STELR

SCIENCE

6

Electricity
Workbook

ATSE

Australian Academy of
Technological Sciences
& Engineering

ATSE Fellow Fact File

Professor Maria Forsyth
FTSE AM FAA

Associate Director
ARC Centre of Excellence for
Electromaterials Science (ACES)

"We need clever solutions to manage our increasing need for energy. STELR is an excellent education resource to introduce students to the fundamentals of electricity and circuit making, teaching them all the basics they need to solve tomorrow's problems."

Professor Maria Forsyth has been at the forefront of global research and collaboration in energy storage for decades. Her work on battery technology has consistently achieved breakthrough results. Her team is now researching sodium battery technology given its safety, sustainability and strong potential for inexpensive large-scale energy storage.

She is a Fellow of the Australian Academy of Technological Sciences and Engineering (ATSE) and the Australian Academy of Science. Both these organsations care deeply about a technology powered, human driven future for the prosperity of Australia

Working on new battery science must have been very challenging work. How many different people have you worked with on these advances and how important was learning from what others had already tried?

Research is a highly collaborative endeavour. Over the past 35 years of working in battery science I have worked with over 25 research groups and hundreds of scientists across the world including from the USA, France, Italy, Spain, UK, Canada, Slovenia, Japan, China and Malaysia. This includes both at Universities, national laboratories and with companies like Toyota who are developing new batteries for electric cars. By working together and exchanging ideas we can make much faster progress since we all bring different backgrounds and experience.

We also have several conferences every year held in different countries where sometimes over 1000 people, all working on battery science, meet and present their work. Here we get to find out the latest discoveries and ideas which we can then use to progress our own work. The meetings at breaks are super important for making new scientific connections and often lifelong scientific friendships that keeps the field moving forward.

AC9S6H01
Examine why advances in science are often the result of collaboration or build on the work of others

How did your knowledge of science allow you to realise the problem with current batteries and work on your own solutions?

In order to come up with new solutions or invent new materials or battery technologies, you have to understand the problems with current batteries and the basic science of molecules and atoms, how they react and how those reactions can be harnessed in a battery. Right now I am working on a next generation sodium (Na) battery which will be an alternative to the lithium ion batteries that power nearly every piece of electronics we use like our phones, watches, laptops, EVs, electric bikes etc. These current batteries aren't always safe - they can catch fire because of the materials that are used and how these materials can react to release a lot of heat. They also lose their capacity (energy) when they get too hot which means the battery wont last as long.

My science has been focused on developing new materials that are safer and also will let the battery work even if it get's hot. To do this we also have to understand how to control the chemistry or electrochemistry in the battery. To swap from Lithium to Sodium (which is more abundant in the earth's crust so the batteries are also more sustainable) we have to understand how the different elements behave. You cant improve existing batteries or invent completely new technologies without understanding science.

AC9S6H02
Investigate how scientific knowledge is used by individuals and communities to identify problems, consider responses and make decisions

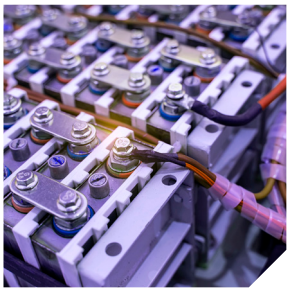
ATSE STELR

SCIENCE | TECHNOLOGIES | NUMERACY | ENGINEERING | EXPERIMENTS












CONTENTS

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15 years of inspiring students to pursue STEM careers

STELR is a STEM in schools initiative from the Australian Academy of Technological Sciences & Engineering

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Purchase our STELR Primary Electricity Kits that support this resource.
shop.stelr.org.au

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www.atse.org.au/STELR

STELR
Australian Academy of Technological Sciences and Engineering
Level 2, 28 National Circuit Forrest ACT 2603
atse.org.au/stelr

Electric circuits

Key ideas

- What does a circuit need to allow electricity to flow?
- How does the position of the switch in the circuit affect which globes turn on?
- What materials conduct electricity?
- What happens to the brightness of the globes when an extra globe is connected into a circuit?

Electric circuits

An **electric circuit** is a pathway in which electricity flows from one terminal of a source of electrical energy, through wires and various other objects, and back to the other terminal.

For electricity to flow through the circuit, there must be an unbroken path between one terminal of the source of electrical energy and the other. A circuit with an unbroken path is called a **complete** circuit. When the circuit is **incomplete** because there is a break in the path along which electricity flows, the circuit will not function.

The objects which are part of the circuit are called the **components** of the circuit.

Question

The picture below shows an example of a complex circuit with many different components.
How many components do you think you can identify? Try again after completing this workbook.

Above: A complex circuit with many components. Source: iStock, superpeet

ACTIVITY 1

Simple electric circuits

What you need

STELR battery
STELR lamp
2 x connecting wires

What to do

Use the equipment you have been given to make a complete circuit. The objects which are part of the circuit are called the components of the circuit.

Question 1.1

How do you know if the circuit is complete?

Question 1.2

Draw a picture or take a photograph of your complete circuit.

Challenge

Make a complete circuit using the battery, light globe and only one connecting wire.

Question 3

Draw a picture or take a photograph of your complete circuit.

ACTIVITY 2

Exploring components - battery pack and globe

What you need

STELR battery pack

STELR lamp

1 x 30cm connecting lead

Blu Tack or plasticine

The STELR battery pack has two 1.5 Volt batteries inside it. The pack holds the two batteries in place so that they can deliver 3 Volts.

What to do

Take the back off the battery pack and look inside.

Question 2.1

Do you think that the two batteries are connected together? Explain why you think that.

Next

Now take out the batteries and look at them closely. You will see that one end is positive, marked with a plus sign. The other end is negative, marked with a minus sign.

Stick the Blu Tack on the table so that the batteries and globe are connected. Use the wire to make the globe light up.

Question 2.2

Which ends of the battery have to be touching each other for the globe to light up?

Question 2.3

On the picture on the right, show where the battery and wire must touch the globe for it to light up.

Activity

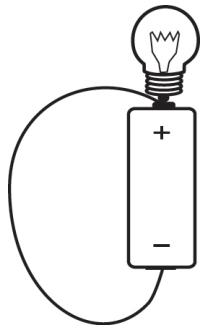
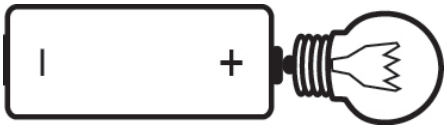
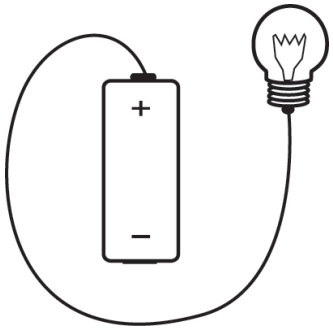
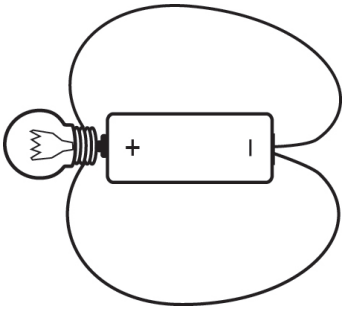
Trace the path that the electricity takes through the globe.

Question 2.4

Below are four diagrams of circuits.

a) Predict which globes will light up and give a reason.

b) Test to see if your prediction was correct.

	My prediction	What actually happened
		
		
		
		

Question 2.5

Now look at the empty battery pack. Look at the wires inside.

Use a coloured pen or pencil to trace the path the electricity takes through the battery pack (when the batteries are inside it).

Question 2.6

Explain why the batteries have to go in the opposite way up.

ACTIVITY 3

Conductors and insulators

A **conductor** is a material that electricity can travel through.

An **insulator** is a material that electricity cannot travel through.

An electric circuit is a complete pathway that electricity can travel around.

In this activity you will make a circuit to test if a material is a conductor or an insulator.

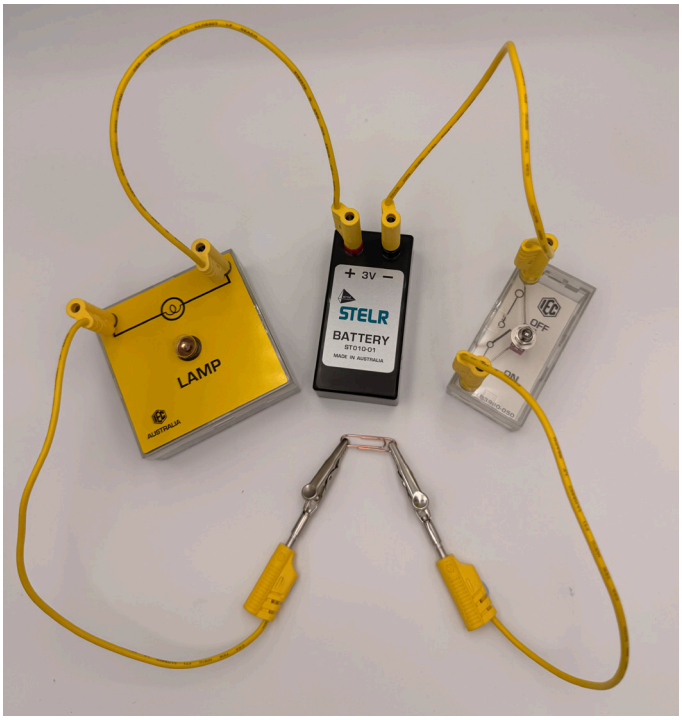
What you need

STELR battery
STELR globe (or testing station)
4 x connecting leads - two with alligator clips on one end
Switch
Materials to test

What to do

Use the equipment to make a circuit to test materials to see if they are conductors or insulators.

Get your teacher to inspect your circuit before you start testing materials.



Above: Example setup of a circuit for testing materials

Question 3.1

Explain how your circuit works.

Question 3.2

Test up to 10 different materials. Fill in the table to show your results:

Object	Material	Prediction	Results
eg: paper clip	eg: metal	eg: conductor	eg: conductor

Question 3.3

What types of materials conduct electricity?

Question 3.4

What types of materials are good electrical insulators (do not conduct electricity)?

ACTIVITY 4

The effect of a switch

What you need

STELR battery pack

1 STELR globe

3 x connecting leads
1 STELR switch

What to do

Tinker with the equipment you have been given and answer the questions below.

Question 4.1

Can you turn the globe on and off using a switch? When you are successful, draw a diagram of your circuit.

Question 4.2

Explain how the switch changes the circuit allowing the light to be turned on and off.

Question 4.3

Give two examples of where a switch is used.

ACTIVITY 5

Exploring components — how a switch works

What you need

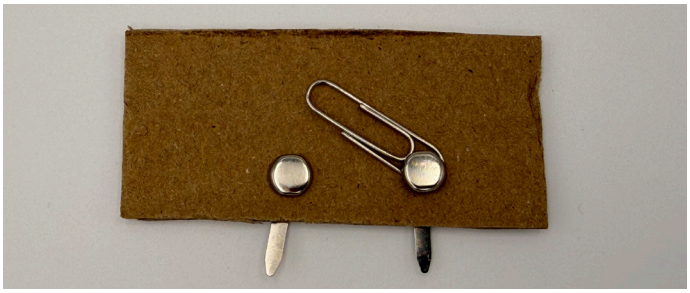
STELR battery pack
STELR lamp
3 x connecting leads
2 x alligator clip attachments
Small piece of cardboard
A paper clip
2 x split (fold-back) pins

What to do

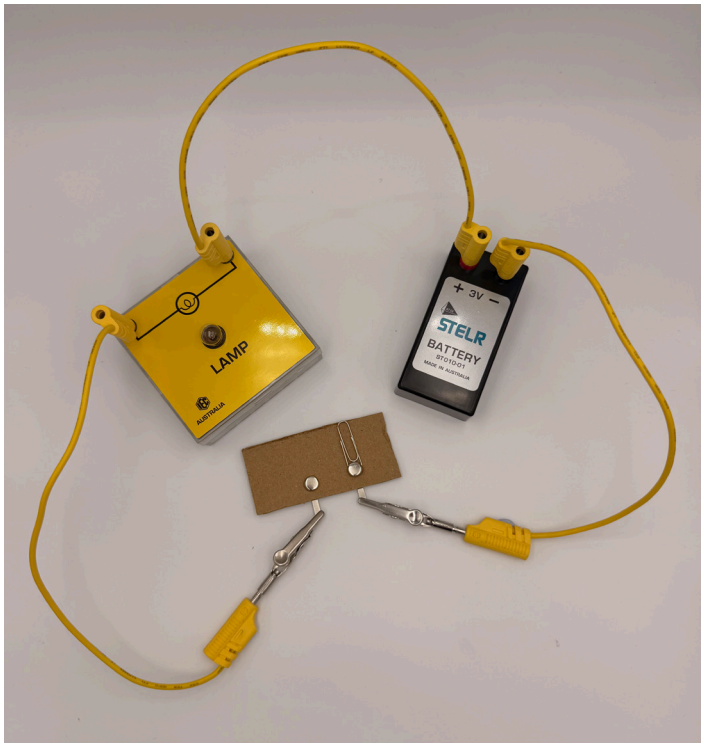
Make a switch by carefully pushing one of the split pins through the cardboard and fold back the two arms. Take the second pin, thread the paper clip on and push it through the cardboard so that it looks like the picture on the left below.

Make sure that the paperclip can touch the first pin when it is swivelled around.

Connect the switch to the battery pack and lamp as shown below.



Above: Split pins have been pushed through the cardboard and a paper clip has been looped around one of the pins. The arms of the split pins extend past the edge of the cardboard.



Above: The alligator clips on the end of the cable are gripping the arms of the fold back pins. The other end of the cable is plugged into the battery pack and lamp.

Question 5.1

What do you have to do to make the lamp light up?

Question 5.2

Complete the following sentences by ticking the correct answer.

When the switch (below) is open, the circuit is

- ☐ Incomplete
- ☐ Complete

When the switch (below) is closed, the circuit is

- ☐ Incomplete
- ☐ Complete

When the switch is open, the light is

- ☐ Off
- ☐ On

When the switch is closed, the light is

- ☐ Off
- ☐ On

Above: The switch is open

Above: The switch is closed

Question 5.3

What do you think would happen if you replaced the metal paper clip with a plastic paper clip? Explain your answer.

ACTIVITY 6

Energy transformations using the testing station

What you need

STELR battery pack

STELR testing station

STELR switch

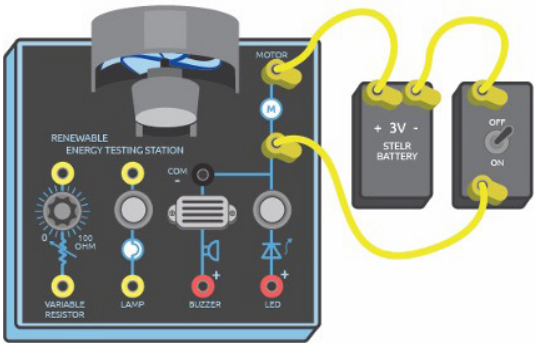
3 x connecting wires

What to do

Connect the battery pack and switch to the motor on the STELR testing station as shown in the diagram below.

Question 6.1

What happens when you turn on the switch?



Question 6.2

Swap the leads around on the testing station so the power is flowing the other way. What happens to the motor/fan now?

Question 6.3

Turn off the switch. Now move the two leads, plugging one into the black (COM) socket and one into the red buzzer socket. Turn on the switch. What happens?

Question 6.4

Swap the lead from the black socket into the red and from the red into the black. Does this change what happens?

Question 6.5

Which terminal of the buzzer does the lead from the + (positive) terminal of the battery need to be plugged into for the buzzer to work?

Question 6.6

Once you have the buzzer working, turn off the switch. Now move the plug from the red terminal of the buzzer to the red terminal of the LED. Turn on the switch. What happens?

Question 6.7

Reverse the two leads. Now what happens?

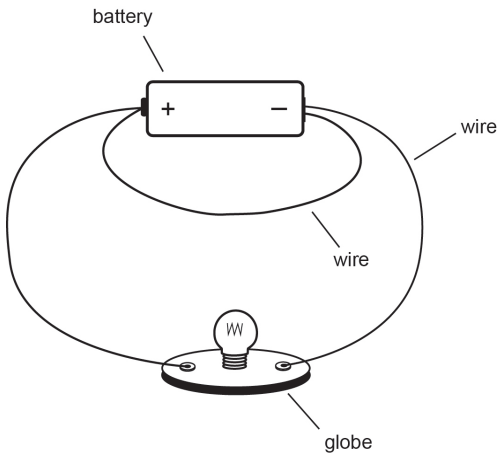
Question 6.8

Complete these sentences:

1. A motor transforms electrical energy into _____ energy.
2. A buzzer transforms electrical energy into _____ energy.
3. An LED transforms electrical energy into _____ energy.
4. The buzzer and the LED only work if the positive (+) terminal of the battery is connected to the _____ terminal of the buzzer or the LED.

Circuit diagrams

Electric circuits can be drawn to show all the components in the circuit and the way they are connected. For example, the diagram below shows a simple closed circuit constructed with two wires, a battery and a globe. The diagram or picture from your simple circuit may look like this:



Symbols

Circuit diagrams may also be drawn using symbols. Symbols are used because many electrical circuits are very complicated and drawing an accurate picture may be difficult.

All scientists and electricians around the world use the same symbols.

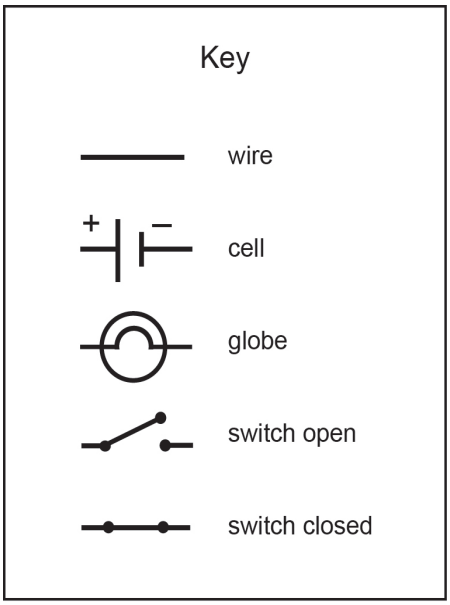
Symbols for some of the components used in electric circuits are shown in the key.

A cell is the scientific name for a single battery.

An open switch is one that is switched off. Electricity cannot flow through it.

A closed switch is one that is switched on. Electricity can flow through it.

To make circuit diagrams as clear as possible they are always drawn with connecting wires in a square or rectangle, like diagram B.



To make circuit diagrams as clear as possible they are always drawn with connecting wires in a square or rectangle. For example, the circuit shown in diagram A would be drawn as shown in diagram B:

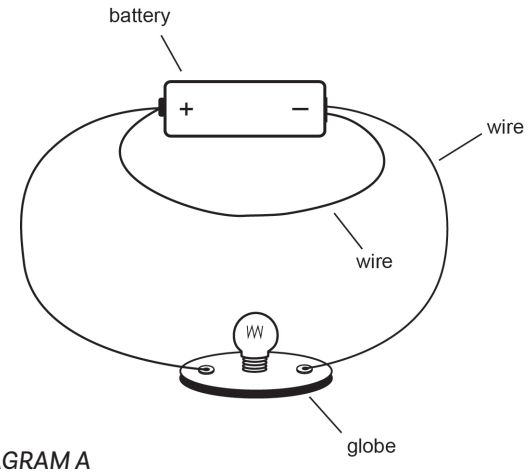


DIAGRAM A
Showing a simple closed circuit constructed with two wires, a battery and a globe

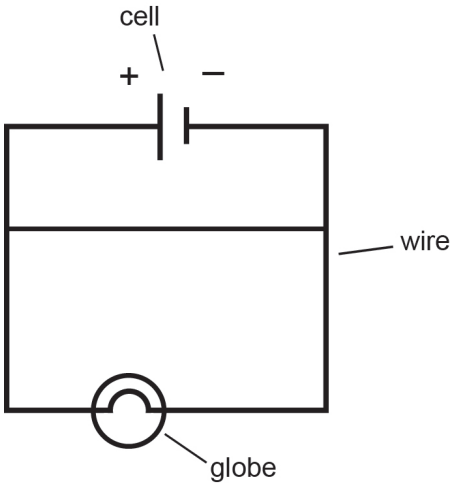
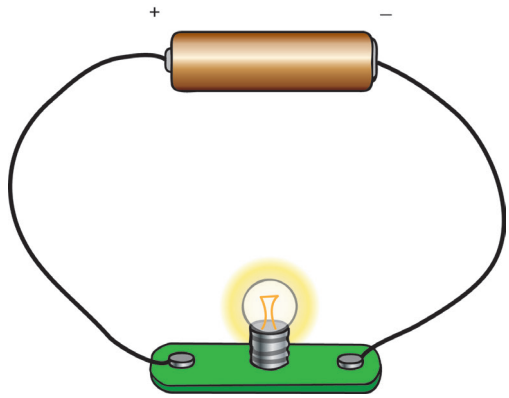
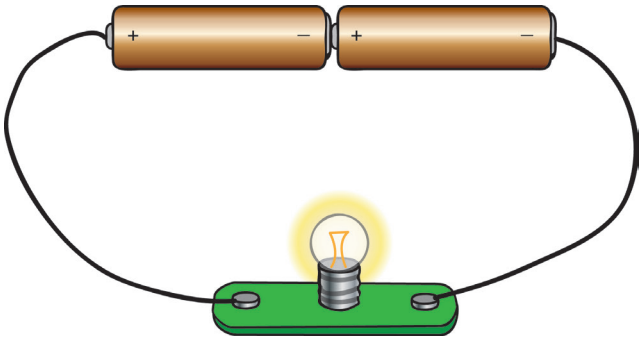


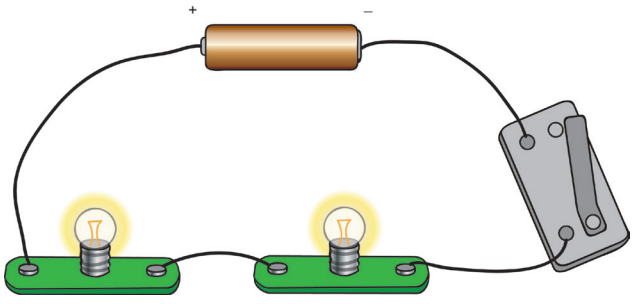
DIAGRAM B
The connecting wires are shown as a square

Question 1

Draw a circuit diagram using symbols next to each of the circuits.







Question 2

Using symbols, draw a circuit diagram of a circuit that contains a single cell connected to two light globes. Between the light globes is a switch which is on.

Challenge question

For the circuit shown below, draw a circuit diagram using symbols.