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A LEVEL
Transition Guide

PHYSICS A

H556
For first teaching in 2015

KS4–KS5 Focus Resistance Electrical Circuits

Version 2

www.ocr.org.uk/physics

A LEVEL *PHYSICS A*

Key Stage 4 to 5 Transition guides focus on how a particular topic is covered at the different key stages and provide information on:

- Differences in the demand and approach at the different levels;
- Useful ways to think about the content at Key Stage 4 which will help prepare students for progression to Key Stage 5;
- Common student misconceptions in this topic.

Transition guides also contain links to a range of teaching activities that can be used to deliver the content at Key Stage 4 and 5 and are designed to be of use to teachers of both key stages. Central to the transition guide is a Checkpoint task which is specifically designed to help teachers determine whether students have developed deep conceptual understanding of the topic at Key Stage 4 and assess their 'readiness for progression' to Key Stage 5 content on this topic. This checkpoint task can be used as a summative assessment at the end of Key Stage 4 teaching of the topic or by Key Stage 5 teachers to establish their students' conceptual starting point.

Key Stage 4 to 5 Transition Guides are written by experts with experience of teaching at both key stages.

Key Stage 4 GCSE Content

Criteria taken from Gateway B, but also covered in 21st Century Physics A

Recall

- that the larger the voltage of the battery in a given circuit, the bigger the current
- that components resist the flow of charge through them
- that the larger the resistance in a given circuit, the smaller the current will be

Understand that two (or more) resistors in series have more resistance than either one on its own, because the battery has to move charges through both of them

Use the equation for Ohms Law

Key Stage 5 A Level Content

A Level Subject Criteria Content

Candidates need to demonstrate knowledge, understanding and application of:

a. potential difference (p.d.); the unit volt

b. electromotive force (e.m.f.) of a source such as a cell or a power supply

c. distinction between e.m.f. and p.d. in terms of energy transfer

Candidates need to demonstrate knowledge, understanding and application of:

a. resistance; R=V/I; the unit ohm

b. Ohm's law

c. I–V characteristics of resistor, filament lamp, thermistor, diode and light-emitting diode (LED)

d. light-dependent resistor (LDR); variation of resistance with light intensity

Candidates need to demonstrate knowledge, understanding and application of:

a. resistivity of a material; the equation R=ρL/A

b. the variation of resistivity of metals and semiconductors with temperature

c. negative temperature coefficient (NTC) thermistor; variation of resistance with temperature

Comment

Students often have a misconception about the way in which electricity from a cell is converted into energy and it is often wrongly described as the 'flow of charge' in a circuit. The idea that the charge is given by the cell and moves around the circuit at high speed is usually a misconception because of the models used at GCSE and the lack of development in students to 'visualize' the process. The disposal of a cell when it fails to function successfully in some electrical devices and simple testing processes display the poor understanding of potential difference and electro-motive force. Students will simply test a cell using a meter, which reads close to 1.5V and the value under load is insufficient to drive some devices. Also, they do not recognise that some cells can be placed in other devices with different resistance and thus changes the voltage supplied, as the effective potential divider within the cell has changed.

The use of a potential divider as a control sub-system to a number of components or devices is not investigated at GCSE. Some students at GCSE level can understand that voltage is divided between the resistors and calculate the sum of the resistors but do not recognise the effect of the resistance when linked to other devices. A level students need to show an understanding of the strengths and weaknesses of a potential divider while in use. Often, students have not taken apart electrical devices and thus haven't seen the number of potential dividers in use for controlling the energy supplied to a device, along with the need to set the correct value of potential difference for optimum operation.

Characteristic curves for a range of devices can only be done successfully if students have an understanding of Ohm's Law. They will need to select an appropriate source and change the voltage independently of the current and also choose a range for voltage supplied and the ammeter scale to give an appropriate graph. The Diode and Light Emitting Diode are the most difficult to change and are usually easier to reinforce learning by computer modelling.

Experiments on characteristic curves give an excellent opportunity to reinforce practical techniques and error analysis. The range of values required for the different components usually measured in these experiments are vastly different: The diode and LED need to be measured in small increments up to 1 volt, whereas the other components can be tested over a much wider range typically up to 9 volts. Students will need to select appropriate ranges and then draw graphs to suit that range. A comparison can be made when the gradients are calculated or the results could be analysed with a spreadsheet. Errors occur throughout the experiment, mostly due to heat loss from components and difficulties taking some results. The fuse experiment requires taking a reading as the wire melts and so the reading suddenly drops to zero, unless a data logging device is connected, then the measurements need to be repeated slowly until an accurate result is obtained (iterative method).

The effect of producing heat from an electrical circuit is a by-product of the previous ideas and this can be developed by using the characteristic curves and to follow up with experiments on the resistivity of a materials.

A Peltier Cell is a simple device using modern materials that converts electrical energy into heat, but the cell has a hot and a cold side on the same principle as a refrigerator. This is a more complex component that would allow brighter students to realise that the experiments, having been known for some time, can still yield new ideas and uses. It may be possible for some students to develop experiments on new materials which confirms their understanding of the whole unit studied.

Misconceptions in Electricity see websites:

http://www.physicsclassroom.com/class/circuits/Lesson-2/Common-Misconceptions-Regarding-Electric-Circuits

and

http://www.nuffieldfoundation.org/practical-physics/models-electric-circuits

Activities

Bare Paint Touch Sensor

Resources: http://www.bareconductive.com/make/making-a-touch-sensitive-circuit-with-electric-paint/

The site has instructions for a basic touch sensor similar to the soil moisture detector project kit, but this can be adapted to suit individual centres. A range of patterns with varying amount of separation may be drawn and then used to compare each students' conductivity. This can be achieved by measuring the separation which can be spanned to make the circuit complete. Circuits can be drawn with different pattern to suit individual centres, but they should be tested prior to the students investigating the resistance of the pattern.

BBC Bitesize

Resources: http://www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_21c/electric_circuits/currentsizerev1.shtml

This is a simple refresher covering resistance and the components that are used to draw characteristic curves. There are a few pages of information and then a quick test to ensure understanding. Students can access this in the lesson or at home. The site cab is used with a group of students to ascertain their knowledge and/or misconceptions.

IET Posters

Resources: http://faraday.theiet.org/posters-print/posters/index.cfm

There is a poster about the concept of p.d. and e.m.f. as well as some posters on the components. The poster can be downloaded as pdf files or obtained for free and then put up on the wall as reference. Posters on the wall can be used as starters or plenaries as a visual aid to simple verbal questioning to check knowledge.

TES PowerPoint and countdown theme

Resources: http://www.tes.co.uk/teaching-resource/LDR-Thermistors-and-Diodes-6117162/

This site requires registration but most resources are free to schools. This is a PowerPoint that can be used to show the characteristics curves for resistors, diodes, LDR and thermistors. There is also a countdown theme mp3 file which can be added to the PowerPoint and then time the delay as the slides are drawn. (Auto time the advancement of slides with an audio file). Each slide develops the information by pressing a key on the keyboard; an automatic delay can be embedded when the slide focuses on a key link to the exam content.

Checkpoint Task

Read each of the four statements below, write down a statement in agreement and another statement giving a contrary opinion for each of the statements:

1. When a lithium ion cell no longer makes a device work it has run out of charge.
2. When a lithium ion cell no longer makes a device work it needs to be re-charged.
3. When a lithium ion cell is connected in the circuit the charge moves instantly through the wires.
4. When a lithium ion cell no longer makes a device work all the charge has been transferred and used by the device.

Decide which of the statements are correct. Write a single paragraph that supports the statement you have chosen.

Checkpoint Task 1, Internal Resistance of Cells, is a follow up experiment to reinforce learning.

Note: Each of the concepts are not correct, they are common misconceptions and the reason for getting the wrong idea is because the makers of electrical cells call lithium-ion cells, 'rechargeable'. Thus giving rise to the idea that charge moves around the circuit and is passed on to the components and then 'used up'. The cells do not get more charge; it is a reversible reaction which allows the charge carriers to pass energy along the circuit. Students with a high grasp of the wrong idea may suggest that the charges would become very large and heavy due to relativistic effects.

This can also lead into a discussion on energy conservation in that many people throw away cells long before the energy is completely dissipated. Few students recognise that the cell may be able to supply energy to other devices with lower energy needs and thus use the energy to the full extent.

Teacher Instructions:

http://www.ocr.org.uk/Images/170287-resistance-electrical-circuits-checkpoint-task-instructions.pdf

Learner Activity:

http://www.ocr.org.uk/Images/170288-resistance-electrical-circuits-checkpoint-task-activity.doc

Activities

Potential Divider with Bare Paint

Resources: http://www.bareconductive.com/make/making-a-potentiometer-with-electric-paint/

This is quite simple to set up, and using the Arduino, very precise measurements can be taken. The relationship between distance and potential difference can easily be verified. The movement along the potential divider is smoother than a rheostat and the values are measured to a higher level of accuracy.

Teaching Advanced Physics from the IOP website

Resources: http://tap.iop.org/electricity/emf/121/page_46054.html

This is a detailed explanation of p.d. and e.m.f., with sample question throughout the passage to check students' progress and there are links to further topics as required.

Computer modelling

Resources: http://www.yenka.com/science/

Yenka is the new name for Crocodile Clips which is a computer model to create circuits and test them, without the problems of the possibility of components failing or not connecting properly. The advantage of a computer model is that there are no errors in the measurements taken and if you use the values generated within the model, you will always get the anticipated result or graphical representation.

Steve4 Physics Video tutorials on You Tube

Resources: http://www.tes.co.uk/teaching-resource/Index-and-links-to-A-level-Physics-video-lessons-6193038/

The link given is made through the TES website, which requires registration, but this transfers to You Tube. There is a series of 4 lectures on internal resistance and then one on voltage dividers, these lectures can be used as revision activities or as a pre-amble to a lesson, where knowledge can be checked and extended.

Activities

Extension to Characteristic Curves

Resources: insert link

Using the student sheet 'Characteristic Curves', build the circuit with the thermistor and LDR but change the condition in which they are used as described below:

- Change the temperature of a thermistor and draw the characteristic curves at two noticeably different values. Draw both curves on the same axes to compare the shape of the curves. (Note that the Maths department refer to a 'family of curves', with similar shapes).

Question: What would be typical values that may occur in the use of such a component? Think about where it may be used at home.

- Change the light level for a LDR and draw the characteristic curves when it is brighter and dimmer.

Question: Where might you find an LDR in everyday life? What is the range of light levels? (Can talk about the amount of light from different light sources.)

- Check values of resistance of all components tested against the manufacturers specifications.

(Questions can be used to provoke independent thought.)

Extension activity

Resources: insert link

A Peltier cell can be used as a more unusual component for testing in that it will take heat from one side and emit energy from the other.

Use the same circuit layout as described in the Checkpoint Task 'Characteristic Curves'.

The Peltier cell has a resistance of about 3 ohms and operates well at 2-3 Amps. Select an appropriate power supply and rheostat. A smoothed supply is essential or a battery pack (take care that batteries do not overheat in use).

The Peltier cell will need to operate with a few amps and a 5 ohm rheostat is suitable with the cell from Mindsetsonline (http://www.mindsetsonline.co.uk/). Ensure that a heat resistant mat is used with the cell and warn students that the Peltier cell can get quite hot with the higher values of current passing through. An infrared thermometer is best to use to measure the temperature as the temperature can change quite quickly and contact thermometers respond too slowly to get a good reading (Maplin has a suitable type).

Resources, links and support

Science Spotlight – Our termly update Science Spotlight provides useful information and helps to support our Science teaching community. Science Spotlight is designed to keep you up-to-date with Science here at OCR, as well as to share information, news and resources. Each issue is packed full with a series of exciting articles across the whole range of our Science qualifications: www.ocr.org.uk/qualifications/by-subject/science/science-spotlight/

Find resources and qualification information through our science page: www.ocr.org.uk/qualifications/bysubject/science/

Contact the team: science@ocr.org.uk

Continue the discussion on the science community forum: http://social.ocr.org.uk/

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To find out more about GCSE and A Level reform please visit: http://www.ocr.org.uk/qualifications/gcse-and-a-level-reform

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