Electric circuits: Key concepts (Grade 10) [NCS]*

Free High School Science Texts Project

1 Electric Circuits

People all over the world depend on electricity to provide power for most appliances in the home and at work. For example, flourescent lights, electric heating and cooking (on electric stoves), all depend on electricity to work. To realise just how big an impact electricity has on our daily lives, just think about what happens when there is a power failure or load shedding.

1.1 Discussion : Uses of electricity

With a partner, take the following topics and, for each topic, write down at least 5 items/appliances/machines which need electricity to work. Try not to use the same item more than once.

- At home
- At school
- At the hospital
- In the city

Once you have finished making your lists, compare with the lists of other people in your class. (Save your lists somewhere safe for later because there will be another activity for which you'll need them.)

When you start comparing, you should notice that there are many different items which we use in our daily lives which rely on electricity to work!

> TIP: **Safety Warning:** We believe in experimenting and learning about physics at every opportunity, BUT playing with electricity and electrical appliances can be **EXTREMELY DANGEROUS**! Do not try to build home made circuits alone. Make sure you have someone with you who knows if what you are doing is safe. Normal electrical outlets are dangerous. Treat electricity with respect in your everyday life. Do not touch exposed wires and do not approach downed power lines.

1.2 Closed circuits

In the following activity we will investigate what is needed to cause charge to flow in an electric circuit.

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1.2.1 Experiment : Closed circuits

Aim:

To determine what is required to make electrical charges flow. In this experiment, we will use a lightbulb to check whether electrical charge is flowing in the circuit or not. If charge is flowing, the lightbulb should glow. On the other hand, if no charge is flowing, the lightbulb will not glow.

Apparatus:

You will need a small lightbulb which is attached to a metal conductor (e.g. a bulb from a school electrical kit), some connecting wires and a battery.

Method:

Take the apparatus items and try to connect them in a way that you cause the light bulb to glow (i.e. charge flows in the circuit).

Questions:

1. Once you have arranged your circuit elements to make the lightbulb glow, draw your circuit.
2. What can you say about how the battery is connected? (i.e. does it have one or two connecting leads attached? Where are they attached?)
3. What can you say about how the light bulb is connected in your circuit? (i.e. does it connect to one or two connecting leads, and where are they attached?)
4. Are there any items in your circuit which are not attached to something? In other words, are there any gaps in your circuit?

Write down your conclusion about what is needed to make an electric circuit work and charge to flow.

In the experiment above, you will have seen that the light bulb only glows when there is a *closed* circuit i.e. there are no gaps in the circuit and all the circuit elements are connected in a *closed loop*. Therefore, in order for charges to flow, a closed circuit and an energy source (in this case the battery) are needed. (Note: you do not have to have a lightbulb in the circuit! We used this as a check that charge was flowing.)

Definition 1: Electric circuit

An electric circuit is a closed path (with no breaks or gaps) along which electrical charges (electrons) flow powered by an energy source.

1.3 Representing electric circuits

1.3.1 Components of electrical circuits

Some common elements (components) which can be found in electrical circuits include light bulbs, batteries, connecting leads, switches, resistors, voltmeters and ammeters. You will learn more about these items in later sections, but it is important to know what their symbols are and how to represent them in circuit diagrams. Below is a table with the items and their symbols:

Component	Symbol
light bulb	Image not finished **Figure 1**
battery	Image not finished **Figure 2**
switch	Image not finished **Figure 3**
resistor	Image not finished **Figure 4**

continued on next page

	OR
	Image not finished **Figure 5**
voltmeter	Image not finished **Figure 6**
ammeter	Image not finished **Figure 7**
connecting lead	Image not finished **Figure 8**

Table 1

1.3.2 Circuit diagrams

Definition 2: Representing circuits
A **physical circuit** is the electric circuit you create with real components.
A **circuit diagram** is a drawing which uses symbols to represent the different components in the physical circuit.

We use circuit diagrams to represent circuits because they are much simpler and more general than drawing the physical circuit because they only show the workings of the electrical components. You can see

this in the two pictures below. The first picture shows the *physical circuit* for an electric torch. You can see the light bulb, the batteries, the switch and the outside plastic casing of the torch. The picture is actually a *cross-section* of the torch so that we can see inside it.

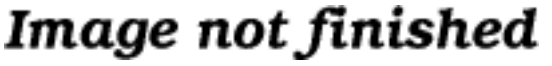


Figure 9: Physical components of an electric torch. The dotted line shows the path of the electrical circuit.

Below is the *circuit diagram* for the electric torch. Now the light bulb is represented by its symbol, as are the batteries, the switch and the connecting wires. It is not necessary to show the plastic casing of the torch since it has nothing to do with the electric workings of the torch. You can see that the circuit diagram is much simpler than the physical circuit drawing!

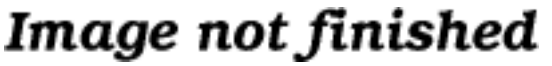


Figure 10: Circuit diagram of an electric torch.

1.3.3 Series and parallel circuits

There are two ways to connect electrical components in a circuit: **in series** or **in parallel**.

Definition 3: Series circuit
In a series circuit, the charge flowing from the battery can only flow along a **single** path to return to the battery.

Definition 4: Parallel circuit
In a parallel circuit, the charge flowing from the battery can flow along **multiple** paths to return to the battery.

The picture below shows a circuit with three resistors connected *in series* on the left and a circuit with three resistors connected *in parallel* on the right. In the series circiut, the charge path from the battery goes through every component before returning to the battery. In the parallel circuit, there is more than one path for the charge to flow from the battery through one of the components and back to the battery.

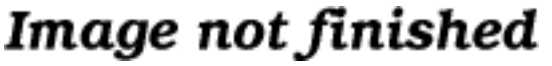


Figure 11

This simulation allows you to experiment with building circuits.

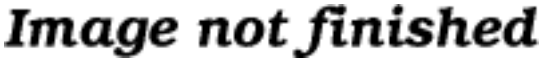


Figure 12

run demo[1]

Exercise 1: Drawing circuits I *(Solution on p. 8.)*

Draw the circuit diagram for a circuit which has the following components:

1. 1 battery
2. 1 lightbulb connected in series
3. 2 resistors connected in parallel

Exercise 2: Drawing circuits II *(Solution on p. 8.)*

Draw the circuit diagram for a circuit which has the following components:

1. 3 batteries in series
2. 1 lightbulb connected in parallel with 1 resistor
3. a switch in series with the batteries

1.3.3.1 Circuits

1. Using physical components, set up the physical circuit which is described by the circuit diagram below and then draw the physical circuit:

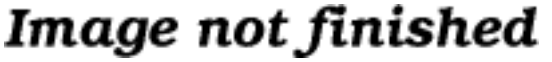


Figure 13

Click here for the solution[2]

2. Using physical components, set up a closed circuit which has one battery and a light bulb in series with a resistor.
   a. Draw the physical circuit.
   b. Draw the resulting circuit diagram.
   c. How do you know that you have built a closed circuit? (What happens to the light bulb?)
   d. If you add one more resistor to your circuit (also in series), what do you notice? (What happens to the light from the light bulb?)
   e. Draw the new circuit diagram which includes the second resistor.

[1] http://phet.colorado.edu/sims/circuit-construction-kit/circuit-construction-kit-dc_en.jnlp
[2] http://www.fhsst.org/lqZ

Click here for the solution[3]

3. Draw the circuit diagram for the following circuit: 2 batteries and a switch in series, and 1 lightbulb which is in parallel with two resistors.
   a. Now use physical components to set up the circuit.
   b. What happens when you close the switch? What does does this mean about the circuit?
   c. Draw the physical circuit.

   Click here for the solution[4]

1.3.3.2 Discussion : Alternative Energy

At the moment, most electric power is produced by burning fossil fuels such as coal and oil. In South Africa, our main source of electric power is coal burning power stations. (We also have one nuclear power plant called Koeberg in the Western Cape). However, burning fossil fuels releases large amounts of pollution into the earth's atmosphere and contributes to global warming. Also, the earth's fossil fuel reserves (especially oil) are starting to run low. For these reasons, people all across the world are working to find *alternative*/other sources of energy and on ways to *conserve*/save energy. Other sources of energy include wind power, solar power (from the sun), hydro-electric power (from water, e.g. dammed rivers) among others.

With a partner, take out the lists you made earlier of the item/appliances/machines which used electricity in the following environments. For each item, try to think of an *alternative* AND a way to *conserve* or save power.

For example, if you had a flourescent light as an item used in the home, then:

- Alternative: use candles at supper time to reduce electricity consumption
- Conservation: turn off lights when not in a room, or during the day.

Topics:

- At home
- At school
- At the hospital
- In the city

Once you have finished making your lists, compare with the lists of other people in your class.

[3] http://www.fhsst.org/lqB
[4] http://www.fhsst.org/lqK

Solutions to Exercises in this Module

Solution to Exercise (p. 6)

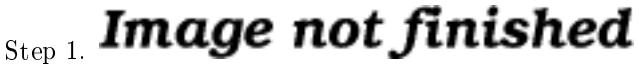
Step 1. 

Figure 14

Solution to Exercise (p. 6)

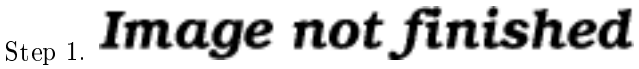
Step 1. 

Figure 15