YEAR 10 PHYSICS, AQA GCSE, LESSON 9 OF 12

# ELECTRIC CIRCUITS

## LESSON 09 INVESTIGATING I–V CHARACTERISTICS

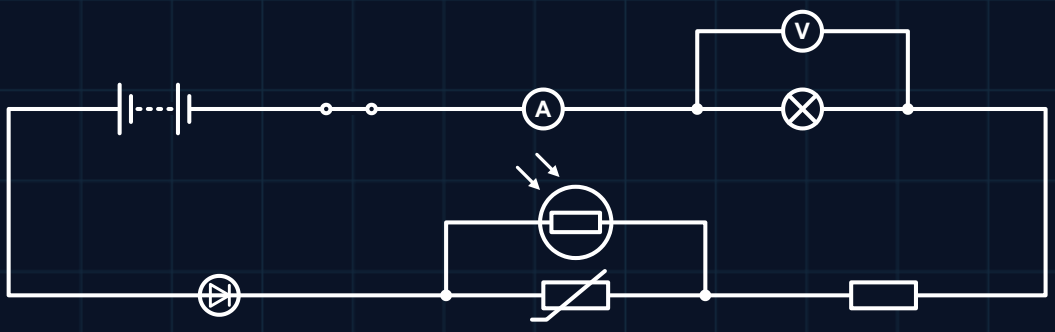
REQUIRED PRACTICAL

Can you produce the fingerprint graphs of a resistor, a lamp and a diode yourself?

### IN THIS LESSON YOU WILL

- set up a circuit to vary the p.d. and measure the current
- take readings in both directions, safely
- plot an I–V graph with positive and negative values
- describe how the method changes for a diode

ANSWER EDITION FOR TEACHERS AND SELF-MARKING




NAME _____ CLASS _____

TEACHER _____ TARGET GRADE _____

START HERE

# HOW THIS BOOKLET WORKS

This is the booklet for **Lesson 9** of the Electric Circuits unit. It builds on the lessons before it; the “Do now” questions and the quick answers at the back help you check what you remember. Keep it: it is your classwork book *and* your revision guide.

**DO NOW**
Quick questions from earlier lessons. Remembering again is what makes it stick.

**LEARN IT**
The explanation, diagrams and worked examples. Read this again when you revise.

**TRY IT**
Practice that builds up: first with support, then on your own.

**LAB**
Record measurements from a virtual lab or a required practical.

**EXAM CORNER**
An AQA-style question with a tip on how the marks are given.

**REVISE IT**
Summary, cover-and-answer questions and an “I can” check to colour in.

! **Revising at home?** (1) Read the Learn it pages. (2) Cover them and answer the “Cover the page” questions in Revise it. (3) Check with the quick answers at the back.

## THE ROUTE THROUGH THE UNIT (THIS LESSON IS HIGHLIGHTED)


01 Complete circuits and symbols

02 Current and charge

03 Potential difference

04 Resistance and V = I R

05 Resistance of a wire RP

06 Series and parallel circuits

07 Resistors in series and parallel RP

08 I–V graphs

**09 Investigating I–V characteristics** RP
Required practical: measure the I–V characteristics of a resistor, lamp and diode

10 Thermistors, LDRs and sensors

11 Power and energy transfer

12 Mains, safety and the National Grid

Lesson

# 09

# INVESTIGATING I–V CHARACTERISTICS

AQA Combined RP 16; Physics RP 4

**BIG QUESTION** **Can you produce the fingerprint graphs of a resistor, a lamp and a diode yourself?**

**BY THE END YOU CAN**

- set up a circuit to vary the p.d. and measure the current
- take readings in both directions, safely
- plot an I–V graph with positive and negative values
- describe how the method changes for a diode

**variable resistor** **protective resistor** **reverse** **range** **interval**

RETRIEVE

## DO NOW

From earlier lessons. No notes!

**1**
Sketch the I–V graph shape for a diode.

**Zero current for negative p.d.; almost none until a small positive p.d., then rises steeply.**

**2**
Why does a lamp's resistance increase as the current increases?

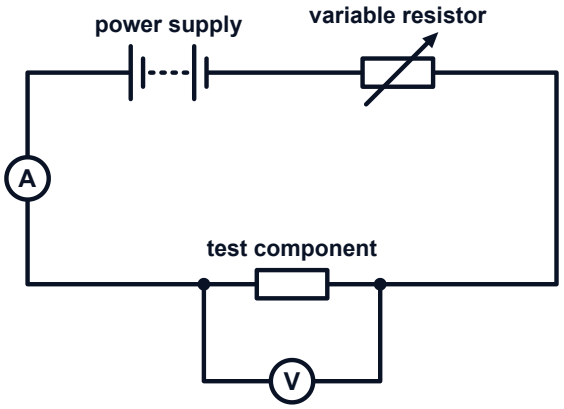
**The filament heats up, so more collisions.**

**3**
How is a voltmeter connected to a component?

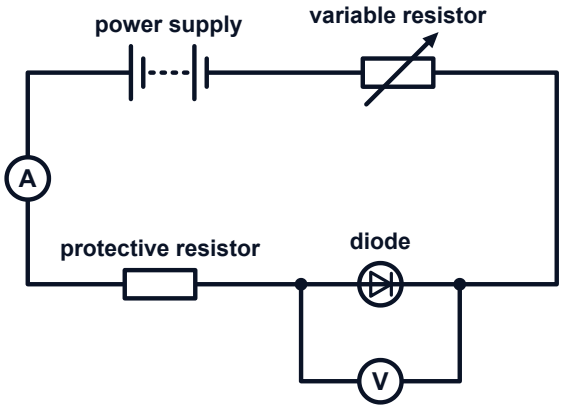
**Across it, in parallel.**

EXPLAIN

# PLAN THE PRACTICAL




Resistor first, then swap in the filament lamp.




Diode: add a protective resistor; voltmeter across the diode only.

The **variable resistor** changes the p.d. across the test component. To get negative values, **swap the connections** to the power supply so the current flows the other way, and record those readings as negative.

1. Set up the circuit with the fixed resistor as the test component.
2. Use the variable resistor to set a range of p.d.s, for example from 0 to 6 V. Record V and I each time.
3. Reverse the connections to the power supply. Repeat, recording V and I as negative values.
4. Repeat for the filament lamp.
5. Repeat for the diode with its protective resistor, taking small steps of p.d. from 0 to about 1 V.

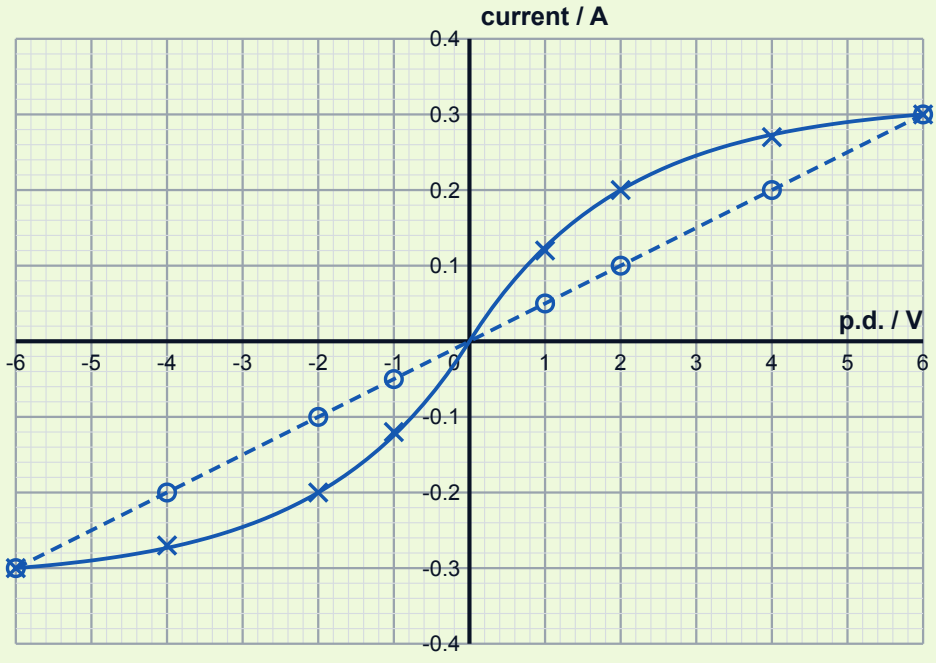
**STAY SAFE**

- The lamp gets hot. Do not touch it while it is on or just after.
- Do not go above the lamp's rated p.d. (for example 6 V).
- Always use the protective resistor with the diode, so the current stays small.

**6** Aim for these p.d.s. Record the actual p.d. if it is slightly different.

| p.d. / V | Resistor: current / A | Lamp: current / A |
|---|---|---|
| −6.0 | −0.30 | −0.30 |
| −4.0 | −0.20 | −0.27 |
| −2.0 | −0.10 | −0.20 |
| −1.0 | −0.05 | −0.12 |
| 0 | 0 | 0 |
| 1.0 | 0.05 | 0.12 |
| 2.0 | 0.10 | 0.20 |
| 4.0 | 0.20 | 0.27 |
| 6.0 | 0.30 | 0.30 |

**7** Plot both components on the same axes. Use a different symbol for each, and add a key.

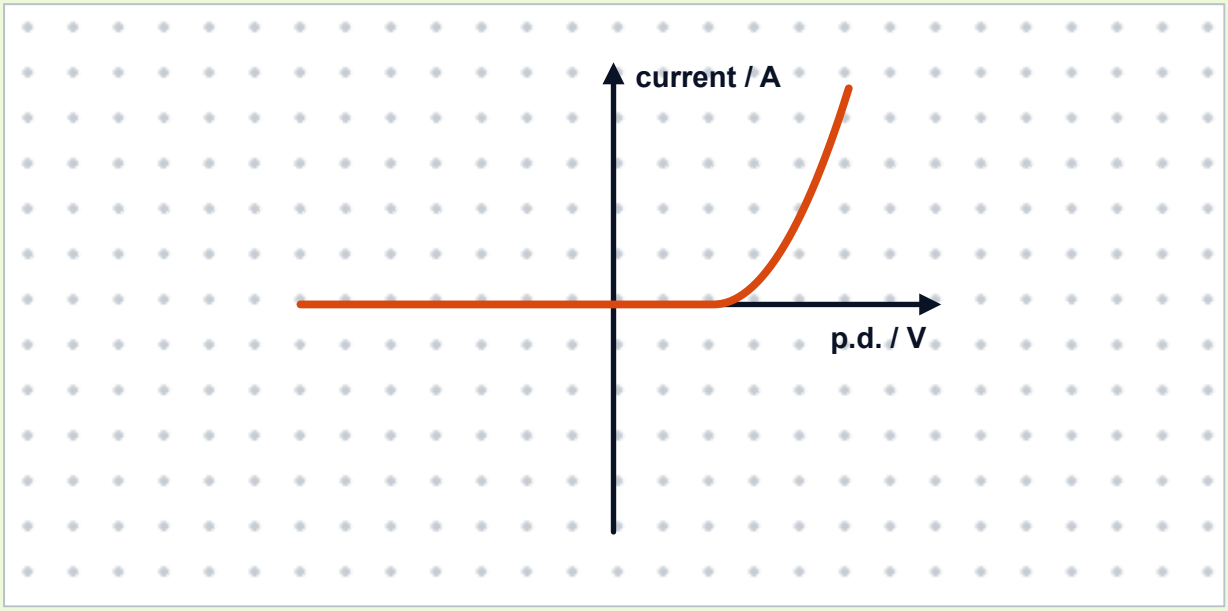



**Crosses and curve: filament lamp. Circles and dashed straight line: fixed resistor.**

8 Diode (with protective resistor).

| p.d. / V | −1.0 | 0 | 0.2 | 0.4 | 0.5 | 0.6 | 0.65 | 0.7 |
|---|---|---|---|---|---|---|---|---|
| current / mA | 0 | 0 | 0 | 0 | 0.5 | 3.0 | 8.0 | 20 |

Sketch the shape of the diode graph from your readings.




PRACTISE

## ANALYSE AND EVALUATE

1 Describe the shape of your fixed-resistor graph. What does it show?

**A straight line through the origin, the same in both directions. Current ∝ p.d., so the resistance is constant.**

2 Use your lamp results to calculate its resistance at 1.0 V and at 6.0 V. Explain the difference.

**(Example) 1.0 ÷ 0.12 = 8.3 Ω; 6.0 ÷ 0.30 = 20 Ω. At a higher current the filament is hotter, so its resistance is higher.**

3 Why is a protective resistor used with the diode? Tick **one** box.

- ☐ to make the diode light up
- ☐ to measure the p.d.
- ☑ to limit the current so the diode is not damaged
- ☐ to reverse the current

4 Why were the diode readings taken in smaller steps of p.d.?

**The current changes very quickly over a small range of p.d. (about 0.5–0.7 V), so small steps are needed to show the shape.**

5 A student plots the reversed readings as positive numbers. What will be wrong with the graph?

**All the points would be in the top-right quadrant. Reversed readings should be negative V and negative I, in the bottom-left quadrant.**

AQA-STYLE

## EXAM CORNER

Write in full sentences. Show every step of a calculation.

> **Get the marks:** Name the equipment and say what it is for. Cover both directions, safety, and the changes for a diode.

9 Describe a method to obtain the I–V characteristic of a filament lamp for positive and negative p.d. State two ways the method would change for a diode. **[6 marks]**

**Lamp method, any four (4): ammeter in series and voltmeter across the lamp; vary the p.d. with a variable resistor or variable supply; record pairs of V and I readings over a range; reverse the supply connections to get negative values; stay below the lamp's rated p.d.; plot I against V. Diode changes, two needed (2): add a protective resistor in series (1); use smaller p.d. steps / a milliammeter (1).**

REVIEW LATER

## REVISE IT

Use this box after the lesson and before tests.

### SUMMARY

- Vary the p.d. with a **variable resistor**; ammeter in series, voltmeter across the component.
- Reverse the supply connections for negative readings, and record them as negative.
- Diode: protective resistor, a milliammeter and small steps of p.d.
- Plot I (up) against V (along), with the origin in the middle.

### COVER THE PAGE AND ANSWER

**1** How do you change the p.d. across the component?

**2** How do you get negative readings?

**3** Why is a protective resistor used with a diode?

**4** Where do reversed readings go on the graph?

### I CAN…

- set up the I–V circuit and explain each part
- take and record readings in both directions
- plot an I–V graph with the origin in the middle
- describe the extra steps for a diode

REFERENCE

# EQUATION TOOLKIT

The equations you have met so far. You will meet these one at a time. Learn each equation **in words** as well as symbols: AQA gives you an equation sheet in the exam (it does not include $R_{total} = R_1 + R_2$), but knowing the equations by heart makes every question faster.

## $Q = I\,t$

Lesson 2

**charge flow = current × time**

C, A, s

Rearranged: I = Q ÷ t and t = Q ÷ I

## $E = Q\,V$

Lesson 3

**energy transferred = charge × p.d.**

J, C, V

Rearranged: V = E ÷ Q and Q = E ÷ V

## $V = I\,R$

Lesson 4

**p.d. = current × resistance**

V, A, Ω

Rearranged: I = V ÷ R and R = V ÷ I

## $R_{total} = R_1 + R_2$

Lesson 6

**total resistance in series**

Ω

Rearranged: (series only)

## FOUR STEPS FOR EVERY CALCULATION

**1**
Write down what you know, with units. Convert units first (minutes → seconds, kW → W, mA → A).

**2**
Write the equation you will use, in symbols.

**3**
Substitute the numbers, then rearrange if needed.

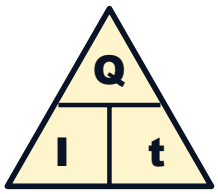
**4**
Give the answer with a unit. Ask: is it sensible?

| CONVERT | HOW | EXAMPLE |
|---|---|---|
| minutes → seconds | × 60 | 3.0 min = 180 s |
| hours → seconds | × 3600 | 2.0 h = 7200 s |
| milliamps (mA) → amps (A) | ÷ 1000 | 250 mA = 0.25 A |
| kilowatts (kW) → watts (W); kilohms (kΩ) → ohms (Ω) | × 1000 | 2.2 kW = 2200 W |
| kilovolts (kV) → volts (V) | × 1000 | 400 kV = 400 000 V |

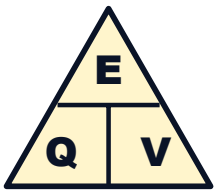
## EQUATION TRIANGLES: HELP WITH REARRANGING

1. Cover the quantity you want to find.
2. The two left **side by side**? **Multiply** them.
3. One **above** the other? **Divide** the top by the bottom.

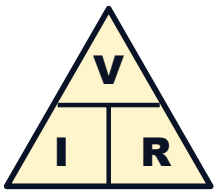
Example: to find I from Q = I t, cover I. Q is above t, so I = Q ÷ t. Triangles only help with rearranging: you still need to learn each equation.




**Q = I t**
Q = I × t
I = Q ÷ t
t = Q ÷ I




**E = Q V**
E = Q × V
Q = E ÷ V
V = E ÷ Q




**V = I R**
V = I × R
I = V ÷ R
R = V ÷ I

CHECK YOURSELF

# QUICK ANSWERS

Answers to the “Do now” and “Cover the page” questions, so you can check yourself when revising. Answers to the longer questions are in your teacher's answer edition.

### DO NOW

1. Zero current for negative p.d.; almost none until a small positive p.d., then rises steeply.
2. The filament heats up, so more collisions.
3. Across it, in parallel.

### COVER THE PAGE

1. Adjust the variable resistor (or variable supply).
2. Swap the connections to the supply.
3. To limit the current and stop damage.
4. In the bottom-left quadrant (negative V and I).