SCHOLAR Tutor Handbook

SQA CfE Higher Physics
Unit 3: Electricity

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SCHOLAR Tutor's Handbook Unit 3: SQA CfE Higher Physics

1. SQA CfE Higher Physics

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Contents

Topic 1

Monitoring and measuring a. c.

This topic introduces students to measuring frequency and voltage of a.c. supplies. During the topic students will examine the difference between a.c. and d.c. supplies. They will then find out how to measure the frequency and peak voltage of an a.c. supply and then use this to calculate the r.m.s. value of current.

Students will also learn that altering the frequency of an a.c. supply has no effect on the current in a resistor.

1.1 The frequency of an a.c. supply

1.1.2 Measuring the frequency of an alternating supply

Activity: Measuring frequency using an oscilloscope

This activity allows student to examine an oscilloscope trace and then enter the frequency of the supply. The student can change the time base setting on the oscilloscope to assist them in calculating the frequency of the signal. It is not meant to replace the actual experiment, simply to supplement it.

1.2 Peak and r.m.s. values of voltage and current

Activity: r.m.s. values of voltage and current

This is an optional reading exercise that should only be attempted by those students who have the mathematical skills to understand it.

1.3 Resistors in a.c. circuits

Activity: The resistor and a.c.

This is an interactive activity that allows the student to investigate the relationship between r.m.s. potential difference, r.m.s. current and resistance (impedance) in a resistive circuit. At this stage it is not necessary for students to distinguish between resistance and impedance. It also allows the student to observe the effect on the alternating current through a resistor as the frequency of the supply is altered. It is not meant to replace the actual experiment, simply to supplement it. If however circumstances dictate that the student cannot be given the chance to carry out the experiment, then this simulation can be used.

This exercise has been designed primarily as an individual activity, although it could be carried out by a small group of students working together, or even as a whole-class activity.

Topic 2

Current, potential difference, power and resistance

2.3 Resistance

Activity: Circuits

In this activity students can place a choice of resistors into the circuit and then alter the potential difference to see how the current is affected. Students could gather data from the experiment and draw a graph for a particular resistor to show voltage and current are directly proportional. Alternatively they could use a various resistors at a given potential difference to find that current is inversely proportional to resistance. Again this is not meant to replace an actual experiment but to supplement practical work. This activity is aimed at being carried out by an individual but it could be used with larger groups.

2.5 Resistors in series

Activity: Quiz: Resistors in series

In this activity students insert resistor into a series circuit and are asked to then calculate the total resistance for the circuit. The student should also note that the voltmeters indicate that the voltage across each resistor totals to give the supply voltage.

2.6 Resistors in parallel

Activity: Quiz: Resistors in parallel

This is a similar activity to the previous activity on series resistors but in this case, the resistors being added in parallel. Students may have more difficulty with this activity in calculating the total resistance.

2.7 Potential divider

Activity: Potential divider output

This is a very simple activity that allows the student to vary the position of the slider and hence alter the output voltage.

Activity: Practical potential divider circuits

This is a pencil and paper activity designed to test the understanding of potential divider circuits by students. Students are given three circuits and asked to explain their operation. Students would perhaps be best advised to attempt one of the circuits and then check their answer before going on to the second circuit. Once they have attempted one of the circuits and read the answer they usually find it much simpler to explain what is happening in the second and third circuits. This is designed as an individual exercise for students.

Topic 3

Electrical sources and internal resistance

In this topic students are introduced to cells and the concepts of e.m.f. and internal resistance. During the topic students are encouraged to think of cells as a source of e.m.f. in series with an internal resistance.

Towards the end of the topic the idea of load matching is introduced. This subject has been missing from the Higher arrangements for some years and may be new to many. Briefly the maximum transfer of power from a source occurs when the external resistance of the circuit is equal to the internal resistance of the source. This can be examined by discussing the necessity of matching the resistance/impedance of speakers with the correct output on a signal generator or amplifier.

3.1 Sources and circuits

Activity: Measuring the e.m.f. and internal resistance of a source

This simulation allows students to vary the external resistance of a circuit and obtain data for the t.p.d. and the circuit current. Students can then use the data obtained to draw a graph. This graph can then be used to find the e.m.f. by projecting backwards to find the intercept on the potential difference axis. The internal resistance can be confirmed by finding the negative of the slope of the line and the short circuit current can be found by projecting the graph to find the intercept on the current axis.

Once again this is intended to supplement but not replace experimental activity carried out by students and is aimed at individual students.

3.2 Load matching (an interesting application of internal resistance)

Activity: Load matching

In this activity students can vary the external load in a circuit to see how it will affect the current from a cell. The power output is also displayed so that students can identify that the maximum transfer of power takes place when the external load is equal to the internal resistance of the cell. Students could draw a graph of their data to identify when the maximum transfer of power takes place. As before this activity is not intended to replace actual practical work carried out by students.

Topic 4

Capacitors

This topic examines capacitors and their functions.

The capacitance of a capacitor is introduced by examining the graph of charge stored against voltage. The energy stored in a capacitor is introduced through the same graph. Once the relationship between energy stored and charge and voltage has been found the equivalent relationships involving capacitance are then established.

The features of capacitors in d.c. is examined next followed by their features in a.c. circuits.

An introduction to the use of capacitance in touch screen devices is included in this topic. Most students will be familiar with these devices but may not have considered how they work or why they do not work when a person is wearing gloves.

4.2 Charge and capacitance

Activity: Investigating V_c and Q_c

This activity allows the student to alter the voltage of the supply and note the total charge stored on the capacitor as a result. A graph can then be drawn and the slope of the line shown to be the capacitance of the capacitor.

4.2.1 Energy stored in a capacitor

Activity: Energy stored on a capacitor

The three equivalent expressions for the energy stored on a capacitor have been given to students in the main text. This short exercise asks students to show that the three equations are equivalent.

It also helps students realise that as the potential difference across the capacitor rises the potential difference across the resistor falls.

Activity: Extra Help: Using the energy relationships E = QV and E = $^1/_2$QV

This activity reinforces the ideas encountered already in this unit and emphasises the difference between the energy stored in a capacitor and the work done in moving a charge in an electric field. The animations in this section are designed to help students understand the difference between these two situations as well as giving help in working with the equations.

4.3 Capacitors in circuits

4.3.1 Charging a capacitor

This activity allows a student to examine the graphs of current and potential difference for a capacitor resistor circuit as the capacitor charges. It also helps students realise that as the potential difference across the capacitor rises the potential difference across the resistor falls. The values for capacitance and resistance can be altered to examine the effect this has on the rate at which the capacitor charges. This can be used either by students individually or with larger groups.

4.3.2 Discharging a capacitor

This is a simple activity showing what happens to current from a capacitor as it discharges. It offers a different approach from the animation above for charging capacitors. Again this can be used by students as individuals or with larger groups.

Activity: Using the energy stored on a capacitor

This short animation illustrates why a charged capacitor is used to power a flashlamp rather than connecting the lamp directly to a battery.

This animation can be demonstrated to a class or left to an individual student. The user should first look to see what happens when the lamp is connected to a battery. A capacitor is then charged, and used to power the lamp.

A useful discussion to follow up this exercise would involve conservation of energy - how can we get a much brighter flash of light when the capacitor has been charged from the same battery that could only make the bulb glow dimly?

4.3.3 Capacitors in a.c. circuits (for interest only)

Activity: The capacitor and a.c. (for interest only)

In the previous topic, students should have used a simulation to investigate the relationship between frequency and impedance in a resistive circuit. A similar Activity is included here to investigate this relationship in a capacitive circuit.

As well as the outcome of this investigation, students need to be able to describe the method used.

Topic 5

Conductors, semiconductors and insulators

This topic discuses the electrical properties of conductors, insulators and semiconductors.

The Hall effect and it uses is discussed.

A comparison is made between the conductivity of conductors and semiconductors at different temperatures. This leads to a discussion of negative coefficient thermistors.

5.2 The structure of the atom

This is a short activity to try and give students a simple picture of the atom.

It may be useful to point out to students some of the limitations of this model e.g. the distance between the nucleus and the orbiting electrons is much greater than shown, and the electrons do not follow planar orbital paths.

5.5 Thermistors

The Hall effects is introduced. This is not treated in any great detail with the emphasis being placed on applications of the Hall effect.

This activity allows students to alter the temperature of a thermistor and measure the resulting resistance. Students can then plot a graph of resistance against temperature. They should note that as the temperature rises the resistance of the thermistor falls hence its conductivity rises. This is typical of semiconductor behaviour as opposed to conductors. Again, this is designed to supplement practical work and not replace it. This activity can be carried out by individuals or by larger groups.

Topic 6

p-n junctions

Semiconductor junctions are the focus of this topic. The effect of adding impurities to pure semiconductor material is examined and then the production of a p-n junction and its properties.

The use of p-n junction diodes to produce LEDs is discussed and methods used to produce different coloured LEDs is examined. Finally photo diodes are discussed and their use in the photovotalic mode in solar cells examined.

6.1 Doping

The section contains a simple demonstration to help students visualise the movement of charge carriers in semiconductor material.

6.2 p - n junctions

Again, shockwave animations have been employed in this section to allow the action of the p-n junction diode to be more readily understood.

Activities are included to show both forward and reverse bias.

6.3 Light emitting diodes and solar cells

The calculation of the recombination energy of an LED goes beyond the Content Statements, although the work has been covered in a previous Topic. Recombination energy of an LED is mentioned in the right-hand column of the 'Arrangements' document, and as such, could be asked in a problem-solving context in an examination.

6.3.1 Light emitting diodes

The activity shows the release of photons from the junction when an electron and a hole recombine.

6.3.4 Photodiodes, solar cells and the photovoltaic effect

An activity is included to show the basic operation of a solar cell in the photovoltaic mode.

Activity: Solar cells and voltage

This activity allows the student to increase the brightness of a light source and measure the light level and output voltage of the solar cell. The student should note that the output voltage from the cell increases rapidly at first with light level but soon reaches a maximum value and then does not alter. This is because modern solar cells are design to give a constant output voltage at most light levels. Students should note that the current will however continue to rise with increases in light level once the voltage plateau has been reached. This activity can be carried out by students individually or in groups.

Topic 7

End of unit test

An online assessment, covering all of the work of the Electricity unit. The questions are set at the same level as the questions in the NAB tests, covering all the areas that it is possible to cover for a Unit test. There are no 'Course-type' questions covering more than one Unit of work.

7.1 Open ended and skill based questions

Open ended questions assess your ability to apply knowledge of physics to unfamiliar situations. These questions often have no one specific answer. The important point is that you identify and discuss relevant physics as fully and logically as you can.

In addition there are questions in which you have to analyse and evaluate experimental data, procedures and conclusions.

7.2 Course style questions

Course style questions are in the style of SQA examination questions.

They have several parts to them and require both numerical and descriptive answers.

These questions are set at a level above NAB level questions.

There are no questions covering more than one Unit of work.

7.3 End of unit assessment

The questions are set at the same level as the questions in the NAB tests, covering all the areas that it is possible to cover for a Unit test. There are no questions covering more than one Unit of work.