**Using non-ohmic devices as sensors**

**Introduction**

This investigation is intended to meet the requirement that students should be capable of designing and constructing their own circuit, rather than building a circuit from a circuit diagram.

The investigative nature allows this to meet the higher order requirements of the Common Practical Assessment Criteria.

Students should be familiar with the characteristics of LDRs and thermistors. They should also have carried out previous practical work involving potential dividers.

**Aims and skills covered**

* To design and construct a circuit to give the required output
* To determine the optimum value of resistor to give the maximum output range.

**Links to Specifications**

**Physics A**

* 4.2.1(a)(b) circuit diagrams using circuit symbols
* 4.2.2(a) potential difference and the unit *volt*
* 4.2.3(c)(i) *I*–*V* characteristics of resistor, filament lamp, thermistor, diode and light-emitting diode (LED)
* 4.2.3(c)(ii) techniques and procedures used to investigate the electrical characteristics for a range of ohmic and non-ohmic components
* 4.2.3(d) light-dependent resistor (LDR); variation of resistance with light intensity
* 4.2.4(c) negative temperature coefficient (NTC) thermistor; variation of resistance with temperature
* 4.3.1(c)(e) analysis of circuits with components in series
* 4.3.3(a) potential divider circuit with components – note candidates expected to know about potentiometer as a potential divider
* 4.3.3(b) potential divider circuits with variable components e.g. LDR and thermistor
* 4.3.3(c)(i) potential divider equations
* 4.3.3(c)(ii) techniques and procedures used to investigate potential divider circuits which may include a sensor such as a thermistor or an LDR

**Physics B**

* 3.1.2a(iii) resistance, including series and parallel combinations
* 3.1.2a(vii) action of a potential divider
* 3.1.2b(ii) recognise standard circuit symbols
* 3.1.2(b)(iii) graphs of current against potential difference and graphs of resistance or conductance against temperature for ohmic and non-ohmic devices or components
* 3.1.2c(ii) use formulae for resistors in series and parallel
* 3.1.2(d)(iii) use of potential divider circuits, which may include sensors such as thermistors and LDRs
* 3.1.2(d)(iv) the calibration of a sensor or instrument

**Practical Skills**

* 1.2.1(a) apply investigative approaches and methods to practical work
* 1.2.1(b) safely and correctly use a range of practical equipment and materials
* 1.2.1(d) make and record observations/measurements
* 1.2.1(e) keep appropriate records of experimental activities
* 1.2.1(f) present information and data in a scientific way
* 1.2.1(g) use software to process data
* 1.2.1(j) use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding included in the specification
* 1.2.2(a) use of appropriate analogue apparatus to record a range of measurements (to include length/distance, temperature, pressure, force, angles and volume) and to interpolate between scale markings
* 1.2.2(b) use of appropriate digital instruments including electrical multimeters to measure resistance
* 1.2.2(c) use of methods to increase accuracy
* 1.2.2(g) design, construct and check circuits using DC power supplies and a range of circuit components.
* 1.2.2(k) use ICT to process data

**CPAC**

* (2) Applies investigative approaches and methods when using instruments and equipment
* (3) Safely uses a range of practical equipment and materials
* (4) Makes and records observations
* (5) Research, reference and report

**Mathematical skills**

* M0.1 Recognise and make use of appropriate units in calculations
* M0.3 Use ratios, fractions and percentages
* M1.1 Use an appropriate number of significant figures
* M2.3 Substitute numerical values into algebraic equations using appropriate units for physical quantities
* M2.4 Solve algebraic equations
* M3.1 Translate information between graphical, numerical and algebraic forms
* M3.2 Plot two variables from experimental or other data
* M3.6 Draw and use the slope of a tangent to a curve as a measure of rate of change

**Equipment (per learner or group)**

* metre rule
* variable Power Supply or Power Supply with Potential Divider
* voltmeter
* ammeter
* digital multimeter to measure resistance
* resistance decade box
* LDR
* thermistor
* leads
* crocodile clips (if using unmounted components)

**Health and safety**

* Safe use of electrical circuits
* ntc thermistors may catch fire or explode if the voltage is too high due to the runaway effect

Before carrying out any experiment or demonstration based on this guidance, it is the responsibility of teachers to ensure that they have undertaken a risk assessment in accordance with their employer’s requirements, making use of up-to-date information and taking account of their own particular circumstances. Any local rules or restrictions issued by the employer must always be followed.

**Notes**

* These practical activities are not controlled assessments, should not be carried out in exam conditions and can be adapted by the centre. Students can collaborate during the activities which should take place as part of the normal teaching sequence. They are intended to be formative with students acquiring and practising skills throughout the course.
* To achieve a pass in the Practical Endorsement each student is required to demonstrate competence in all the skills, apparatus and techniques listed in section 1.2 of the specification and assessed against the Ofqual Common Practical Assessment Criteria (CPAC) at the end of the course.
* The skills, apparatus and techniques can be demonstrated during any practical work undertaken during the A Level course whether an OCR practical activity or not.
* Whilst using a multimeter may appear very simple, students are often confused by the ranges. They should be taught to start on higher range and increase sensitivity until they have an appropriate reading. Some multimeters will be auto-ranging, but still cause problems giving 0 or E readings for out of range which also happens when leads or connections are faulty.

CLEAPSS document R151 “*Ammeters,Voltmeters etc,for Class Use*” and the Laboratory Handbook sections 12.3.1 “*DMMs compared to analogue meters*”, 12.3.2 “*Provision of digital multimeters*” and 12.3.3 “*Which DMMs to buy*”, contain useful information on selection and use of digital multimeters.

* Similarly resistance decade boxes appear simple, but again students may start with zero resistance, which can then blow the fuse. Good practice is to start with a higher value of resistance, rather than lower.

**Recording**

* Learners should not need to re-draft their work but rather keep all their notes as a continuing record of Practical Activity.
* As evidence for the Practical Endorsement learners should have clearly sketched their circuit diagrams and have evidence of at least one multimeter reading to establish the order of resistance of the device being used. Learners should have demonstrated that their circuit meets the criteria of the task
* Learners should annotate their work if discrepancies are noted or errors are made and corrected to support the use of the lab book as a contemporaneous record