epiSTEMe Technician Notes

Electricity: electrical circuits

Introduction

The epiSTEMe Electricity: Electrical Circuits Module is designed to be taught over about nine lessons (including pre-test, post-test and student questionnaire). The lessons are broken down in 2, 3 or 4 parts, allowing teachers some flexibility over how quickly they progress through the material with different classes. Resources are therefore listed by lesson part, as in some cases, the teacher may not teach all the parts of the 'same' lesson in the same session.

Practical work

Many of the lessons include practical work done in groups, and it is often suggested in our teaching notes that this is reinforced by teacher demonstrations with a demonstration circuit and/or simulation software. It is assumed that in all student practical work the cells and lamps used in circuits will have the same ratings. This is important, as (a) students will draw inferences about how current and p.d. are behaving in some circuits by comparing the brightness of different lamps; (b) at this level most students will be confused by more complex phenomena such as the uneven dividing of potential across dissimilar lamps in a circuit branch. Due to the conceptual difficulty of the topic, it is important that students obtain and see clear outcomes that can be explained in terms of straightforward rules about current and p.d. in simple circuits, that can prepare them for more advanced work later in the school. For example, in upper secondary level students are often expected to calculate values of p.d., I. R etc in circuits, but research shows that students are only able to meaningfully relate such calculations to what is going on in circuits if such quantitative work builds on well established qualitative thinking about the physics.

It is important then that all the apparatus is tested by the school science technicians before lessons. So, for example, where one cell is used to power two lamps in series, the lamps should be chosen so that they clearly glow. If necessary instructions and diagrams may need to be customised to ensure practical work is effective if changes to apparatus are required.

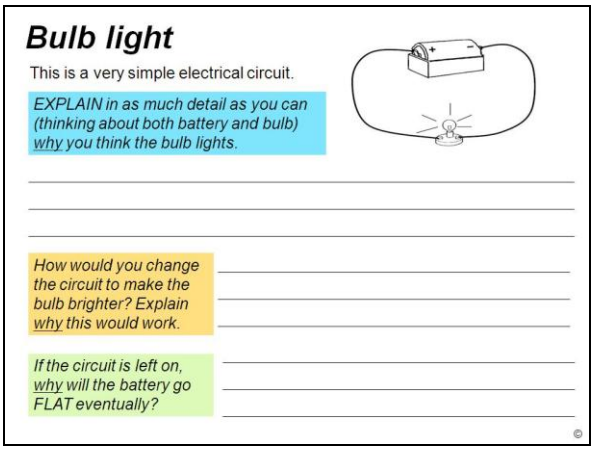
Teachers are recommended to use demonstration circuits and/or simulation software (which presents ideal circuit outcomes) to reinforce student practical work and ensure the correct outcomes are observed. Demonstration circuits may simply be identical to the circuit built by students, but arranged so the whole class can see. However, where possible it may be sensible to provide the teacher with alternative kit that is easier to demonstrate to a full class, e.g. the large demonstration meters rather than the standard meters used by students, perhaps 12V lamps with a suitable supply etc.

LESSON 1

Lesson 1, Part 2: WHAT IS GOING ON IN THE CIRCUIT?

Teaching this lesson part will require:

- Demonstration circuit as shown in slide 2



Slide 2

Lesson 1, Part 3: THE 'BIG CURCUIT'

Teaching this lesson part will require:

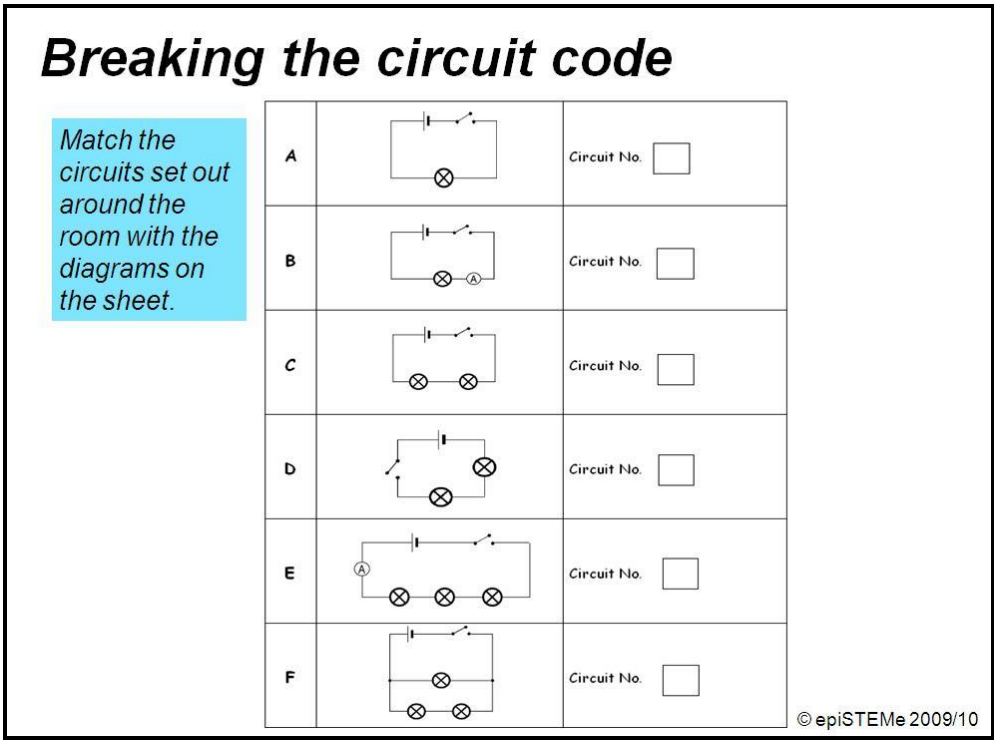
- The BIG CIRCUIT demonstration: the demonstration will require setting up a circuit that will run around the entire room. The lamp must light instantly. Of course lamps take a finite time to warm up enough to glow: so it is important that the set up uses a lamp/supply combination that appears to give a glow from the lamp *as soon as* the switch is closed.
- From the National Strategies document: 'Explaining how electric circuits work' (2008), pp.10-11. "The BIG circuit consists of a 12-volt power supply and a large bulb (12 volt/24watt) set up with insulated connecting wire running round the perimeter of the room. It is a good idea to tape the wire to the walls of the room and to mark it with 'BIG CIRCUIT' labels all the way around."

LESSON 2

Lesson 2, Part 3: BREAKING THE CIRCUIT CODE

Teaching this lesson part will require:

- Six demonstration circuits that match those shown on the 'Breaking the circuit code' side (slide 20). The small-group activity will require setting up 6 circuits in the classroom *before* the groups start working.



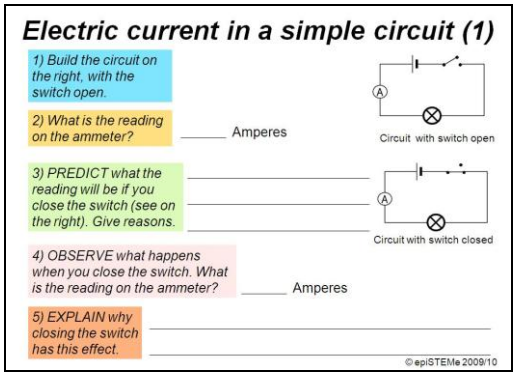
Slide 20

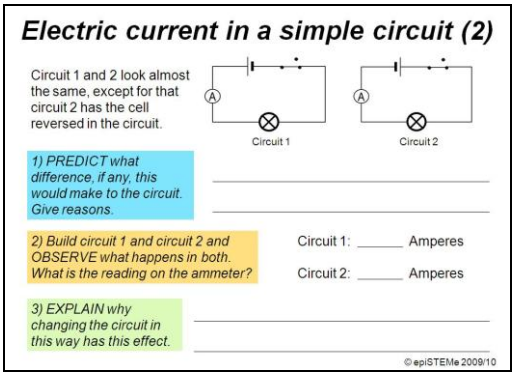
LESSON 3

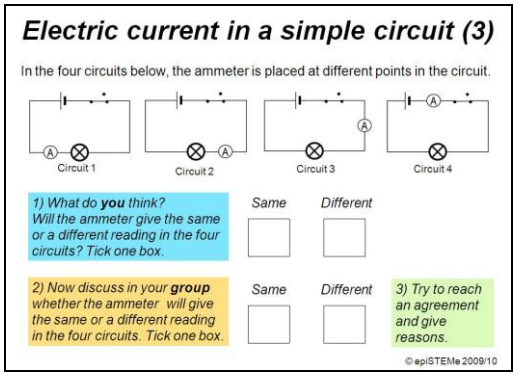
Lesson 3, Part 1: BUILDING A SIMPLE SERIES CIRCUIT AND MEASURING CURRENT

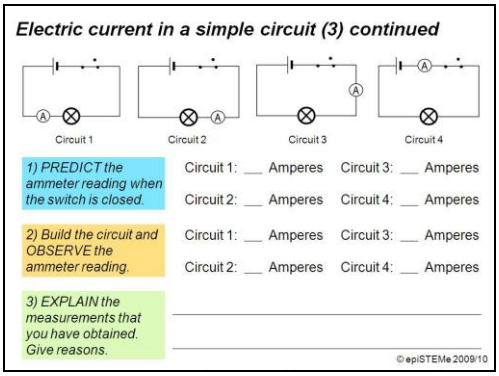
Teaching this lesson part will require:

- Sufficient electrical kit for each student group to build the circuits (each group will need lamp, switch ammeter, cell and connecting leads) – see slides 23-26.
- Teacher demonstration circuit (e.g. using large demonstration meter if available) or suitable simulation software (see appendix)







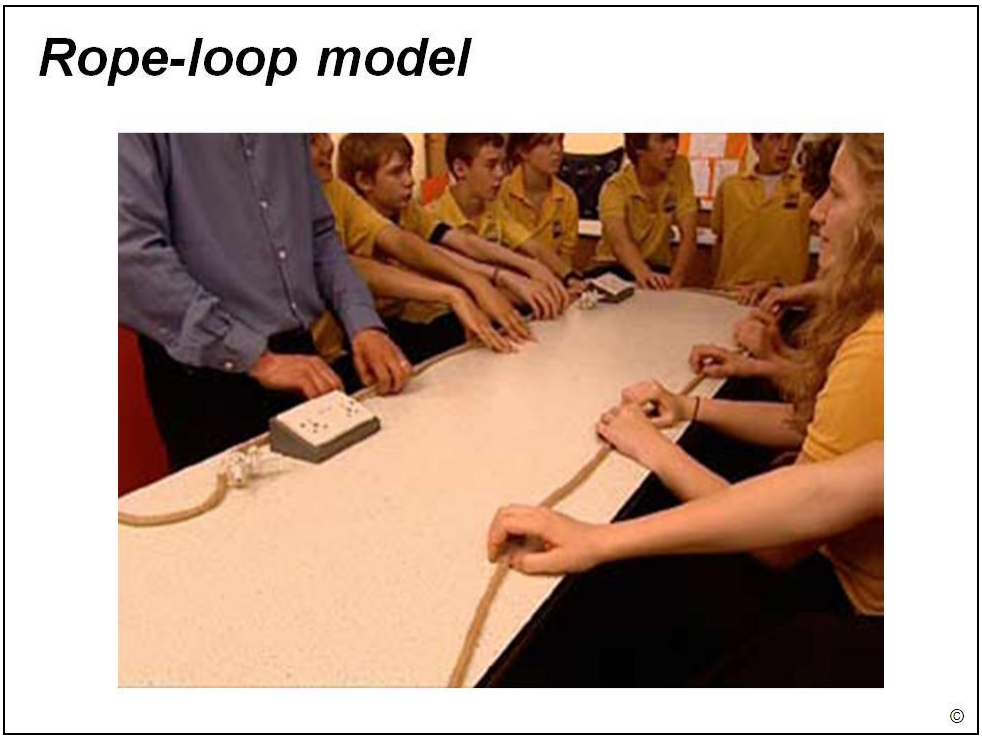


Slides 23-26

Lesson 3, Part 2: MAKING SENSE OF CURRENT

Teaching this lesson part will require:

- Rope for rope loop model. "A long length of rope is needed, which can be passed in a BIG loop (prompting links to the BIG circuit) around all of the members of the class. Lightweight (4–6 mm diameter) rope used by climbers is ideal. If the rope is too heavy the frictional forces are too big and it is very difficult to get the rope moving across thirty pairs of fingers." National Strategy: *Explaining how electric circuits work*, p.13.
- For more information on the rope-loop model, see National Strategy: *Explaining how electric circuits work,* p 12 and the video at http://www.teachers.tv/video/18955).



Slide 29

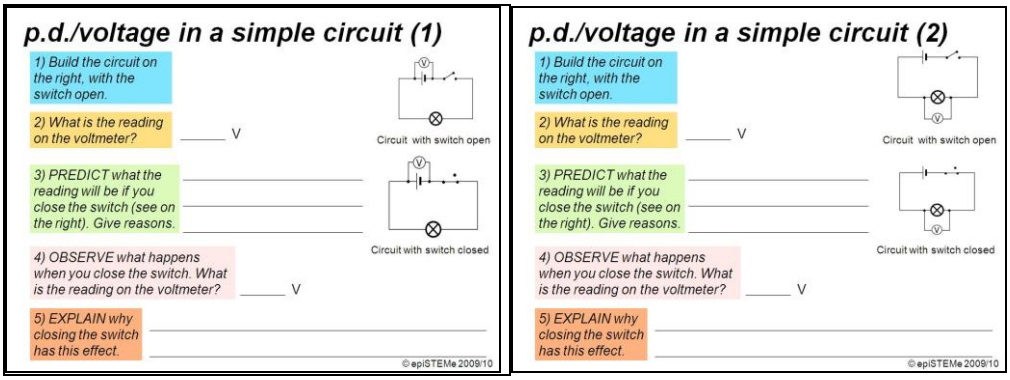
- Marbles for role-play activity. Sufficient marbles for the students to use them as quanta of energy to be moved round the room when simulating a circuit. (If marbles are not available, they can be substituted by a suitable alternative energy proxy – tokens that can be readily and visibly moved around the room to represent energy being transferred).

LESSON 4

Lesson 4, Part 1: BUILDING A SIMPLE SERIES CIRCUIT AND MEASURING P.D.

Teaching this lesson part will require:

- Sufficient circuit kit for each group of students to build circuits for 'p.d./voltage in a simple circuit' (each group will need cell, lamp, switch, voltmeter as well as connective leads) – see slides 33-34.
- Teacher demonstration circuit (e.g. using large demonstration voltmeter if available) or suitable simulation software.

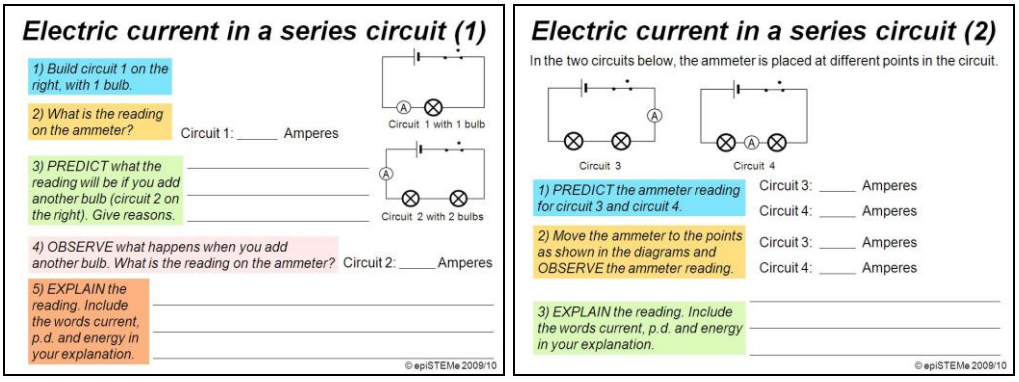


Slides 33-34

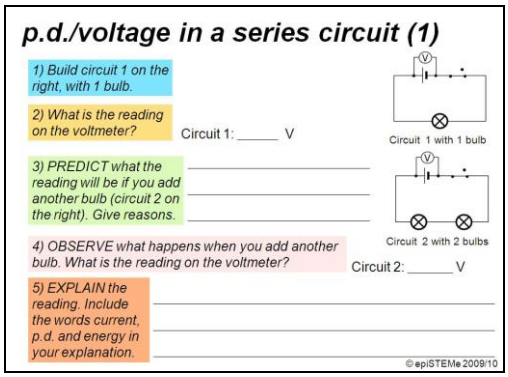
Lesson 4, Part 2: BUILDING SERIES CIRCUITS WITH DIFFERENT NUMBERS OF LAMPS

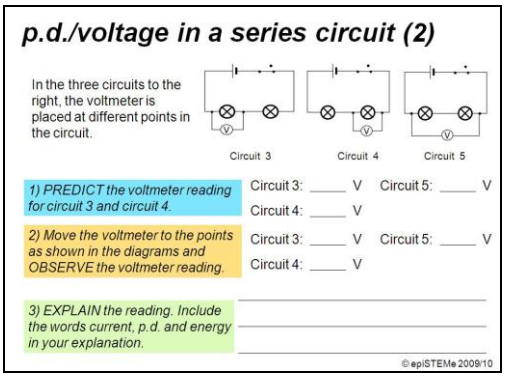
Teaching this lesson part will require:

- Sufficient circuit kit for each group of students to build circuits for 'p.d./voltage in a simple circuit' (each group will need cell, 2 lamps, switch, ammeter, voltmeter as well as connective leads) – see slides 36-39.
- If the teacher decides to set the examples with three lamps in series as group work, then each student group will require 3 lamps (see slides 40-41).
- Teacher demonstration circuit (e.g. using large demonstration meters if available) or suitable simulation software.

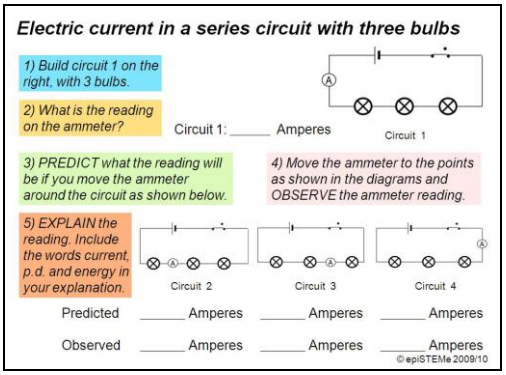


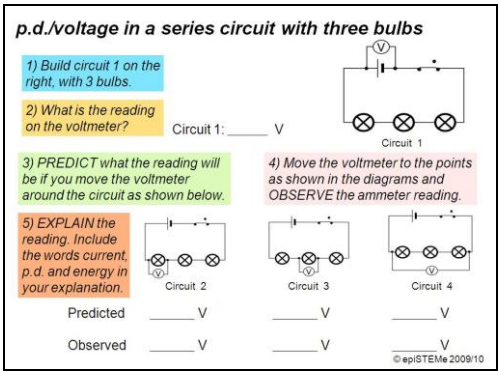
Slides 36-37





Slides 38-39





Slides 40-41

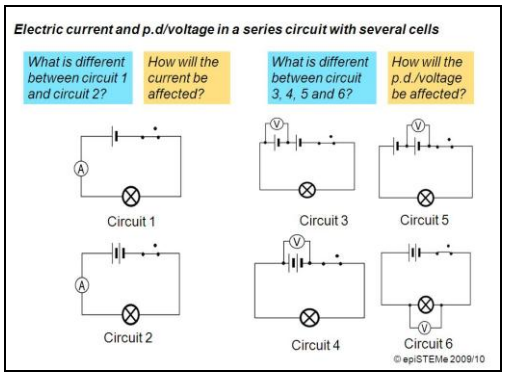
LESSON 5

Lesson 5, Part 1: CIRCUITS WITH DIFFERENT NUMBERS OF CELLS

Resources

Teaching this lesson part will require:

- Demonstration kit for building circuits (2 cells, lamp, display meters, switch, connecting leads); optional use of simulation software – see slide 42.
- If using group practical work, enough electrical kit for each group to build circuits (each group needs 2 cells, lamp, ammeters, voltmeter, switch, connecting leads) – see slide 42.



Slide 42

Lesson 5, Part 2: MODELLING SERIES CIRCUITS

Resources

- No practical apparatus is required for this lesson part, but the teacher *may* wish to demonstrate circuits or use simulation software to review previous practical work.

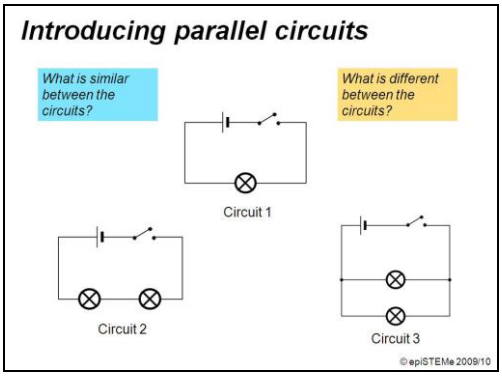
LESSON 6

Lesson 6, Part 1: INTRODUCING PARALLEL CIRCUITS

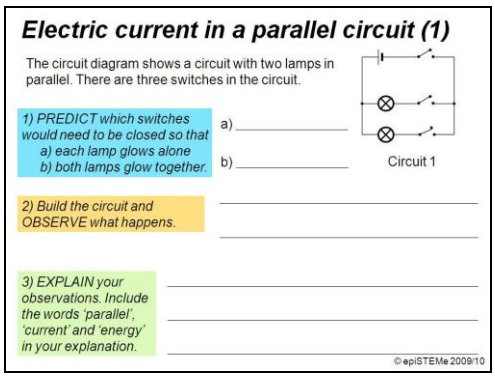
Resources

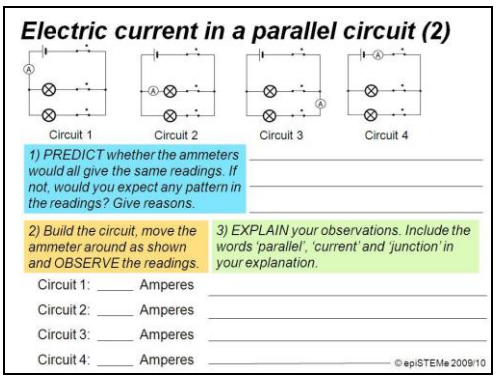
Teaching this lesson part will require:

- Three demonstration circuits, with a single lamp, two lamps in series, two lamps in parallel should be set up (with switches open) for the start of the class – see slide 54
- Preferably use 12V lamps and suitable supply, so that the effects are clear
- Sufficient Three demonstration circuits, with a single lamp, two lamps in series, two lamps in electrical kit for each group of students to construct circuits (each group needs cell, 2 lamps, 3 switches, ammeter and connecting leads) – see slides 54, 55
- Optional: simulation software



Slide 54





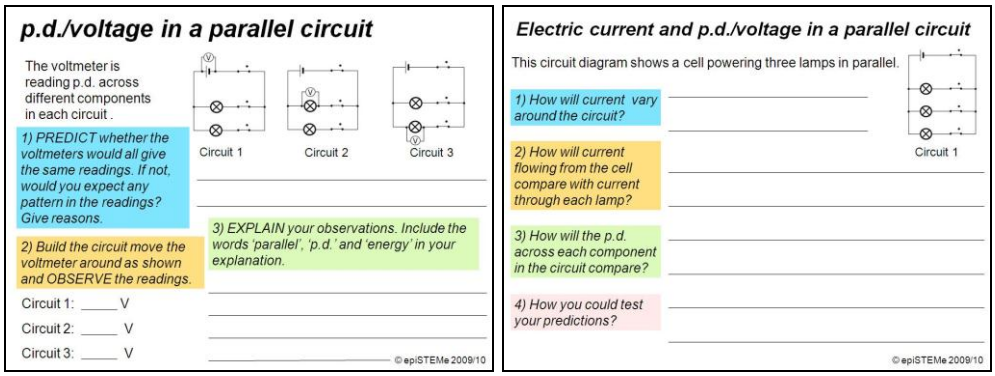
Slides 55-56

Lesson 6, Part 2: POTENTIAL DIFFERENCE AND PARALLEL CIRCUITS

Resources

Teaching this lesson part will require:

- Sufficient electrical kit for each student group to build circuits (each student group needs cell, 2 lamps, 3 switches, voltmeter, ammeter and connecting leads; each student group undertaking the extension activity with need an additional lamp and switch) – see slides 59-60
- Optional demonstration circuit and/or simulation software



Slides 59-60

LESSON 7

Lesson 7, Part 1: MODELLING PARALLEL CIRCUITS

Resources

Teaching this lesson part will require:

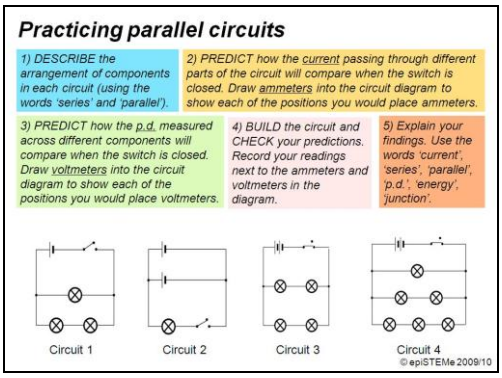
- rope for rope loop model of circuits (see note above, lesson 3, part 2)
- marbles (or other tokens) for role play (see note above, lesson 3, part 2)
- optional: the teacher may wish to use a demonstration circuit or simulation software to reiterate points for earlier lessons

Lesson 7, Part 2: CHALLENGING CIRCUITS [EXTENSION]

Resources

If this lesson part is to be taught, it will require:

- Sufficient electrical kit for each student group to build circuits (each group will need 2 cells, switch, 6 lamps and sufficient connecting leads) – see slide 72
- Optional use of a demonstration circuit (as per student circuit) or simulation software



Slide 72

LESSON 8

Lesson 8, Part 1: EVALUATING MODELS OF CIRCUITS

Resources

This lesson part does not require any equipment, unless the teacher wishes to reinforce earlier work (with demonstration circuits/simulation software, the rope loop and/or marbles for role play).

Lesson 8, Part 2: COMPARING CIRCUITS

Resources

This lesson part does not require any equipment.

LESSON 9

Lesson 9, Part 1: CIRCUIT DOMINOES

Resources

Teaching this lesson part will require:

- Sets of dominos copied from provided master sheets

There are three versions of the domino task (to allow differentiation between classes, or between groups within mixed ability classes):

1) only closed circuits, and no measuring instruments (simplest *****);
2) open and closed circuits mixed, but no measuring instruments (more difficult ******);
3) only closed circuits, but with or without meters (most difficult *******).

The class teacher will decide which version(s) to use for a particular class.