Electricity and Magnetism: Teaching Approaches 01

Contents

This is the 'Teaching Approaches', showing selected possible activities suitable for the classroom. To develop your expertise in the episode, work with the 'Physics Narrative' and the 'Teaching and Learning Issues'. Navigate to any part of the topic using the Topic Menu, or use the tabs below to stay within this episode.

Some activities to start out

What kind of teaching activities might you draw upon to address the learning challenges for this first episode of the electricity narrative? First of all we provide details of two activities which will help pupils make links to their earlier work on electric circuits.

Think again about electric circuits	three diagnostic questions	• to probe the pupils' initial understanding of electric circuits • to encourage pupils to think through their ideas about electric circuits
Make or break!	a class practical design and make activity	• to capture interest • to review the idea of a complete circuit • to engage pupils in designing and making circuits using appropriate lab equipment • to encourage pupils to talk and think about simple electric circuits

Think again about electric circuits

What the activity is for

The questions are used for two main reasons:

- to encourage individual pupils to begin to think through their ideas about electric circuits
- to provide the teacher with formative assessment information about the pupils' initial thinking

What to prepare:

- question sheets for think again questions 1-3

What happens during this activity

Pupils work individually or in pairs on the questions and are encouraged to think and to write down their answers with as much detail as possible. The questions might be set for homework prior to the first lesson so that you have time to read through the responses. Alternatively, they might be used at the start of the first lesson while you move around looking at what the pupils are writing.

Make or break!

This is a design and make activity through which you can review the idea of a complete circuit with the pupils and help them to build a circuit using the available laboratory equipment.

What the activity is for

- to capture interest
- to review the idea of a complete circuit
- to engage pupils in designing and making circuits using appropriate laboratory equipment
- to encourage pupils to talk and think about simple electric circuits

What to prepare:

- low voltage supplies, such as power packs or batteries
- buzzers and bells
- connecting wires, both 4 mm leads and insulated wire
- copper wire, copper strip, stiff card, plastic foam or sellotape

What happens during this activity?

Start by demonstrating with a simple circuit containing a battery and a buzzer or bell that a complete circuit is needed for a buzz or ring. Then explain that the pupils are going to use this simple principle to design and make one of three devices:

- a burglar alarm for the classroom door: open the door and the bell rings
- a pressure pad alarm: stand on the mat and the bell rings (or sit on the chair and the bell rings)
- a steady hand tester: touch the wire with the loop and the bell rings

Divide the pupils up into teams of three or four and allocate a device to each team. Insist that the teams spend 10 minutes in talking through and drawing out their ideas before starting to work with the equipment. Equipment and materials should be set out so that the teams can collect whatever items they think will be useful. Be prepared for requests for additional items!

Allow plenty of time at the end of the lesson for each team to:

- describe their "invention"
- explain how the device works

To add to the sense of occasion, you might get some pupils to invite a senior member of staff into the lesson to try out the alarmed chair!

Experience has shown that the pupils really enjoy this activity and that it provides an excellent opportunity for talking around basic electric circuit ideas. Be prepared for pupils insisting that their door alarm is left in place, and then showing their friends from other classes how it works at break time!

Activities to develop understanding

We suggest four further teaching activities. The first sets the scene for the development of the electric circuit model and the second focuses on introducing the electric circuit model via a teaching analogy:

The BIG circuit	teacher demonstration	• to open up the problem of understanding how an electric circuit works • to probe pupils' existing ideas about electric circuits • to set the target of developing a scientific model to explain how an electric circuit works
From rope loop to electric circuit model	teacher presentation and class discussion	• to introduce the rope loop teaching analogy to the pupils, making links to the electric circuit model • to talk through some of the basic features of the electric circuit model by referring to the rope loop
Building and describing electric circuits	whole class work or small group challenges	• to reinforce the ideas of charge flow, current in components and energy shifted by components • to allow pupils to explore and summarise their understanding
Check questions	three diagnostic questions	• to check the pupils' understanding of ideas developed in this episode • to help identify where further teaching and learning effort may be needed

The Big Circuit!

What the activity is for

Having had the chance to think through their ideas aided by the diagnostic questions, the pupils are now shown a “real” circuit and are encouraged to bring their ideas out into the open through class discussion.

The BIG circuit consists of a power supply (battery) and bulb. The power supply is at the front of the room, the bulb at the back, and the connecting wires run right round the perimeter of the room, taped to the classroom walls.

Why use such a BIG circuit? The idea here is that the BIG circuit helps focus attention on the need for some mechanism to link energy shifted by the battery and by the bulb and, most importantly, that the bulb lights very quickly, even when it is some distance from the battery.

What to prepare:

- a 24 watt/12 volt bulb works very well, being big enough for the whole class to see.
- a 2 volt power supply
- 2 very long leads

What happens during this activity

First of all draw the pupils’ attention to the size of the BIG circuit. They are actually sitting in the middle of it and: “it’s an absolute whopper of a circuit!” With due ceremony, build up slowly to switching on the BIG circuit, asking the pupils to predict whether the bulb will light straight-away.

Talk through what happens with the pupils:

What happens when the switch is closed?....bulb heats up and lights up.
Where does this energy come from in the first place?…the chemical store of the battery.

This happens pretty quickly, even though there is a big distance between battery and bulb:

What connects energy changes in battery and bulb?
How does it happen so quickly?

We can see light being given out from the bulb and we can feel the heating effect, but we cannot see how this happens. What is going on in the BIG circuit to allow the bulb to light?

The Big Circuit!

We think that in response to what happens with the BIG circuit, pupils will talk about electricity, electric current, flow and energy. These ideas can be built upon by developing a model for simple electrical circuits.

> The aim of the next few lessons is for you to become experts in understanding and explaining how electric circuits work. Although we cannot see what is happening inside the wires and other parts of the circuit, scientists have a model to explain what is going on. We want to understand this electric circuit model.

Teacher with a big circuit

Clip 1 Clip 2

Do the charges move instantly?

Find out when the charges start to move.

It would appear that when we turn on a switch the electric charges move immediately in all parts of the circuit and instantly light a bulb. Even if we connect all the wires available in the laboratory, to make a BIG circuit, the light bulb still appears to react immediately.

Actually it does take a very short time for the electrons to start moving. The electric field that sets the electrons in motion takes a finite time to pass through the wires. The field propagates (moves) at approximately the speed of light: 300 000 km per second, that is 300 mm in a thousand-millionth of a second.

Does this delay matter? An electrical signal would take a mere hundredth of a second to pass from the UK to the USA through cables under the Atlantic Ocean. However, a modern computer will time itself on a signal changing many millions of times a second. With signals that are fractions of a millionth of a second long, even small delays in signals travelling along wires must be taken into account when designing circuit boards.

The bulb in our circuit does not turn on immediately, but the delay is so short that it is only significant in the most extreme applications.

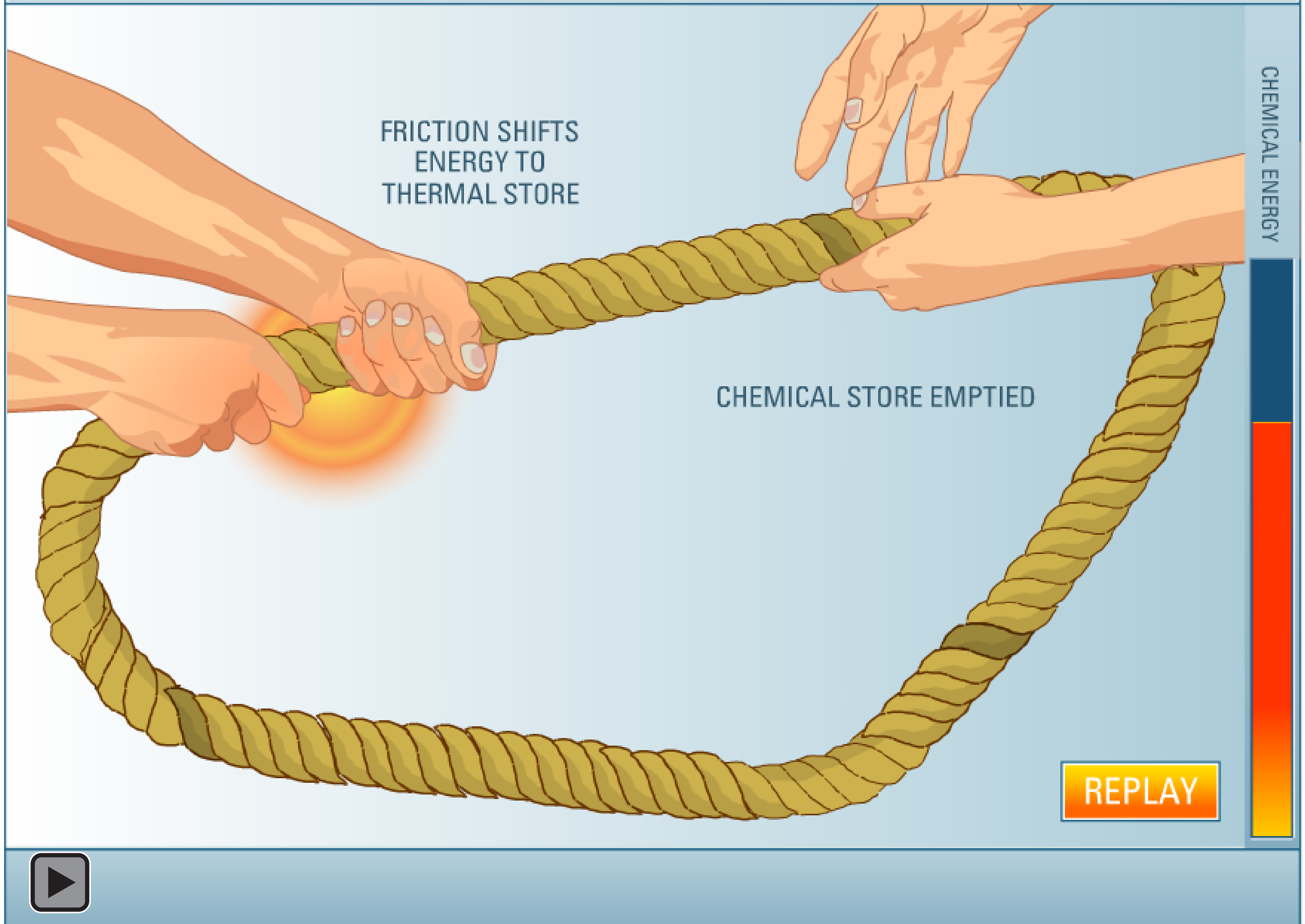
From rope loop to electric circuit model

What the activity is for

The rope loop is presented as a teaching analogy, which provides a way of helping pupils develop an understanding of abstract concepts (such as charge, current, resistance) by relating them directly to the movement of a length of rope around in a loop.

Notice how the same things are happening as in the electric circuit: a chemical store is being emptied (teacher as battery), and at a distance, something is getting warmed up (pupil as bulb).

A rope loop model



From rope loop to electric circuit model

Part 1: To introduce the rope loop analogy to the pupils

What to prepare:

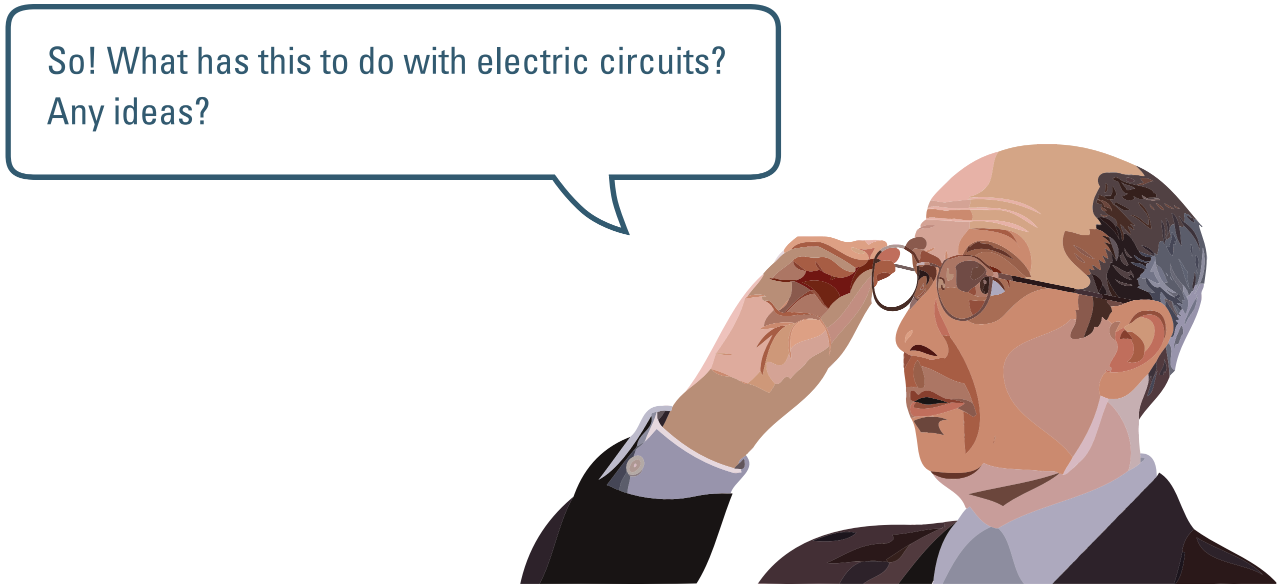
- a long length of rope (4-6 mm diameter is ideal), which can be passed in a BIG loop (prompting memories of the BIG circuit!) around all of the pupils in the class.

What happens during this activity:

The class is organised to stand in a big circle (you might carry out this activity in the school hall or outside) and the rope loop is passed out with each pupil allowing it to pass lightly over their curled fingers. The teacher (or nominated pupil) then starts to move the loop of rope round by passing it from hand to hand.

One pupil is instructed to grip the rope a little more tightly as it passes through their hand, and the teacher keeps the rope moving.

We have found it very effective to engage the pupils in this activity with little or no introduction, and then at this point (with the basic rope "circuit" set up) the teacher starts to pose questions:



The key features of the analogy to establish are that:

- the battery is represented by the teacher moving the rope
- the bulb is represented by the pupil gripping the rope
- the electric current (or moving charges) is represented by the moving rope
- energy is shifted through working (due to friction) at the "bulb"

From rope loop to electric circuit model

Part 2: Addressing the key features of the electric circuit model

The rope loop can now be used to consolidate the key features of the electric circuit model:

The charges originate in the circuit

Now it's very clear. The rope isn't coming from me. I'm just making it move around. In just the same way, the charges don't come from the battery. It just makes them move around the circuit.

The charges all around the circuit are set into motion together

Look everybody! As soon as I set the rope moving here, it starts moving all around the loop. In just the same way, as soon as the circuit is completed, the charges start moving in all parts of the circuit.

Current is conserved

The same amount of rope returns to me as leaves me every second. The rope does not get used up or disappear on the way round. In just the same way, the charge does not get used up on the way around the circuit, so the current is the same everywhere.

Energy is shifted where there is resistance

Now Julia can feel her hands warming up because she is gripping the rope. There is warming due to the effect of friction as the rope passes through her fingers. No-one else feels any real heating effect because they are not resisting the movement of the rope.

From rope loop to electric circuit model

Part 3: Back to the BIG circuit!

The point to make here is that it just does not matter how BIG the circuit is (unless it crosses the Atlantic!) As soon as the charges start moving energy is shifted by the bulb.

Teacher with a big circuit

Clip 1 Clip 2

Building and describing circuits

Four foci

We suggest you use very simple circuits here, to allow your class to concentrate on a restricted range of points:

- the energy in = the energy out
- currents are the same through all elements
- charge flows are the same in all elements
- relationship between charge flow and current

One way to use this software is to build a small series of circuits, and then use the diagrammatic descriptions of energy, current, and charge flow to label them, respecting the relative magnitudes of these different, but related quantities. You will want your pupils to be confident in applying their understanding of the restricted range of points above before they move on to applying this understanding to more complicated arrangements of cells and lamps.

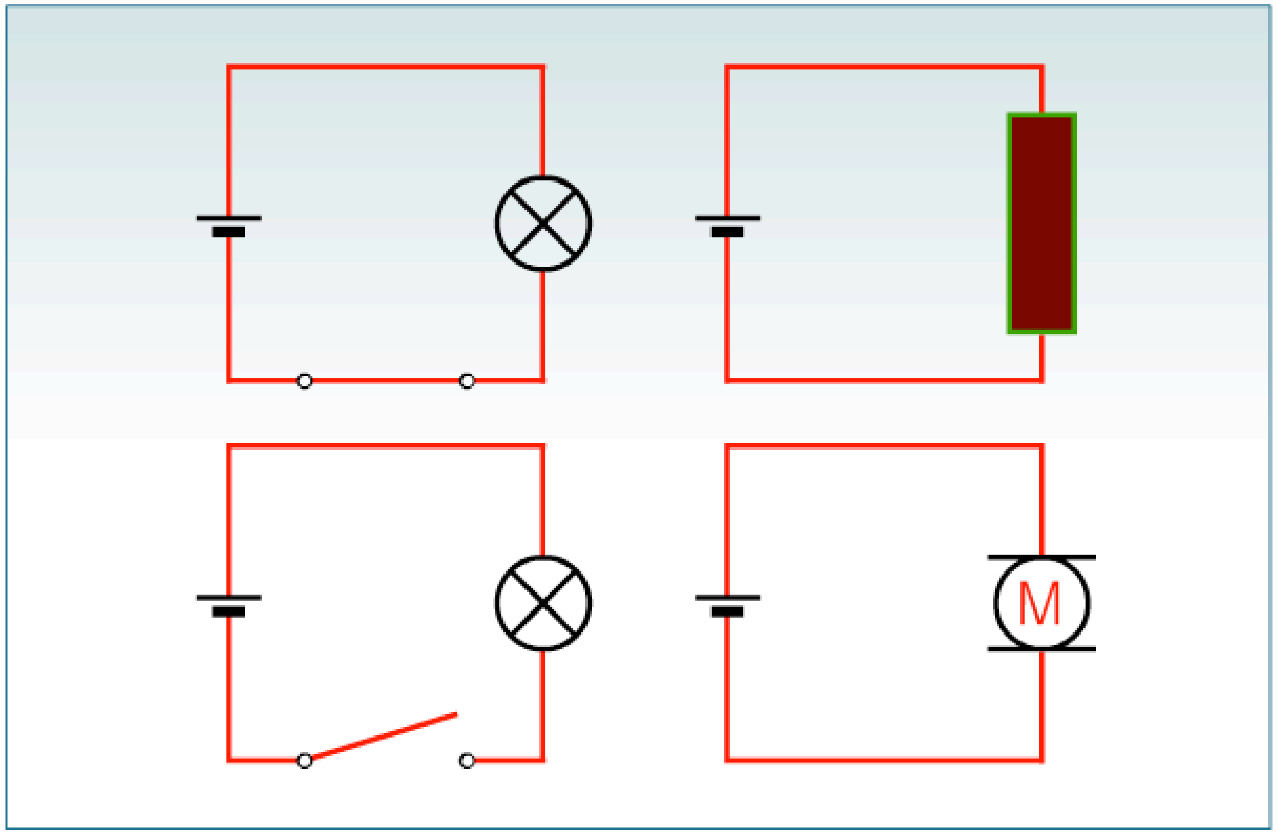
Some more specific suggestions

Set up these four simple circuits on the right and get the pupils to describe the energy transfers using the pop-up labels provided on the interactive diagram.

For the same circuits, add different labels for charge flow.

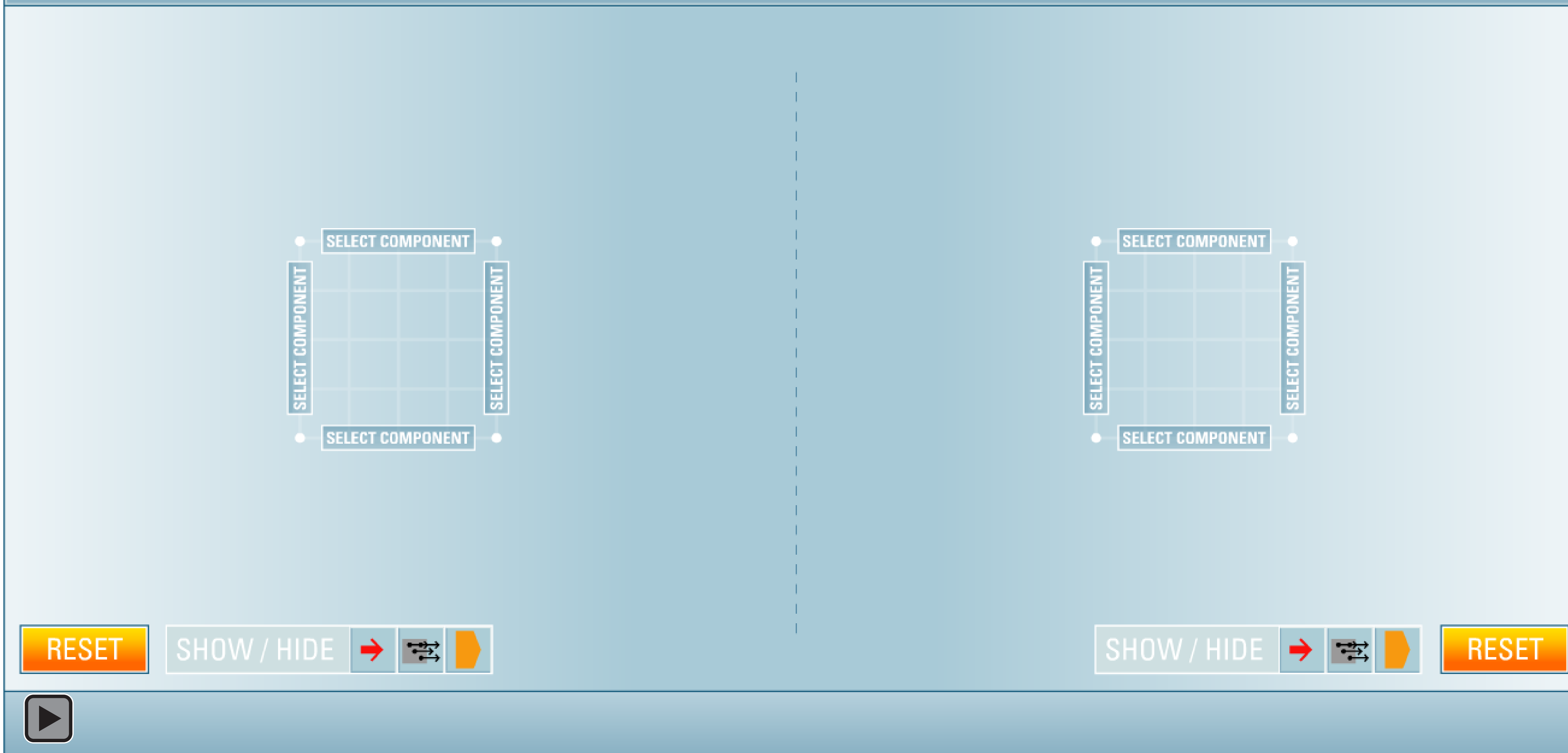
Again for these circuits use a mixture of current and charge flow labels to set challenges. First increase the current and then get the pupils to alter the charge flow labels to match, or change the flow labels and get the pupils to match the currents.

This activity may be best for review using whole class discussion, or small group activities.



Building and describing circuits

Making circuits



Check questions

What the activity is for

The diagnostic questions can be used to check the pupils' understanding of key ideas introduced in this episode.

What to prepare:

- paper copies of these three questions

What happens during this activity:

The questions might be used for homework or as the basis for discussion in class.

Electric current

This question probes the pupils' ideas about what is actually happening (unseen) inside the wires of the circuit. The best description of the electric current in the circuit is there is an electric current through one wire to the bulb; it passes through the bulb and back to the battery; the current in the other wire is the same size.

Electric charge

This question probes whether pupils think of charges as flowing out of the battery into an empty wire, or picture (correctly) the wire already full of charges that the battery sets in motion.

Incorrect
Correct
Incorrect
Incorrect
Correct
Correct

Charge and energy

This question probes the pupils' understanding of the difference between charge and energy. The question also serves to emphasise the importance of accurate use of the scientific terms involved.

Incorrect
Correct
Incorrect
Incorrect