# Physics PAG 6: Circuit components

# Combined Science PAG P6: Circuits

# Suggested Activity 1: Investigate the I–V characteristics of circuit elements

## Instructions and answers for teachers & technicians

These instructions cover the learner activity section which can be found on [page 9](#_Student_Activity). This Practical activity supports OCR GCSE Physics.

**When distributing the activity section to the learners either as a printed copy or as a Word file you will need to remove the teacher instructions section.**

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| --- |
| This is a **suggested** practical activity that can be used as part of teaching the GCSE (9-1) Gateway Science (A) and Twenty First Century Science (B) specifications.  These are **not controlled assessment tasks**, and there is **no requirement to use these particular activities**.  You may modify these activities to suit your learners and centre. Alternative activities are available from, for example, [Royal Society of Biology](https://www.rsb.org.uk/education/teaching-resources/secondary-schools), [Royal Society of Chemistry](http://www.rsc.org/learn-chemistry), [Institute of Physics](http://www.iop.org/education/teacher/resources/index.html), [CLEAPSS](http://science.cleapss.org.uk/) and [publishing companies](https://global.oup.com/education/content/secondary/key-issues/gcse_science_2016/?region=uk), or of your own devising.  Further details are available in the [specifications](http://www.ocr.org.uk/science) (Practical Skills Topics), and in these [videos](https://www.youtube.com/playlist?list=PLBD9B84FF4BD54AA4). |

**OCR recommendations:**

**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.**

**CLEAPSS resources are useful for carrying out risk-assessments: (**<http://science.cleapss.org.uk>**).**

**Centres should trial experiments in advance of giving them to learners. Centres may choose to make adaptations to this practical activity, but should be aware that this may affect the Apparatus and Techniques covered by the learner.**

### Introduction

In this activity, learners will investigate the I-V characteristics of a resistor, filament bulb and diode.

### DfE Apparatus and Techniques covered

The codes used below match the OCR Practical Activity Learner Record Sheet ([**Physics**](http://www.ocr.org.uk/Images/295647-gcse-physics-learner-record-sheet.doc) / [*Combined Science*](http://www.ocr.org.uk/Images/304431-gcse-combined-science-learner-record-sheet.doc)) and Trackers ([**Physics**](http://www.ocr.org.uk/Images/323482-gcse-physics-practical-tracker.zip) / [*Combined Science*](http://www.ocr.org.uk/Images/323483-gcse-combined-science-practical-tracker.zip)) available online. **There is no requirement to use these resources.**

**6a** *[18a]*) Use of appropriate apparatus to measure: i) current; ii) potential difference; iii) resistance

**6b** *[18b]*) Use of appropriate apparatus to explore a variety of circuit elements

**7** *[19]*) Use of circuit diagrams to construct and check: i *[i]*) series circuits including a variety of common circuit elements; ii *[ii]*) parallel circuits including a variety of common circuit elements

### Aims

Use of appropriate apparatus to measure current, potential difference (voltage) and resistance of a resistor, filament bulb and diode.

Plot an I-V graph for a resistor, filament bulb and diode.

Use graphs and relate the curves produced to their function and properties.

### Intended class time

50-60 minutes

### Links to Specifications:

### Gateway Science (Suite A) including Working Scientifically (WS)

P3.2c recall that current (I) depends on both resistance (R) and potential difference (V) and the units in which these are measured

P3.2d recall and apply the relationship between I, R and V

P3.2e explain that for some resistors the value of R remains constant but that in others it can change as the current changes

P3.2g use graphs to explore whether circuit elements are linear or nonlinear

P3.2h use graphs and relate the curves produced to the function and properties of circuit elements

WS1.1b, Use models to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts representational, spatial, descriptive, computational and mathematical models

WS1.2a, use scientific theories and explanations to develop hypotheses

WS1.2b, plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena

WS1.2c, apply a knowledge of a range of techniques, instruments, apparatus, and materials to select those appropriate to the experiment

WS1.3b, translating data from one form to another

WS1.3e, interpreting observations and other data

WS1.3f, presenting reasoned explanations

WS1.3h, identifying potential sources of random and systematic error

WS1.4a, use scientific vocabulary, terminology and definitions

WS2a, carry out experiments

WS2c, presenting observations using appropriate methods

WS2d, communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions

### Twenty First Century Science (Suite B) including Ideas about Science (IaS

P3.2.3 recall that current (I) depends on both resistance (R) and potential difference (V) and the units in which these quantities are measured

P3.2.4(a) recall and apply the relationship between I, R, and V, to calculate the currents, potential differences and resistances in d.c. series circuits

P3.2.5 recall that for some components the value of R remains constant (fixed resistors) but that in others it can change as the current changes (e.g. heating elements, lamp filaments)

P3.2.6(a) use graphs to explore whether circuit elements are linear or non-linear and relate the curves produced to their function and properties

P3.2.6(b) describe experiments to investigate the I-V characteristics of circuit elements. To include: lamps, diodes, LDRs and thermistors. Be able to draw circuit diagrams for the circuits used

IaS1.1 present observations and other data using appropriate formats

IaS1.2 when processing data use SI units where appropriate (e.g. kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate

IaS1.3 when processing data use prefixes (e.g. tera, giga, mega, kilo, centi, milli, micro and nano) and powers of ten for orders of magnitude

IaS1.4 be able to translate data from one form to another

IaS1.5 when processing data interconvert units

IaS1.6 . when processing data use an appropriate number of significant figures

IaS1.7 when displaying data graphically select an appropriate graphical form, use appropriate axes and scales, plot data points correctly, draw an appropriate line of best fit, and indicate uncertainty (e.g. range bars)

IaS1.8 when analysing data identify patterns/trends, use statistics (range and mean) and obtain values from a line on a graph (including gradient, interpolation and extrapolation),

IaS 2.9 in a given context evaluate data in terms of accuracy, precision, repeatability and reproducibility, identify potential sources of random and systematic error, and discuss the decision to discard or retain an outlier

IaS 2.11 in a given context interpret observations and other data (presented in diagrammatic, graphical, symbolic or numerical form) to make inferences and to draw reasoned conclusions, using appropriate scientific vocabulary and terminology to communicate the scientific rationale for findings and conclusions

IaS 2.12 explain the extent to which data increase or decrease confidence in a prediction or hypothesis

IaS 3.1 use ideas about correlation and cause to: - identify a correlation in data presented as text, in a table, or as a graph M2g - distinguish between a correlation and a cause effect link - suggest factors that might increase the chance of a particular outcome in a given situation, but do not invariably lead to it - explain why individual cases do not provide convincing evidence for or against a correlation - identify the presence (or absence) of a plausible mechanism as reasonable grounds for accepting (or rejecting) a claim that a factor is a cause of an outcome

### Mathematical Skills covered

M1a Recognise and use expressions in decimal form

M2a Use an appropriate number of significant figures

M2g g Use a scatter diagram to identify a correlation between two variables

M3a Understand and use the symbols: =, <>, >, ∝, ~

M3b Change the subject of an equation

M3c Substitute numerical values into algebraic equations using appropriate units for physical quantities

M3d Solve simple algebraic equations

M4a Translate information between graphical and numeric form

M4b Understand that y=mx+c represents a linear relationship

M4c Plot two variables from experimental or other data

M4d Determine the slope and intercept of a linear graph

### Health and Safety

Check with your teacher the circuit is set up correctly

Turn off switch between readings to ensure components don’t get too hot

Be aware that components can get very hot so do not touch the components until they are cooled down

Always have components on a heat proof mat

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.

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

Based on the components available the teacher should assess the maximum permissible current and define this to the learners.

### Technician Notes

### For this practical the teacher will require:

* 12V variable supply or 4 x 1.5V cells
* Potentiomater/Rheostat
* 4mm connecting leads
* Ammeter (Multimeter)
* Voltmeter (Multimeter)
* 12V Bulb
* Fixed Resistor at least 10 ohm
* Semiconductor diode
* Switch
* Heat proof mat

### Answers for quiz questions

|  |  |  |
| --- | --- | --- |
| **1. (a) (i)** | A student measures the current through a thermistor at varying potential differences. They plot a graph for their results. Sketch below the graph they would expect to see. **[2 marks]** |  |
|  | Current (I)  Graph - Current and Potential Difference  Potential Difference (V)  ✓✓ |  |

|  |  |  |
| --- | --- | --- |
| **(ii)** | Use the graph to write down how the resistance of the thermistor changes with temperature.**[3 marks]** |  |
|  | As the current increases the temperature of the thermistor increases ✓  At low temperatures the thermistor has high resistance ✓  At high temperatures the thermistor has low resistance ✓ |  |

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| --- | --- | --- |
| **(b)** | Voltmeter with dial pointing to 1A voltmeter is used to measure the output voltage produced from the circuit. The voltmeter is not connected to the circuit and not recording a voltage**.** |  |
|  | Name the error on the voltmeter and suggest how it should be dealt with. **[2 marks]** |  |
|  | Zero error ✓Reset the meter/subtract 1.0V from all readings ✓ |  |

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| --- | --- | --- |
| **(c)** | Draw below the circuit symbol for an LDR. **[1 mark]** |  |
|  | Circuit symbol for an LDR  ✓ |  |

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| --- | --- | --- |
| **(d)** | A student has a resistor of unknown resistance. They find that the current through the resistor is 120 mA when the potential difference is 12 V. Work out the resistance of the resistor. **[4 marks]** |  |
|  | Resistance = potential difference ÷ current ✓  120 mA = 0.12 A ✓  Resistance = 12 V ÷ 0.12 A ✓  = 100 ohm ✓ |  |

### Document updates

v1 Published on the qualification pages

v1.1 January 2017 Consolidated labelling and formatting of activities

v1.2 June 2021 Updated to meet digital accessibility standards



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# Physics PAG 6: Circuit components

# Combined Science PAG P6: Circuits

# Suggested Activity 1: Investigate the I–V characteristics of circuit elements

## Learner Activity

### Introduction

### In this activity, you will investigate the I-V characteristics of a resistor, filament bulb and diode.

### Aims

Use of appropriate apparatus to measure current, potential difference (voltage) and resistance of a resistor, filament bulb and diode.

Plot an I-V graph for a resistor, filament bulb and diode.

Use graphs and relate the curves produced to their function and properties.

### Intended class time

50-60 minutes

### Equipment (per group)

* 12V Variable supply or 4 x 1.5V cells
* Potentiomater/Rheostat
* 4mm connecting leads
* Ammeter (Multimeter)
* Voltmeter (Multimeter)
* 12V Bulb
* Fixed Resistor at least 10 ohm
* Semiconductor diode
* Switch
* Heat proof mat

### Health and Safety

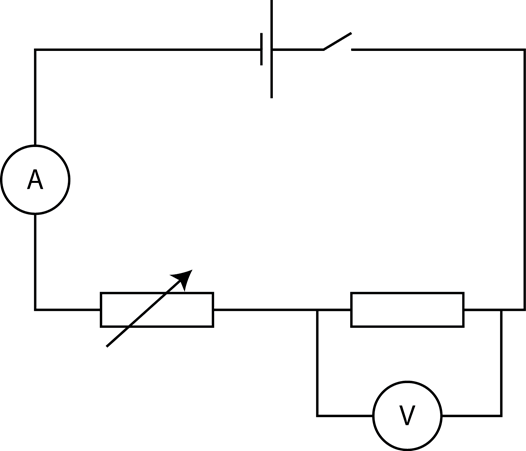
Check with your teacher the circuit is set up correctly

Turn off switch between readings to ensure components don’t get too hot

Be aware that components can get very hot so do not touch the components until they are cooled down

Always have components on a heat proof mat

### Method

1. Connect the circuit as shown with the switch open, check with your teacher it is set up safely and correctly.
2. Close the switch and move the slider on the rheostat until there is a zero current reading on the ammeter
3. Move the slider slowly until you get a reading for voltage and current and record these values in your table
4. Move the slider up in approximately equal steps another 5 times so you have a total of six readings for voltage and current and record all of these value in your table
5. Swap the leads round on the powerpack and repeat for negative values
6. Replace the fixed resistor with a filament bulb and repeat steps 2-5
7. Replace the fixed resistor with a diode and repeat steps 2-5

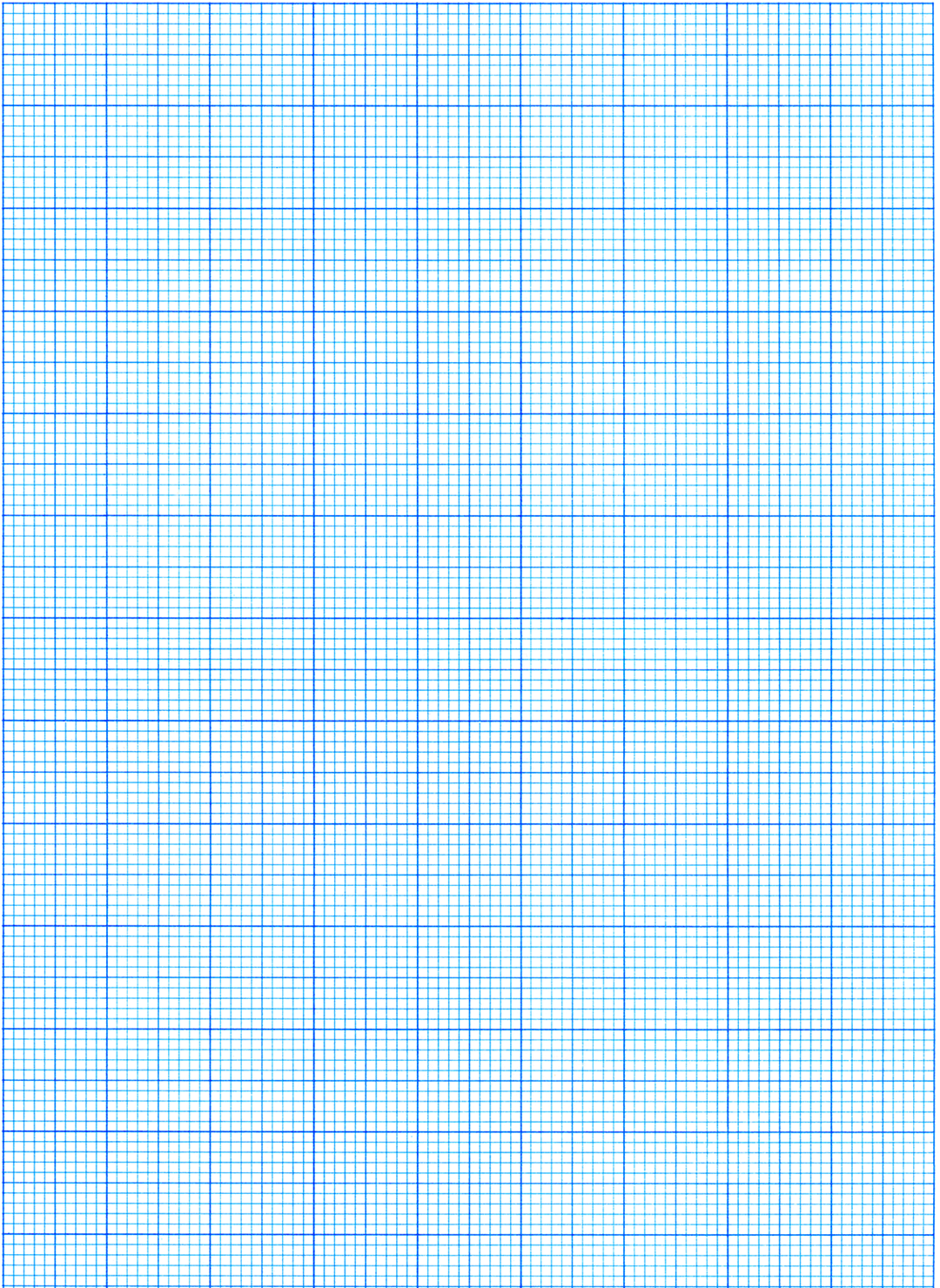
### Results

1. Record all your results in the table provided
2. Plot a scatter graph of current on the y-axis and voltage on the x-axis and draw a line of best fit for the bulb, the diode and the resistor

| **Diode** | |
| --- | --- |
| **Voltage(V)** | **Current(A)** |
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| **Filament bulb** | |
| --- | --- |
| **Voltage(V)** | **Current(A)** |
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| **Resistor** | |
| --- | --- |
| **Voltage (V)** | **Current(A)** |
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### Graph paperGraph paperEvaluation

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| 1. Look at the three graphs you have drawn. Write down the similarities and the differences between them. What do you think the relationship between voltage and current is? |  |
|  |  |

1. Pick three points on your line (not from your results table) for each graph and divide voltage by current to work out the resistance as R=V/I. Use an appropriate number of significant figures.

| **Resistor** | | |
| --- | --- | --- |
| **Voltage(V)** | **Current(A)** | **Resistance V/I(Ω)** |
|  |  |  |
|  |  |  |
|  |  |  |

| **Diode** | | |
| --- | --- | --- |
| **Voltage(V)** | **Current(A)** | **Resistance V/I(Ω)** |
|  |  |  |
|  |  |  |
|  |  |  |

| **Filament bulb** | | |
| --- | --- | --- |
| **Voltage(V)** | **Current(A)** | **Resistance V/I(Ω)** |
|  |  |  |
|  |  |  |
|  |  |  |

|  |
| --- |
| 1. What is the relationship between current and resistance in a resistor? |
|  |

|  |
| --- |
| 1. What is the relationship between current and resistance in a filament bulb? |
|  |

|  |
| --- |
| 1. What is the relationship between current and resistance in a diode? |
|  |

### Extension

|  |
| --- |
| 1. Using your knowledge of the properties of a metal write down why you think the resistance behaves the way it does in a filament bulb. |
|  |

### Quiz - test your knowledge and understanding

|  |  |  |
| --- | --- | --- |
| **1. (a) (i)** | A student measures the current through a thermistor at varying potential differences. They plot a graph for their results. Sketch below the graph they would expect to see. **[2 marks]** |  |
|  | P.d (V)  Current (A) |  |

|  |  |  |
| --- | --- | --- |
| **(ii)** | Use the graph to write down how the resistance of the thermistor changes with temperature. **[3 marks]** |  |
|  |  |  |

|  |  |  |
| --- | --- | --- |
| **(b)** | Voltmeter with dial pointing to 1A voltmeter is used to measure the output voltage produced from the circuit. The voltmeter is not connected to the circuit and not recording a voltage**.** |  |
|  | Name the error on the voltmeter and suggest how it should be dealt with. **[2 marks]** |  |
|  |  |  |

|  |  |  |
| --- | --- | --- |
| **(c)** | Draw below the circuit symbol for an LDR. **[1 mark]** |  |
|  |  |  |

|  |  |  |
| --- | --- | --- |
| **(d)** | A student has a resistor of unknown resistance. They find that the current through the resistor is 120 mA when the potential difference is 12 V. Work out the resistance of the resistor. **[4 marks]** |  |
|  |  |  |

### DfE Apparatus and Techniques covered

If you are using the OCR Practical Activity Learner Record Sheet ([**Physics**](http://www.ocr.org.uk/Images/295647-gcse-physics-learner-record-sheet.doc) / [*Combined Science*](http://www.ocr.org.uk/Images/304431-gcse-combined-science-learner-record-sheet.doc)) you may be able to tick off the following skills:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Physics** | | | |  | ***Combined Science*** | | | |
| 6a-i | 6a-ii | 6a-iii | 6b |  | *18a-i* | *18a-ii* | *18a-iii* | *18b* |
| 7-i | 7-ii |  |  |  | *19-i* | *19-ii* |  |  |