

## TAP 121-2: Internal resistance of a source of emf

Some of the energy given to charges by a cell (or other source of emf) is dissipated inside the cell itself, as the charges move through the cell (or other source of emf). What is left is available as a potential difference (energy per unit charge) across a circuit connected to the cell. If the emf of the source is  $E$ , and its internal resistance is  $r$ , then when a current  $I$  flows the potential difference  $V$  is  $V = E - I r$ .

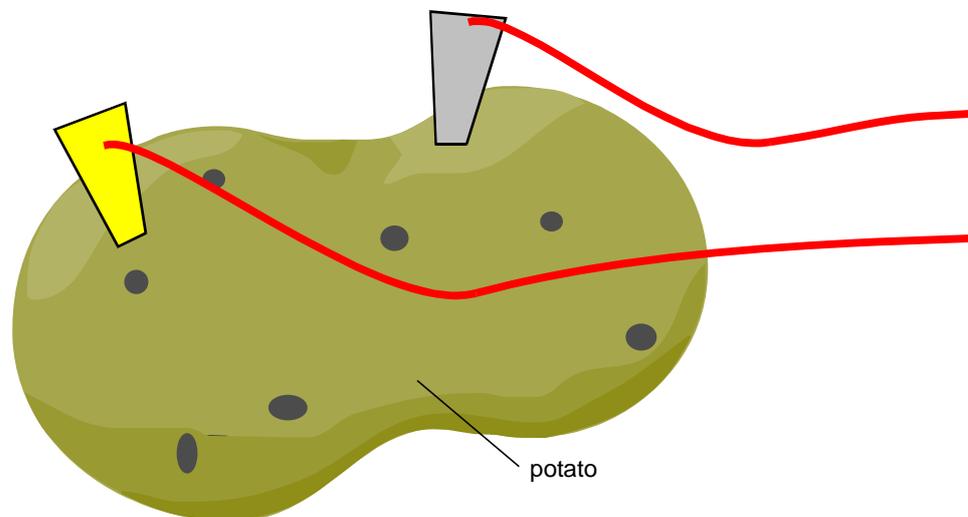
Collect this apparatus

- ✓ 2 digital multimeters
- ✓ potato
- ✓ 0.5 cm × 2 cm copper sheet, 0.5 cm × 2 cm zinc sheet
- ✓ 2 pairs of crocodile clips
- ✓ resistance substitution box
- ✓ 5 × 4 mm leads

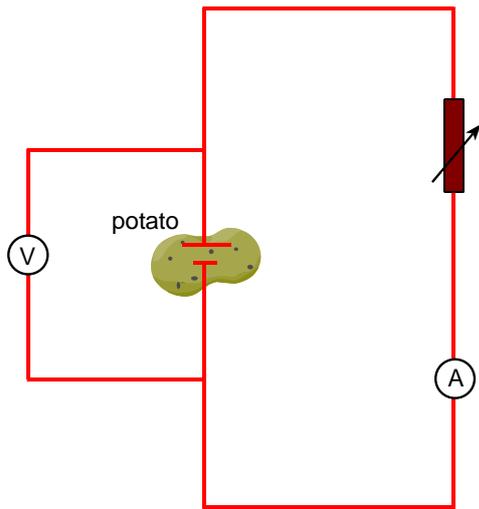
### Getting, and making sense of, the data

First take a quick look. Then collect some detailed data that you can use to model the behaviour of the cell.

1. Assemble your cell. Use the copper and zinc sheets as electrodes, inserting one in each end of the potato. Use crocodile clips to make connections to the circuit.



2. Set up a circuit to measure the pd across the cell and the current drawn from the cell, initially with 4.7 kΩ as a load for the cell.



3. Alter the load resistance. Notice the changes to the current drawn and the pd supplied. Sketch a graph of pd / current to indicate the general trend.
4. Look back to the introduction above. Does your pattern seem likely to fit this description?
5. Now draw up a table of current and pd for a range of load resistances. You will need to be careful in selecting the values to use at both ends of the scale so that your measuring instruments can cope.
6. Plot a graph of  $V / I$ . Does it fit the pattern above?

#### Outcomes

1. You will recognise the drop of pd as a source supplies an increasing current.
2. You will be able to match this pattern to the description above.

### **Practical Advice**

This is designed as a simple introduction to the phenomenon, followed by a more detailed look.

The advantage of using a potato is the path the current might take between the electrodes is transparent. The idea of resistance internal to the cell and energy dissipated there is easier to appreciate if the cell is visible.

### **Alternative Approaches**

You could make 'cells' with artificially high internal resistance by soldering a resistor in series with a standard dry cell.

Solar cells, cheaply available from surplus suppliers, make good sources with appreciable internal resistance. The internal resistance alters with incident illumination and thus some experimentation is needed, with a 48 W lamp, to get optimum conditions. Then you can use 50 mA fsd and 20 V fsd meters to get a good plot. A 16 W rheostat functions as a variable load. You are warned that solar cells are not uniform in performance and some fine-tuning may be necessary.

Solar cells can be purchased cheaply from recycling mail order suppliers and then mounted on plastic electrical ducting.

### **Social and Human Context**

The dip in the brightness of car headlamps when the starter motor is used appears to be the most common experience to draw on.

### **External References**

This activity is taken from Advancing Physics Chapter 2, 240E