

BOOKLET 3 • ELECTRONICS AND ANALOGUE
CONTROL

Circuits and Circuit Symbols

One set of symbols, so any engineer
can read your circuit.

National 5 Engineering Science



Daily Review

Booklet 2 — Energy

- 1 What is the unit of energy?
- 2 State the relationship between power, energy and time.
- 3 What is meant by wasted energy?
- 4 Can a machine ever be more than 100 % efficient?
- 5 Name one energy transfer that happens in a torch.

PART 1

Quantities and Symbols

Three quantities, sixteen symbols, and the language every circuit is drawn in.

By the end of this part...

- 1 I can describe voltage, current and resistance
- 2 I can use the correct circuit symbols for components

What a circuit is for

Booklet p.4

The job

Engineers design circuits to control how energy flows.

Three quantities

Voltage, current and resistance describe every circuit.

One language

Standard symbols let any engineer read your circuit.

Voltage, current and resistance

Booklet p.4

Quantity	Symbol	Unit	What it means
Voltage	V	volt (V)	the energy given to each unit of charge
Current	I	ampere (A)	the rate of flow of electric charge
Resistance	R	ohm (Ω)	how strongly a component opposes current

Supply and control

Booklet p.4-5 — Circuit Symbols



Cell

supplies electrical
energy



Battery

two or more cells
joined together



Switch

opens and closes
the circuit

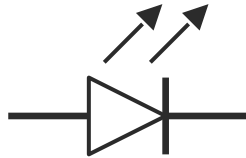
Output devices

Booklet p.4-5 — Circuit Symbols



Lamp

produces
light when
current flows



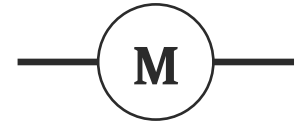
LED

lights when
current flows
the right way



Buzzer

produces
sound when
current flows



Motor

rotates when
current flows

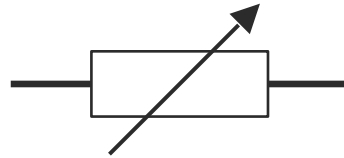
Controlling the current

Booklet p.4-5 – Circuit Symbols



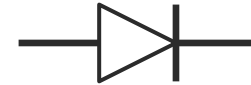
Resistor

limits the current in
a circuit



Variable resistor

resistance can be
adjusted by hand

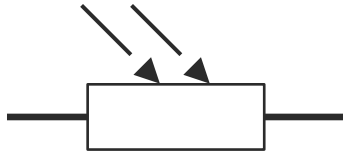


Diode

allows current to
flow in one
direction only

Sensors

Booklet p.4-5 – Circuit Symbols



LDR

resistance changes with light
level

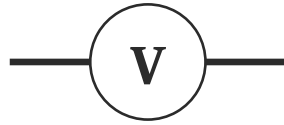


Thermistor (NTC)

resistance changes with
temperature

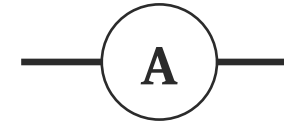
The two meters

Booklet p.4-5 – Circuit Symbols



Voltmeter

measures the voltage across a component

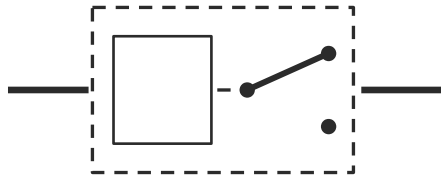


Ammeter

measures the current in the circuit

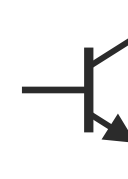
Switching a bigger circuit

Booklet p.4-5 — Circuit Symbols



Relay

uses a small current to switch a
larger circuit



NPN transistor

a fast electronic switch

Watch out

THE MISTAKE

- Ammeter and voltmeter drawn the same
- The battery drawn the wrong way round
- LDR and thermistor mixed up

THE CORRECT ANSWER

- The letter in the circle says which one it is
- The long line is +, the short line is –
- The LDR has light arrows; the thermistor has none

Your turn – the symbol table

Booklet p.4-5 – Circuit Symbols

The Symbol column in the table is blank.
Draw the correct symbol for all sixteen
components.

Booklet p.4-5 – the Circuit Symbols table

Circuit symbols – Answers (1 of 2)

ANSWERS

Booklet p.4-5 – the Symbol column



Cell



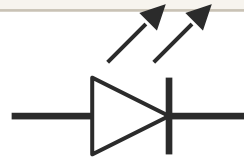
Battery



Switch



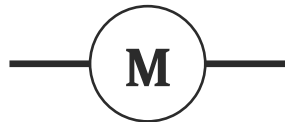
Lamp



LED



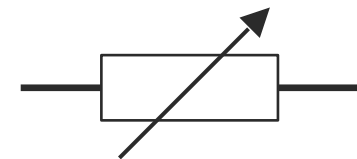
Buzzer



Motor



Resistor

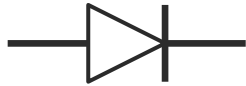


Variable resistor

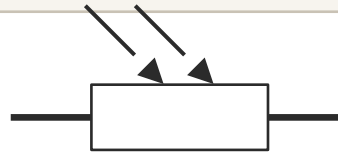
Circuit symbols – Answers (2 of 2)

ANSWERS

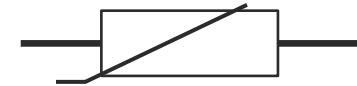
Booklet p.4-5 – the Symbol column



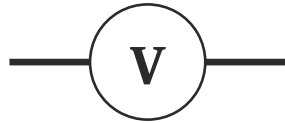
Diode



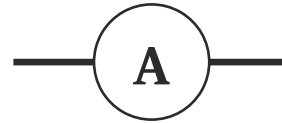
LDR



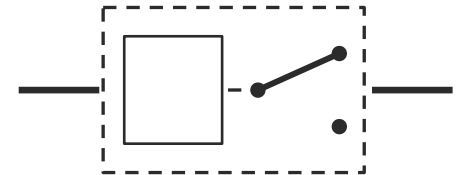
Thermistor (NTC)



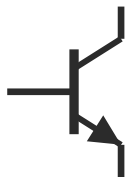
Voltmeter



Ammeter



Relay



NPN transistor

Show me – draw the symbol

SHOW ME BOARDS

- 1 Draw the symbol for a cell.
- 2 Draw the symbol for an ammeter.
- 3 Draw the symbol for an LDR.
- 4 Draw the symbol for a diode.
- 5 Draw the symbol for a buzzer.

Show me – draw the symbol

SHOW ME BOARDS

EXTRA PRACTICE

- 1 Draw the symbol for a battery.
- 2 Draw the symbol for a voltmeter.
- 3 Draw the symbol for a thermistor.
- 4 Draw the symbol for an LED.
- 5 Draw the symbol for a motor.

Show me – quantity and unit

SHOW ME BOARDS

- 1 What does the symbol I stand for, and what is its unit?
- 2 What is the unit of voltage?
- 3 Which quantity is measured in ohms?
- 4 Give the symbol and the unit for resistance.
- 5 Which quantity is the rate of flow of charge?

Show me – quantity and unit

SHOW ME BOARDS

EXTRA PRACTICE

- 1 What does the symbol V stand for, and what is its unit?
- 2 What is the unit of current?
- 3 Which quantity is measured in volts?
- 4 Give the symbol and the unit for current.
- 5 Which quantity says how strongly a component opposes current?

Checkpoint

- 1 Name the three quantities in a circuit and give the unit of each.
- 2 Draw the symbol for an LDR and say what it does.
- 3 Why do engineers all use the same circuit symbols?

Daily Review

Booklet p.4-5 — Symbols and Quantities

- 1 Draw the symbol for a battery.
- 2 Draw the symbol for a buzzer.
- 3 What is the unit of resistance?
- 4 What does the symbol I stand for?
- 5 What does a diode do?

PART 2

Series and Parallel

One loop or several branches — and a meter that has to go in the right place.

By the end of this part...

- 1 I can describe the difference between series and parallel circuits
- 2 I can connect a voltmeter and an ammeter correctly
- 3 I can apply the voltage and current rules in series and parallel
- 4 I can build and test simple circuits on a breadboard or in Yenka

Series – one path

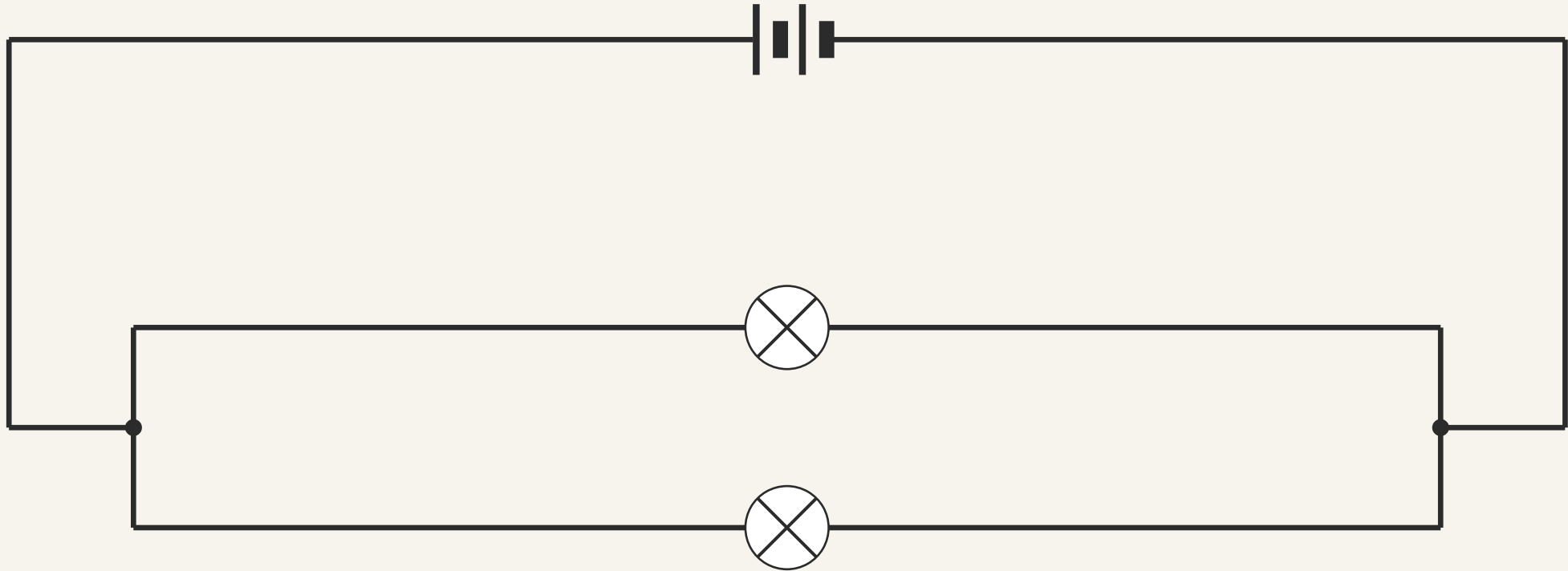
Booklet p.5



One loop, so the current is the same everywhere.

Parallel – the current splits

Booklet p.5



Separate branches, so each one gets the full supply voltage.

The rules

Booklet p.5

SERIES

One path, joined end to end.
The current is the same everywhere, and the supply voltage is shared out.

PARALLEL

Separate branches. The current splits and adds back, and every branch gets the full supply voltage.

Your turn – TASK 2

Booklet p.5 – TASK 2: Series and Parallel Rules

Fill in the three-row table.
Voltage, current and total resistance,
in series and in parallel.

Booklet p.5 – TASK 2

TASK 2 – Answers

ANSWERS

Booklet p.5 – Series and Parallel Rules

Quantity	Series circuit	Parallel circuit
Voltage	shared between the components	the same across each branch
Current	the same at every point	splits between the branches
Total resistance	$R_T = R_1 + R_2 + \dots$	the reciprocal formula – see Lesson 2

Show me — series or parallel?

SHOW ME BOARDS

- 1 Two lamps, one after the other, in a single loop.
- 2 Three lamps each on their own branch across a battery.
- 3 A circuit where the current is the same at every point.
- 4 A circuit where each lamp has the full supply voltage across it.
- 5 Fairy lights where one bulb failing stops them all.

Show me — series or parallel?

SHOW ME BOARDS

EXTRA PRACTICE

- 1 A torch with a cell, a switch and one lamp in one loop.
- 2 Two motors that can be switched on separately.
- 3 A circuit where the supply voltage is shared out.
- 4 A circuit where the current splits at a junction.
- 5 Car headlights that stay lit if one bulb fails.

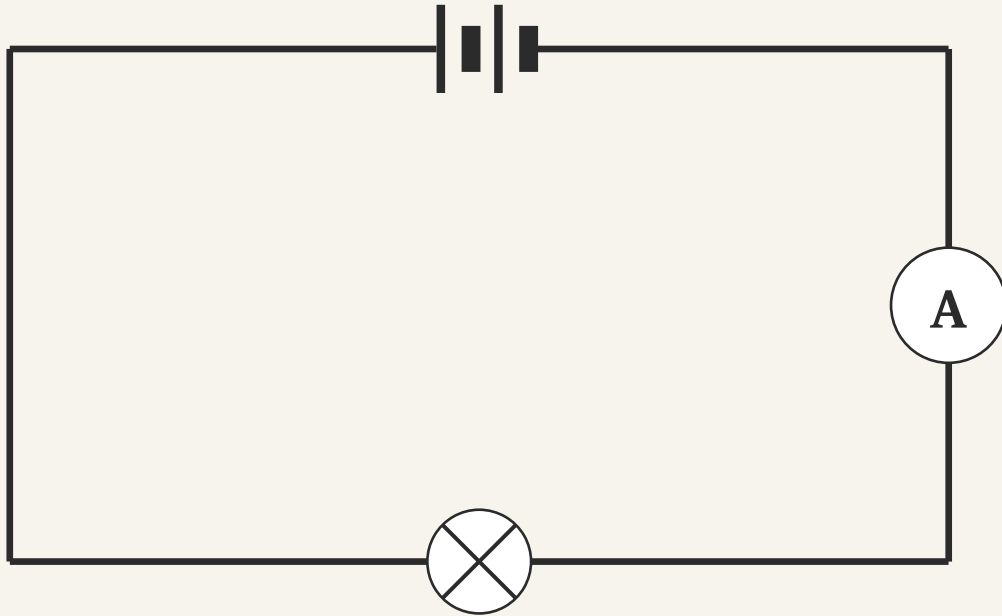
Measuring voltage and current

Booklet p.6

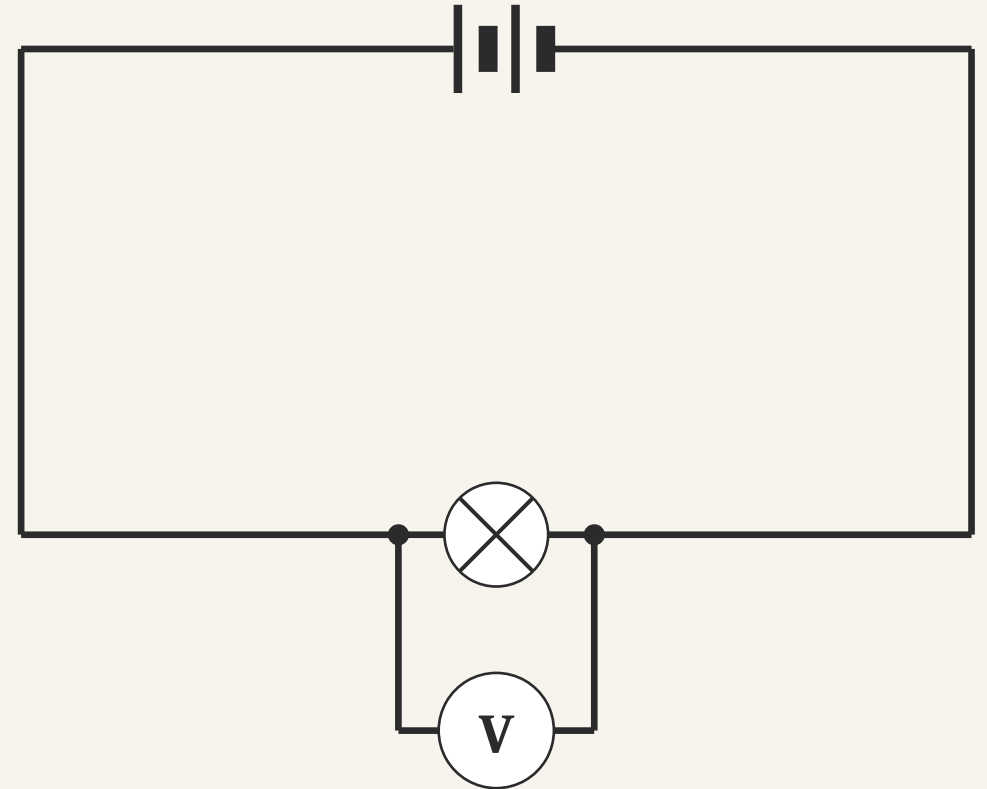
Meter	Measures	How to connect	Resistance
Voltmeter	voltage (V)	in parallel with the component	very high
Ammeter	current (A)	in series with the component	very low

Where each meter goes

Booklet p.6



Ammeter — in series



Voltmeter — across the lamp

Why the meter's resistance matters

Booklet p.6

Ammeter — very low

In series, so its resistance adds to the circuit. Very low, so it does not change the current it is measuring.

Voltmeter — very high

In parallel, so it offers the current another path. Very high, so almost none takes it.

Before you switch on

Booklet p.6 — the pre-power-up check

- Is the supply voltage set to the correct value?
- Are all the wires and components connected securely?
- Are the resistor values correct?
- Is the polarity of LEDs, diodes and the supply correct?

PRACTICAL TASK 1 — what you need

Booklet p.6 — Measuring Voltage and Current

Aim

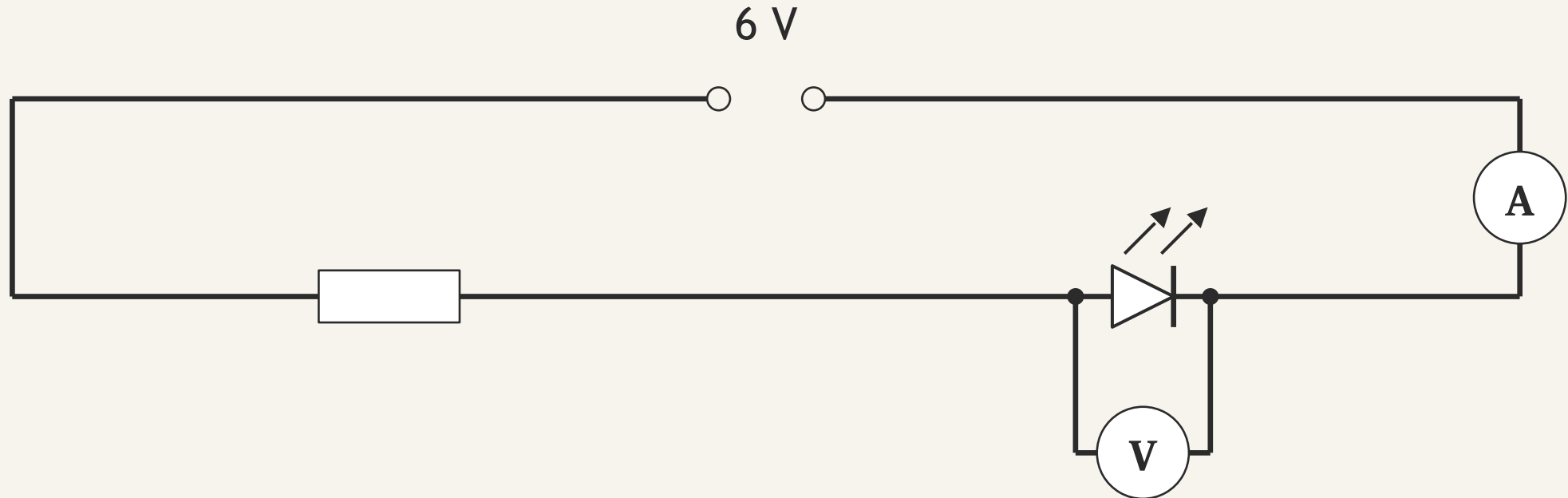
To build a simple LED circuit on a breadboard and measure the voltage and the current at each point.

Equipment

6 V dc supply · LED · protection resistor · breadboard · connecting leads · 2 multimeters and probes

The circuit you are building

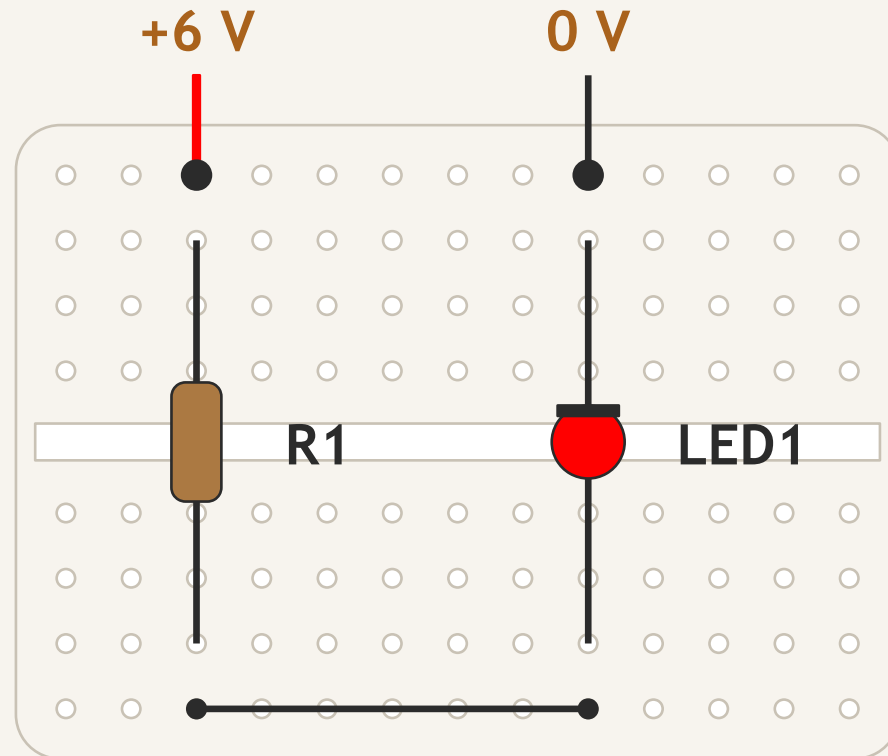
Booklet p.6 — PRACTICAL TASK 1



The protection resistor is what keeps the LED alive.

The same circuit on the board

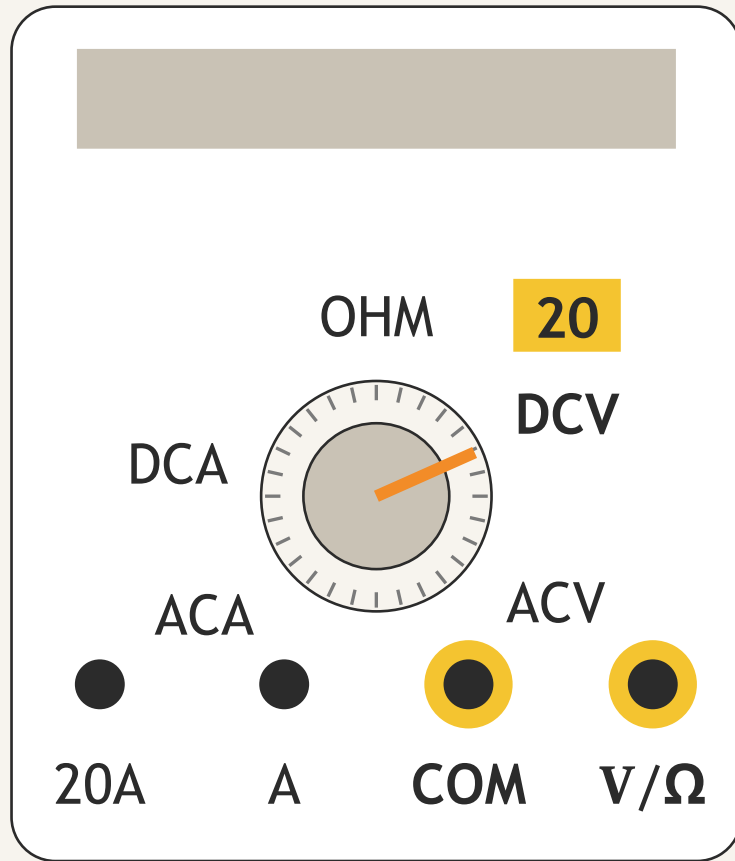
Booklet p.6 – PRACTICAL TASK 1



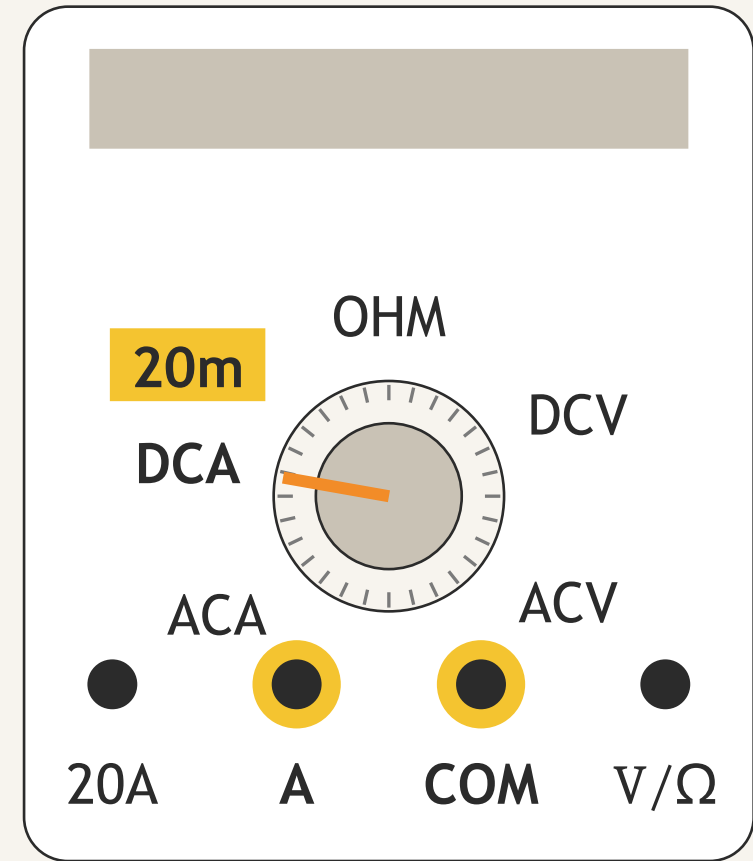
The red lead goes to the resistor. Only a component crosses the channel.

Setting the multimeter

The same meters you use in Physics



Voltage — across



Current — in series

Your turn – the practical

Booklet p.6 – PRACTICAL TASK 1

R1 bridges the centre channel.
LED1 bridges it further along –
flat side up, long leg in the lower bank.
Jumper the two lower rows together.
Supply leads into the two top rows:
red to R1, 0 V to LED1.
Then measure each voltage, and the current.

Booklet p.6 – PRACTICAL TASK 1

What you should have measured

ANSWERS

Booklet p.6 – PRACTICAL TASK 1

	Voltage	Current
Supply	about 6 V	the circuit current
LED	about 2 V, and it barely moves	the same current
Resistor	the rest of the supply	the same current

Series circuit: the voltages add up, the current is the same everywhere.

Your turn – the practice questions

Booklet p.7 – PRACTICE: Electricity and Circuits

Answer questions 1 to 10 in your booklet.
The marks are printed beside each question.
Every answer that is a number needs its unit.

Booklet p.7 – PRACTICE, Q1-10

PRACTICE — Answers, Q1-5

ANSWERS

Booklet p.7 — Electricity and Circuits

Q	The answer	Marks
1	the volt (V)	1
2	the ampere (A)	1
3	the ohm (Ω)	1
4	in parallel with — across — the component	1
5	in series, so the current flows through it	1

PRACTICE – Answers, Q6-8

ANSWERS

Booklet p.7 – Electricity and Circuits

Q	The answer	Marks
6	the current is the same at every point	1
7	the voltage across each branch is the same, and equal to the supply voltage	1
8	6 V across each lamp	1

PRACTICE — Answers, Q9-10

ANSWERS

Booklet p.7 — Electricity and Circuits

Q	The answer	Marks
9	any two — supply voltage correct, connections secure, resistor values correct, polarity correct	2
10	in series, so a very low resistance drops almost no voltage and does not reduce the current	2

LOOKING AHEAD

Ohm's Law

Now we can put numbers on it.

Plenary

- 1 Name the three quantities in a circuit, with their symbols and units.
- 2 Draw the symbol for a relay and say what it does.
- 3 State the current rule and the voltage rule for a series circuit.
- 4 Where does an ammeter go? Where does a voltmeter go?
- 5 Give one check you make before switching a circuit on.

- 1 Which quantity is measured in ohms, and what is its symbol?
- 2 Draw the symbol for a thermistor and say what it does.
- 3 State the current rule and the voltage rule for a parallel circuit.
- 4 Why must an ammeter have a very low resistance?
- 5 A 9 V supply feeds three identical lamps in series. Find each voltage.

Extension

- 1 Why does a car use a parallel circuit for its lights?
- 2 What would happen if you connected an ammeter in parallel with a lamp?
- 3 Two lamps in series share 9 V, but one is brighter. What does that tell you about the voltage across each?

- 1 Why is a house wired in parallel rather than in series?
- 2 What would happen if you connected a voltmeter in series with a lamp?
- 3 The LED in the practical stays at about 2 V however you change the resistor. Why is the resistor still needed?