Electricity and Magnetism: Teaching Approaches 04

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.

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Introducing voltage

Voltage	teacher demostration	• to introduce and discuss what is meant by voltage measurement in relation to both batteries and bulbs • to demonstrate how to use a voltmeter to measure voltages in different parts of a circuit
Predicting and measuring voltages	class practical activity	• to encourage pupils to talk and think about the meaning of voltage in relation to specific circuits • to enable pupils to measure voltages with a voltmeter • to emphasise the point that there is an energy balance in any electric circuit; battery voltage equals sum of voltages across circuit components
Checking an initial understanding	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

Voltage

Part 1: Introducing the idea of voltage

What the activity is for

First of all, attention is focused on introducing what is meant by voltage. It is important that pupils have an understanding of what it is that they are measuring when they measure voltages in different parts of a circuit.

What to prepare:

- a 12 volt direct current power supply
- a 12 volt/24 watt bulb in holder
- connecting leads

What happens during this activity

It is a good idea to start with a demonstration of what happens in a simple circuit when the voltage of the supply is changed. You might start with the output of the power supply at about 6 volt and then switch it up to about 12 volt. You might also make links here to the practical work carried out by the pupils earlier in which they changed the number of batteries in a circuit.

Teacher: OK, so we start with the power supply set down here at around 6 volt. What do you notice about the brightness of the bulb?
Pupil: It's dim.
Teacher: Yes, that's right. Now supposing I turn up the power supply here, increase the voltage on this scale. What do you think will happen? Predictions?
Pupil: It'll get brighter.
Teacher: Well, let's give it a go (teacher turns up voltage). Brighter yes. Where have you seen this kind of thing before?
Pupil: If you add batteries it makes the bulb brighter.
Teacher: That's right! So if I add batteries or turn up the voltage, what happens with the bulb?
Pupil: You get more energy from the bulb.
Teacher: Excellent! In fact the voltage is a measure of how much energy is shifted by the battery as each charge passes. If I increase the battery voltage more energy is shifted by the bulb. The bulb gets brighter.

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Voltage

Part 2: Using a voltmeter

What the activity is for

The purpose of this activity is to introduce the voltmeter as an instrument that is used to measure voltages, and to develop further what those measurements actually mean.

What to prepare:

- a 12 volt direct current power supply
- a 12 volt/24 watt bulb in holder
- demonstration voltmeter
- connecting leads

What happens during this activity

Following on from the previous demonstration and discussion, introduce the voltmeter as the instrument to be used in making measurements of the energy shifted, whether by the battery, or by the bulb.

Demonstrate how to connect the voltmeter by talking through the following kind of sequence with the pupils:

Step 1: Make the complete circuit to light the bulb.

Step 2: Connect the voltmeter, the right way around, across the power supply and take the reading.

First of all let's make a measurement of the energy shifted by the power supply. To do this we must connect the meter across the supply and we need to connect it the right way around, with the positive terminal of the voltmeter to the positive side of the supply.

Step 3: Connect the voltmeter, the right way around, across the bulb and take the reading.

When connecting the voltmeter to the circuit emphasise the differences between using an ammeter to measure electric currents and using a voltmeter to measure voltages. The key point is that whereas the circuit must be broken to insert an ammeter, the voltmeter is connected across the relevant component in the complete circuit. The ammeter is connected in series; the voltmeter is connected in parallel.

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Voltage

The voltmeter reading across the power supply and the reading across the bulb will be the same. This is a fundamental point which needs to be talked through with the class:

Teacher: So the reading across the battery is 10.5 volt. The voltage value, 10.5 volt, is a measure of how much energy is provided by the battery per coulomb of charge. A bigger voltage means more energy per coulomb of charge. What was the reading across the bulb?
Pupil: Same
Teacher: That's right, 10.5 volt. Why must it be the same?
Pupil: Is it because the energy given by the battery equals the energy given out in the bulb?
Teacher: Exactly right! Excellent answer!

From here the ideas might be taken further:

When we say that the voltage across the battery is 10.5 volt, this actually means that the battery provides 10.5 joule of energy per coulomb of charge. The voltage is a measure of the number of joule of energy per coulomb of charge.

With the bulb, the voltmeter reading is also 10.5 volt. This means that 10.5 joule of energy are shifted by each coulomb of charge as it passes through the bulb.

An energy hill diagram for the circuit might also be introduced as a focal point for further discussion and to support pupil understanding.

240 volt and a pair of scissors

You might use a variation on this story:

My next door neighbour is a man called Don. Don can get a bit impatient with things at times. A couple of weeks ago he was vacuum cleaning the carpet in the front room. He switched on the vacuum cleaner and it worked OK for a minute or so but then stopped. Don bent down to see what was the matter and the vacuum cleaner just started up again.

Don resumed with his job, but just as quickly the vacuum cleaner stopped again. After this had happened no fewer than four times, stopping and starting, the cleaner seemed to die altogether. Don was getting mightily irritated by all of this and decided that there must be a bad connection in the plug. He spotted a pair of scissors lying on the chair, picked them up and cut off the plug. Unfortunately for Don, this was at the very moment when the vacuum cleaner started up again. There was a huge BANG and a FLASH.

Now Don isn't small by any means. He probably weighs over 15 stone. Even so he was lifted off his feet as the scissors cut through the live cable. He was lucky to be thrown free because he showed me the blades of the scissors afterwards and they were melted into a crazy shape.

The mains supply provides 240 volt, or 240 joule of energy per coulomb of charge. If you have lots of coulombs of charge arriving in a big current with this amount of energy, the effect can be exceptionally dangerous. Just ask Don!

Predicting and measuring voltages

What the activity is for

Having demonstrated what is involved in measuring voltages, the pupils are now given the opportunity to make some measurements for themselves. The approach taken is to encourage the pupils to think about and talk through the voltage ideas first, before making the actual voltage measurements. To this end, the pupils are asked to make predictions of voltage values before they make each measurement.

What to prepare:

- batteries, bulbs, voltmeters, connecting leads
- support sheet: Predicting and measuring voltages

What happens during this activity

You might introduce this activity in the following kind of way.

OK, we have the idea that the voltmeter measures how much energy is shifted by the charges as they move around the circuit. So, in this first circuit you measure the battery voltage and this gives the number of joules of energy shiftted by each coulomb of charge. If you then measure the voltage across the bulb what would you expect to get?

Predicting and measuring voltages

First of all talk it through with your partner. Think about what we've been saying about energy and voltage.

…OK, people are suggesting that the voltage should be the same in both places. As Anita says the energy put in at the battery comes out at the bulb.

Well, collect the equipment and use a voltmeter to measure the voltage values for yourselves. There are 3 circuits to investigate. Go to it!

For this activity, the pupils should ideally work in pairs. Each pair should have one voltmeter, which is placed in the different positions in the circuits as shown on the support sheet.

As the pairs of pupils complete their measurements, it is a good idea to collect the voltage values on the board or on a large sheet of poster paper, so that the pattern of findings becomes apparent to all.

Be sure to give the pupils an opportunity to talk through these new ideas during the lesson as they review the voltage values for the whole class.

Checking an initial understanding

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:

- three questions sheets

What happens during this activity

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

Four batteries

This question is designed to probe pupils' understanding of battery voltage.

(a) Battery d

(b) It has the largest voltage, so it pushes the biggest current round.

Battery voltage

This question probes understanding of the relationship between the battery voltage and the voltage across the external circuit.

(a) $V_1 = 3$ volt

(b) This must be the reading on the voltmeter because the voltage across the battery equals the voltage across the single resistor. The energy per coulomb supplied to the circuit at the battery equals the energy per coulomb transferred to the surroundings at the resistor.

Batteries

This question probes pupils' understanding of current and voltage.

(a) You cannot buy a 1.5 ampere battery because batteries are specified in terms of voltage. The current in a circuit depends on both the battery voltage and the circuit resistance. It does not make sense to talk of a 1.5 ampere battery. The battery can supply a full range of currents.

Voltage in series circuits

Predicting and measuring voltages in a series circuit	class practical activity	• for pupils to think about and talk through the voltage ideas relating to series circuits • for pupils to predict and measure voltage values for some simple series circuits
Bulb and buzzer in series	class practical activity	• for pupils to think about and talk through a circuit in which there are two components of unequal resistance • for pupils to connect the components in series, measure the voltage drop across each, and explain their findings
Testing pupils on series circuits	four 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

Predicting and measuring voltages in a series circuit

What the activity is for

Pupils should be given the opportunity to make some measurements for themselves.

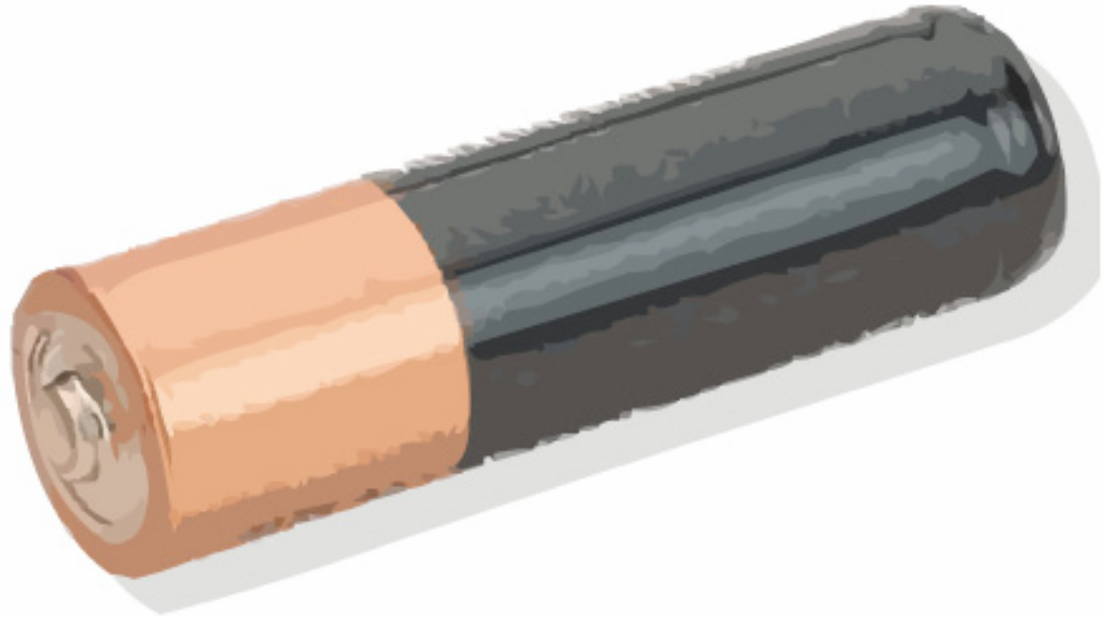
The approach taken is to encourage the pupils to think about and talk through the voltage ideas first, before making the actual voltage measurements. To this end the pupils are asked to make predictions of voltage values before they make each measurement.

What to prepare:

- batteries, bulbs, voltmeters, connecting leads
- support sheet: Predicting and Measuring Voltages

What happens during this activity

You might introduce this activity in the same way as before, but emphasising careful placement of the leads so as to measure the voltage across the correct circuit element.



Bulb and buzzer in series

What the activity is for

This activity provides the opportunity for pupils to talk and think about a circuit in which there are two components (bulb and buzzer, for example) of unequal resistance. The pupils are directed to set up the series circuit and to measure the voltage drop across each component. They must then come up with an explanation for their findings.

What to prepare:

- batteries, bulbs, buzzers, voltmeters, connecting leads
- support sheet: Bulb and buzzer

What happens during this activity

You might introduce this activity in the following kind of way:

OK, so what happened with the circuit with the two bulbs in series. What were the voltage readings?

The voltage drop across the bulbs was the same.

Good! Now in this circuit we have two components in series again, but this time it's a bulb and a buzzer. The plan is for you to set up the circuit, measure the voltage across the different parts and then figure out what's going on.

Testing pupils on series circuits

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:

- copies of these diagnostic questions

What happens during this activity

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

Resistors in series

This question is designed to probe pupils' understanding of how voltage is shared between two identical resistors in series.

(a) V_1 reads 3 volt
(b) The battery voltage is shared, half across each resistor.

Different batteries

This question probes pupils' understanding of the relationship between the battery voltage and the total voltage across external resistors.

(a) V_1 = 6 volt; V_2 = 3 volt;

Different resistors

This question probes pupils' understanding of how voltage is shared between unequal resistors.

(a) V_1 = 4 volt; V_2 = 5 volt; V_3 = 4 volt

Bigger resistance

This question probes pupils' understanding of how voltage is shared between unequal resistors.

(a) V_1 reads between 6 volt and 3 volt
(b) The battery voltage is shared, with the larger share across the larger resistor.

Voltage in parallel circuits

Predicting and measuring voltages in a parallel circuit	class practical activity	• for pupils to think about and talk through the voltage ideas relating to parallel circuits • for pupils to predict and measure voltage values for some simple parallel circuits • for pupils to think about, and talk through, a circuit in which there are two components of unequal resistance
Bulb and buzzer in parallel	class practical activity	• for pupils to measure the voltage drop across each, and explain their findings
Testing pupils on parallel circuits	four 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

Predicting and measuring voltages in a parallel circuit

What the activity is for

The approach taken is to encourage the pupils to make predictions of voltage values before they make each measurement.

What to prepare:

- batteries, bulbs, voltmeters, connecting leads
- support sheet: Predicting and measuring voltages in a parallel circuit

What happens during this activity

For this activity, the pupils should ideally work in pairs and each pair should have one voltmeter that is placed in the different positions in the circuits as shown on the worksheet.

As the pairs of pupils complete their measurements, it is a good idea to collect the voltage values on the board or on a large sheet of poster paper, so that the pattern of findings becomes apparent to all.

Give the pupils a chance to talk through these new ideas, as they review the voltage values for the whole class.

Bulb and buzzer in parallel

What the activity is for

This activity provides the opportunity for pupils to talk and think about a circuit in which there are two components (bulb and buzzer) of unequal resistance. The pupils are directed to set up the parallel circuit and to measure the voltage drop across each component. They must then come up with an explanation for their findings.

What to prepare:

- batteries, bulbs, buzzers, voltmeters, connecting leads
- support sheet: Bulb and buzzer

What happens during this activity

This activity follows on from bulbs and buzzers in series. You might introduce this activity in the following kind of way:

OK, so what happened with the circuit with the two bulbs in parallel. What were the voltage readings?

The voltage drop across both bulbs was the same as the battery voltage.

Good! Now in this circuit we have two components in parallel again, but this time it's a bulb and a buzzer. The plan is for you to set up the circuit, measure the voltage across the different parts and then figure out what's going on.

Testing pupils on parallel circuits

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:

- copies of the diagnostic questions

What happens during this activity

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

Identical resistors

This question is designed to probe pupils' understanding of how voltage is dropped across identical resistors in a simple parallel circuit.

(a) V_1 = 8 volt

(b) V_2 = 8 volt

Power supply

This question is designed to probe pupils' understanding of how voltage is dropped across identical resistors in a simple parallel circuit.

(a) Voltage across bulb B_1 = 4 volt

(b) Voltage across bulb B_1 = 4 volt; B_2 = 4 volt