuit.

What to discuss

1. Why is Mr Dhlamini having such problems with his lights?

2. Why do you need to have a switch in a circuit?
3. As there are no switches in your micro-electricity kits how are you going to show that there is a switch in your circuits?
4. How do the bulbs compare in brightness? What does this tell us about the current in the bulbs and the circuit? What instrument can you use, and how will you connect it in a circuit, to measure current at different points in a circuit?
5. If you remove one of the light bulbs so that there are only two in the circuit, what is the brightness of the remaining two light bulbs compared to when there were three bulbs? Try this out with your set up.
   Describe why there is a difference?
6. In your discussions you will have used the words, 'electricity', 'current' and may be even 'charges' several times, perhaps now is the time to discuss with each other what the terms actually mean. Choose someone from your group to write the meanings of the three words on a piece of flipchart paper. Your teacher will later ask someone from each group to stick the explanations (definitions) on the wall.

PART B

What to do

Your next task is to solve Mr Dhlamini's problem.

1. First as a group, discuss how Mr Dhlamini should connect his lights so that he can switch them on and off separately.
2. Draw a circuit diagram which Mr Dhlamini can use to solve his problem.
3. Use the micro-electricity kit to make a model of your proposed circuit.

What to discuss

1. What are the differences between Mr Dhlamini's circuit and your circuit, and what are the advantages of your circuit? Are there any advantages of Mr Dhlamini's circuit?
2. How do the bulbs compare in brightness? What does this tell us about the current in the bulbs and the circuit?
3. If you remove one of the light bulbs so that there are only two in the circuit, what will the brightness of the remaining two light bulbs be compared to when there were three bulbs? Once you have made your prediction make changes to your circuit to test your prediction.
4. How will the brightness of three light bulbs compare when one of the bulbs is connected in series and the other two are connected in parallel? Once you have made your prediction change your circuit to test your prediction. Explain.
5. A battery is a source of energy. Discuss the following energy transfers;

a) from the battery to the electrons of the connecting wires;
b) from the connecting wires to the filament (tungsten) inside each of the light bulbs;
c) from the light bulbs to the surrounding environment.

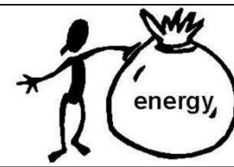
6. When we talk about current we need to give it a direction. What is the conventional direction of an electrical current?
7. Something Mr Dhlamini has not thought of is that his battery does not have an ever-ending source of energy and will go 'flat' after a few hours. One nice feature of a car battery is that it can be recharged.
   Discuss possible ways in which Mr Dhlamini could recharge his battery.

EXPERIMENT 27 – WHAT IS ELECTRICAL POTENTIAL DIFFERENCE?

CSEC OBJECTIVE (S): Section D – Objective 3.2

Grade Level – 10

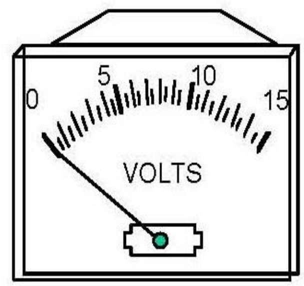
Electrical potential difference means the difference in electrical potential energy per coulomb (unit charge) between two points. In this activity you will consolidate your understanding of the concept of electrical potential difference.



PART A

In this Activity, you will work in small groups. You will again be answering some of Mr Dhlamini's questions.

Mr DLAMINI'S CAR BATTERY IS FLAT!



Mr Dhlamini takes his car battery to the local store to recharge it. He sees that Mpho, who works at the store, uses a 'little machine' to check the battery. After he has recharged the battery the reading on the 'little machine' is 12 V. He learns that the 'little machine' is called a voltmeter. He asks Mpho if he can borrow the voltmeter for a few days to check the battery. Mpho tells him that he must be very careful when he connects the voltmeter, otherwise he could damage it. He shows him how to connect the voltmeter to the one terminal of the battery and then the other.

Mr Dhlamini has also taken your advice, given in an earlier activity. He has connected his three light bulbs in parallel and is very pleased with them. On his way home he thinks about the voltmeter and asks himself these two questions:

a) How does a voltmeter work, and what does it measure when it is connected across a battery?
b) What does the word "volts" on the voltmeter mean?

You are going use your prior knowledge of voltmeters and potential difference to answer Mr Dhlamini's questions.

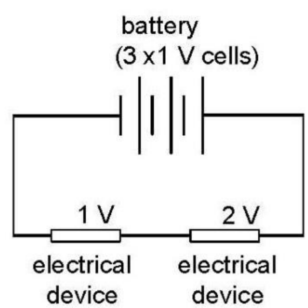
Support your answers with labelled drawings of circuit symbols. Put your answers and drawings onto flip chart paper or big pieces of plain paper.

PART B

The whole class will do a role play of voltage, energy and current. You will act out what happens in the series circuit given on the right.

This is a fun activity but it is important because it will help make some of the following concepts clearer and easier to understand;

- differences in potential energy,
- a current is composed of moving charges,
- charges do not get used up, only the potential energy of the charges is used up as they move in the circuit,
- charges leaving the battery have high potential energies and charges entering the battery have no potential energy.



What you need

1. 3 buckets or any other large containers. One bucket is the battery. The other two buckets are

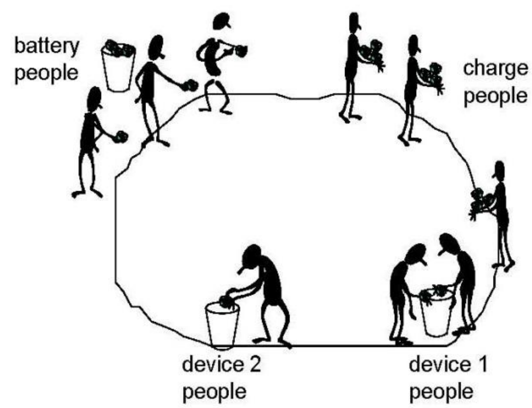
the electrical devices.

2. Mark out the circuit with string or rope, or else use chalk. You can also do this outside and draw the circuit in the sand.
3. Crumpled pieces of paper, or stones, or any other small objects, that can represent “bundles of energy”.

   Fill the battery bucket with the “bundles of energy”.

What to do

1. Choose one person or two people (not your teacher) to be the director(s), who will be in charge of the “circuit”. Your teacher is the assistant director who gives help and guidance. The director will decide who is doing what, make sure all the instructions are clear, decide when the role play stops etc.
2. Choose three people to be “battery people”. The “battery people” give the “charge people” “bundles of energy” from the battery bucket.
3. Choose two people to be the two electrical devices, the “device people”. The devices are not identical. One device must have a voltage of 1 volt across it, and the other 2 volts across it.
4. The rest of the class are the “charge people” travelling around the circuit. As each “charge person” travels through the battery they get a “bundle of energy” from each “battery person”. This means each “charge person” will have three “bundles of energy”.The “charge person” gives each “device person” the correct number of “bundles of energy” as he/she travels through the device. The “charge person” then continues travelling around the circuit and returns to the “battery people” to get more “bundles of energy”.



What to discuss

1. The following terms, “volts” and “battery” were mentioned briefly, and the terms “coulombs”, “cells”, “current” and “potential difference” were purposely left out in your role play instructions. Use these terms and write a paragraph explaining the whole process of what happens when charges move in a series circuit.
2. The SI unit for potential difference is ‘the volt’ represented by the symbol ‘V’, however there is another unit which can be more meaningful. In Grade 10 you met the following equation:-

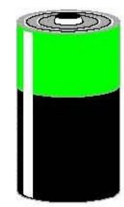
   potential difference = energy transferred/coulomb of charge

$$V = \frac{W}{Q}$$

   Discuss this equation and then derive the second unit, and explain why it is more meaningful.

EXPERIMENT 28 – THE MAXIMUM POTENTIAL ENERGY OUTPUT OF A BATTERY
CSEC OBJECTIVE (S): Section D – Objective 3.2

Grade Level – 10

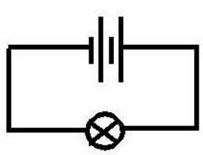


If we measure the potential difference across the terminals of a cell or battery when it is not supplying a current, we measure the maximum electrical potential energy which the cell or battery can deliver to a coulomb of charge. We call this maximum electrical potential the emf of the cell. It was originally thought that an electromotive force (abbreviated emf) caused charges to move. We don't think of it that way anymore, we think instead in terms of energy transferred.
In this Activity you will again be meeting Mr Dhlamini and his excitement about the voltmeter. Soon after Mr Dhlamini gets home from seeing Mpho at the store he connects his car battery to the light circuit of his house. He follows Mpho's careful instructions and he connects the voltmeter in parallel with the car battery. To his surprise, the reading on the voltmeter is less than 12 volts. His first response is that the voltmeter is not working properly.
Then he thinks maybe his battery is leaking "energy". He then starts to worry. How can the newly recharged car battery have less volts and it hasn't even being used.

What you need
a basic micro-electricity kit, a voltmeter

What to do

1. Make a battery with the two 1.5 V cells and the cell holder. Connect the voltmeter across the terminals of the 3 V battery. Note the voltmeter reading.
2. Draw a diagram of the voltmeter connected across the battery.



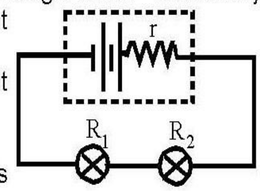
3. Set up the simple series circuit given on the left.
4. Connect the voltmeter across the battery and take a reading.
5. Connect the voltmeter across the light bulb and take a reading.
6. Draw up a table to record the three readings.

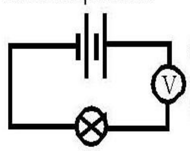
What to discuss

1. What was the emf of your battery? Use the values that you measured to describe the emf value in terms of joules and coulombs.
2. This is part of a conversation between Lebala and Phoka when they set up a similar circuit. The only difference between the circuits is that they used a 9 V battery.
   Lebala: "You know Phoka, I am confused! When we measured the potential difference of the battery before we put it in the circuit it was 9 V. But when we measured it when it was in the circuit it was only 7 V. Where have the other 2 V gone?"
   Phoka: "I think they are 'lost'."
   Lebala: "Phoka, how can you just lose some volts, eh?"
   Phoka: "You know, the battery was quite hot after we finished taking our measurements. Maybe it has something to do with the battery."
   Consider the above conversation. Did any of you observe the same thing as Lebala? Try and explain what happened to the 'lost volts'.
3. One of the important features of a voltmeter is that it is designed so that it has a very high resistance.

Why is it designed in this way?

4 The diagram alongside represents a series circuit of a battery and two light bulbs. The battery symbol includes the two cell symbols and the resistance offered to a current by the battery. Use the symbols r, R_1 and R_2 given in the diagram, to represent the total resistance of the circuit as an equation.





5 The circuit on the left shows a voltmeter that is connected in series with a light bulb. The voltage of the battery is 3 V.

Consider the following questions about the circuit.

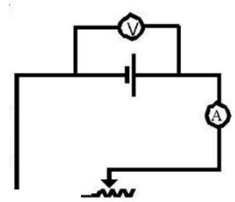
a) Will there be a reading on the voltmeter? If there is a reading on the voltmeter, will it be the same as the emf reading of the battery or will it be the same as the reading across the light bulb?
b) Will the light bulb glow? In other words will there be a current in the circuit?

Answer the questions and give a reason for each of your answers.
compare your actual observations of the circuit with your predictions.
Where your answers do not agree with your observations, explain why that is so.

TO THINK ABOUT

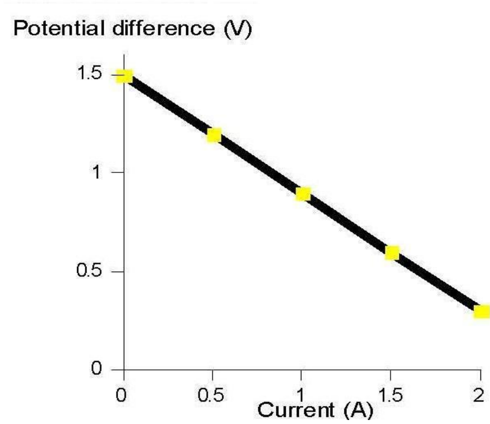
1. A range of results were obtained from the circuit on the right. The rheostat (variable resistor) is connected in the circuit to vary the current.

Set up the circuit and then Reassess your answers.



The table and the graph below show the relationship between the potential difference across a cell and the current that flows from it.

Current (A)	Potential difference across cell (V)	"Lost voltage" (V)
0	1.5	0
0.5	1.2	0.3
1	0.9	0.6
1.5	0.6	0.9
2	0.3	1.2



Answer the following questions.

a) What is the meaning of the term, "lost voltage"?
b) Explain why the "lost voltage" value is zero when the potential difference value across the cell is 1.5 V.
c) Describe how an increase in current will have an effect on the potential difference values.

2. A current of 5 A in the resistance-wire of a hot-plate transfers 66 000 joules of heat in 1 minute. What is the potential difference between the terminals of the hot-plate?