CfE Electricity – BMcMULLEN

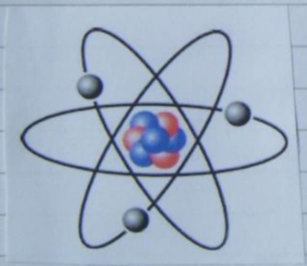
The Atom

Everything that is around us is made up of different elements.

Each element is made up of atoms.

Atoms are made up of:

- protons (+) } Found in the nucleus.
- Neutrons (0) } Found in the nucleus.
- Electrons (−) } Found in the orbits.



This is a recap of 'The Atom' from the Radioactivity Topic.

KEY:
- (blue) → Protons
- (red) → Neutrons
- (grey) → Electrons

In an atom:

Number of protons in the nucleus = Number of Electrons in the orbit.

NB Atoms have a neutral charge.

Charges

The two types of charge are called positive and negative.

Attraction

Opposite charges attract one another.

(+) → ← (−)

Repulsion

Like charges repel one another

← (+)   (+) →   OR   ← (−)   (−) →

Static Electricity has many applications based on attraction and repulsion.

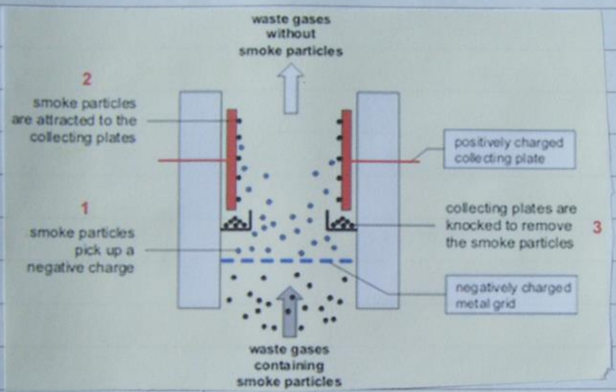
1) Electrostatic precipitators

Many power stations burn fossil fuels such as coal and oil.

Smoke is produced when these fuels burn. These smoke particles are tiny solid particles, which can damage buildings and cause breathing difficulties.

This diagram only shows the waste gases as the solid smoke particles have already been removed by the Electrostatic Precipitator.

How does it work?

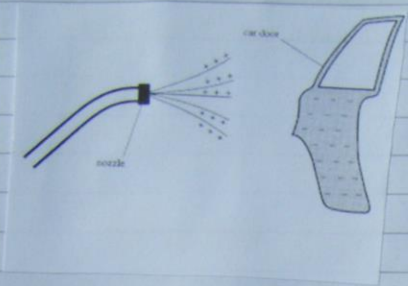


2) Car Spraypainting

The bodywork of a car is painted to prevent it from rusting and to make it aesthetically pleasing to look at.

The car is painted in a dust free environment. Notice that the painter also wears a mask to protect him from the paint fumes.

How does it work?



Paint from the spraygun is positively charged before it leaves the gun. (This is due to electrons being removed from it)

The car body is given a negative charge, which is opposite that of the paint.

The paint droplets are attracted to the car body, producing an even coat with very little waste.

Other applications of static electricity involve:

- Spraying crops with pesticides and herbicides
- Paramedics using defibrillators, with charge passing through the patient to make the heart contract using a high voltage supply.

You will have seen this used in hospital drama series such as Casualty or Holby City.

Electrical Current

Electrical current is defined as the number of coulombs of charge that pass a point per second.

Electrical current has the symbol I and it is measured in Amperes (A) and not Amps.

From the definition above:

$$I = \frac{Q}{t}$$

Q → charge (C)

t → time (s)

I → Current (A)

NOTE 1 Ampere = 1 Coulomb per second

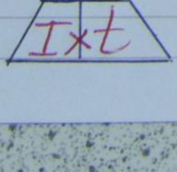
ie $1A = 1Cs^{-1}$

On the Data Sheet the equation is listed as

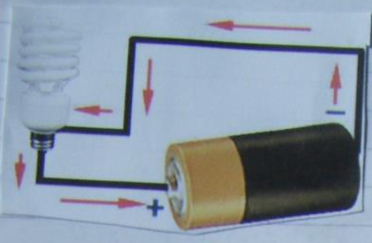
$$Q = It$$

⇒ Remember Quit!!

This is something that you will never do in Physics!!



1. $Q = It$
2. $I = \frac{Q}{t}$
3. $t = \frac{Q}{I}$



In Physics we talk about current in terms of 'electron flow'.

ie Out of the negative terminal of the battery or dc supply and then back into the positive.

Calculations involving Charge and Current

Ex1

A current of 0·4A flows through a lamp for 6 minutes.

Calculate the charge that has passed through the lamp in this time.

$Q = ?$

$I = 0{\cdot}4A$

$t = 6\text{minutes} = 360s$

$Q = It = 0{\cdot}4 \times 360$

$\Rightarrow Q = 144C$

Ex2

Calculate the current flowing in a circuit if $3{\cdot}6\times10^3C$ of charge are transferred in 30 minutes.

$Q = 3{\cdot}6\times10^3C$

$I = ?$

$t = 30\text{minutes}$

$= 30\times60 = 1800s$

$I = \frac{Q}{t} = \frac{3{\cdot}6\times10^3}{1800}$

$\Rightarrow I = 2A$

Ex3

The charge on an electron = (−) 1.6×10^{-19} C

Calculate:

Q a) How many electrons are required to produce a charge of 8×10^{-16} C?

b) How long would it take this charge to pass a point in a circuit to produce a current of 3A?

A a) $Q = 8 \times 10^{-16}$ C

$\therefore 1.6 \times 10^{-19}$ C → 1 electron

$\Rightarrow 8 \times 10^{-16}$ C → $\frac{8 \times 10^{-16}}{1.6 \times 10^{-19}}$ = 5000 electrons

b) $Q = 8 \times 10^{-16}$ C

$I = 3$A

$t = ?$

$t = \frac{Q}{I} = \frac{8 \times 10^{-16}}{3}$

$\Rightarrow t = 2.67 \times 10^{-16}$ s

Ex4

An LED TV draws a current of 0.3A.

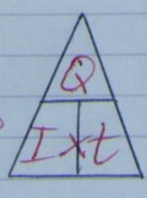
Calculate the charge passing through the LED TV if it is switched on for a 2 hour film.

$Q = ?$

$I = 0.3$A

$t = 2h = 2 \times 60 \times 60$

$= 7200$s

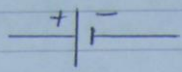


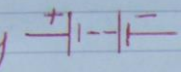
$Q = It$

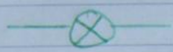
$\Rightarrow Q = 0.3 \times 7200$

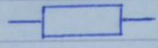
$\Rightarrow Q = 2160$C

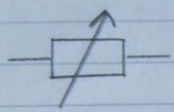
Circuit Symbols

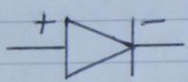
1) Cell 

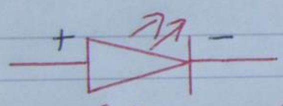
2) Battery 

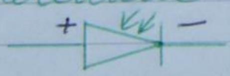
3) Lamp 

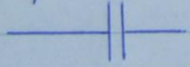
4) Resistor 

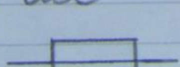
5) Variable Resistor 

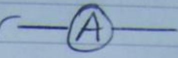
6) Diode 

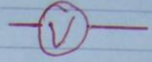
7) 
LED (Light Emitting Diode)

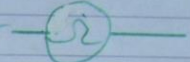
8) Photodiode


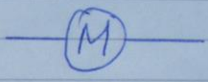
9) Capacitor


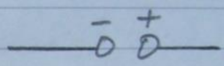
10) Fuse


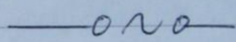
11) Ammeter 

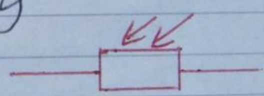
12) Voltmeter 

13) Ohmmeter 

14) Electric Motor 

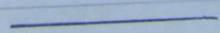
15) DC Supply 

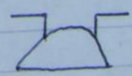
16) AC Supply 

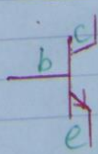
17) LDR 
(Light Dependant Resistor)

18) Thermistor


19) switch 

20) Wire 

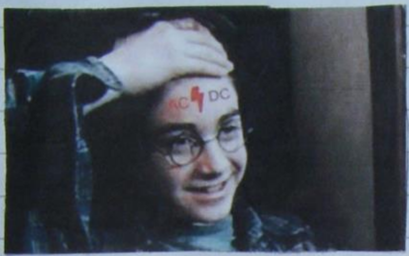
21) Buzzer 

22) npn transistor 

AC ϟ DC

When Harry Potter attended the Hogwarts School of Witchcraft and Wizardry, he was really deep down just a wee Physics Geek!!

Here is the Proof below.



What does AC and DC stand for?

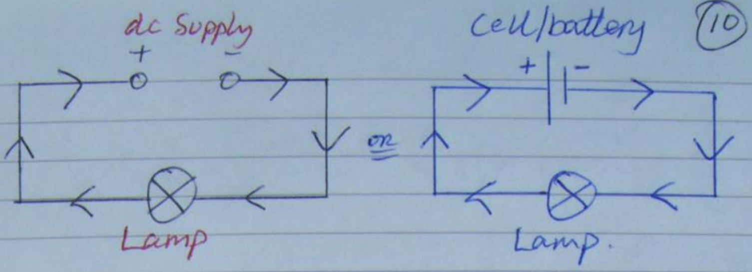
AC → Alternating Current

DC → Direct current.

1) DC → Direct Current

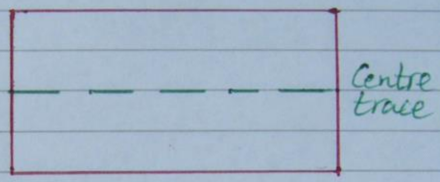
DC current comes from a battery or a dc power supply. (Out of the negative term and back into the positive terminal!!)

- The current flows in One direction Only.
- The current stays constant

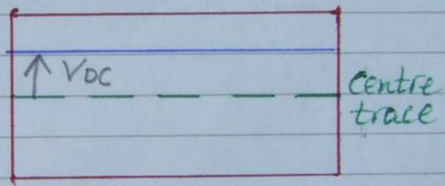


Connecting a battery or dc supply to an oscilloscope.

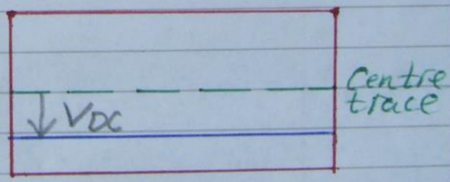
1) No battery or supply connected



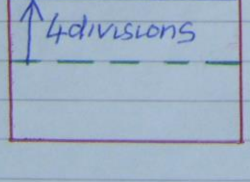
2) A battery is connected with the correct polarity. (+ve to +ve and -ve to -ve)



3) A battery is connected with the opposite polarity. (+ve to -ve and -ve to +ve)



Ex5



Oscilloscope setting

Y-gain = 5V per division

Calculate or find:

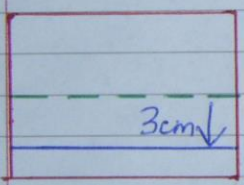
Q a) DC Voltage

b) Is the battery connected to the oscilloscope with the correct polarity?

A a) V_{DC} = 5V/division x 4divisions = **20V**

b) Yes, as the horizontal dc line has jumped up from the centre trace.

Ex6



Oscilloscope setting

Y-gain = 2V per cm

(On oscilloscopes 1division = 1cm)

Calculate or find:

Q a) DC Voltage

b) Is the battery connected to the oscilloscope with the correct polarity?

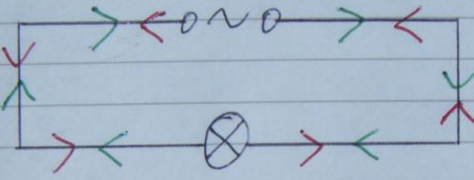
A a) V_{DC} = 2V per cm x 3cm = **6V**

b) No, as the horizontal dc line has dropped down from the centre trace.

2) AC → Alternating current

AC current comes from an ac supply or a transformer.

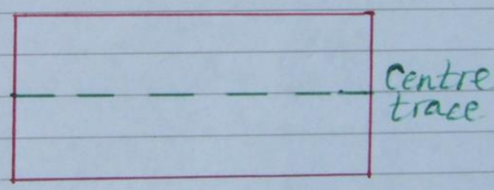
- The current changes direction every half cycle.
- The current varies continuously.



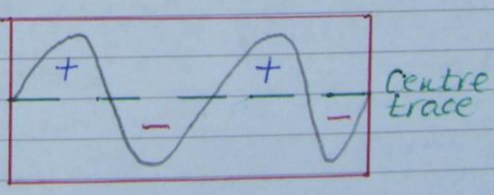
- 1st half cycle
- 2nd half cycle.

Connecting an ac supply to an Oscilloscope

1) No ac supply connected



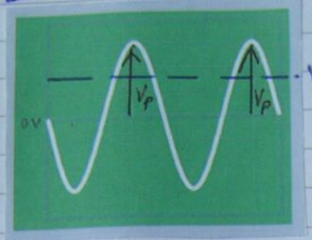
2) An ac supply now connected to the Oscilloscope



\+ on the ac waveform refers to the 1st and the 3rd half cycles.

– on the ac waveform refers to the 2nd and the 4th half cycles.

* In the UK: mains voltage = 230V (a.c)
mains frequency = 50Hz



V_p → Peak Voltage

V_{rms} → Root mean square voltage (sort of average ac voltage)

NB Average ac voltage = 0V

This is due to the +ve and −ve parts of the cycle cancelling each other out.

What is important about Vrms in ac?

This allows us to compare the ac voltage with the dc voltage.

- V_{rms} in AC = V_{DC}
- V_p in AC > V_{DC}

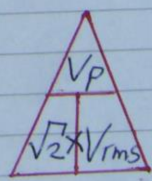
In AC

$$V_p = \sqrt{2} \times V_{rms}$$

V_p: Peak Voltage (Volts)

$\sqrt{2}$: (1.414 ≈ 1.5)

V_{rms}: Root mean square voltage (Volts)



1. $V_p = \sqrt{2} \times V_{rms}$
2. $V_{rms} = \dfrac{V_p}{\sqrt{2}}$

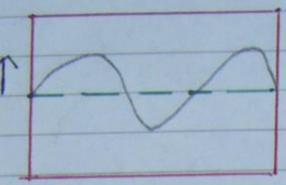
AC Voltage Calculations

Ex 7

OSCILLOSCOPE SETTING ⇒ Y-gain = 10V per cm

Q

2cm



Calculate or find:

a) V_p, the peak Voltage

b) V_{rms}, the rms Voltage

c) The equivalent Voltage in dc.

A

a) $V_p = 10V \text{ per cm} \times 2cm = \underline{\underline{20V}}$

b) $V_{rms} = \frac{V_p}{\sqrt{2}} = \frac{20}{\sqrt{2}} = \underline{\underline{14.1V}}$

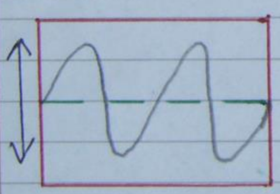
c) $V_{DC} = V_{rms} \text{ in AC} = \underline{\underline{14.1V}}$

Ex8

OSCILLOSCOPE SETTING ⇒ Y-gain = 0.5V per div

Q

6divs



Calculate or find:

a) V_p

b) V_{rms}

c) The equivalent voltage in dc.

A

a) $V_p = 0.5V \text{ per div} \times 3\text{divs}$ (Centre to top or bottom)

⇒ $\underline{\underline{V_p = 1.5V}}$

b) $V_{rms} = \frac{V_p}{\sqrt{2}} = \frac{1.5}{\sqrt{2}} = \underline{\underline{1.19V}}$

c) $V_{DC} = V_{rms} \text{ in AC} = \underline{\underline{1.19V}}$

Electrical Circuits

We discussed electrical current on page 5 with its definition and units.

Another quantity that is mentioned very often is 'Voltage'.

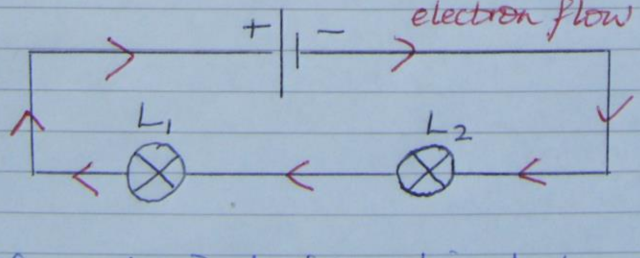
* Voltage is defined as the energy given to each coulomb of charge in a circuit. *

Voltage has the symbol V and it is measured in Volts (V).

Voltage can also be discussed in terms of the 'electrical push' that a supply gives to the charges.

Series Circuits

This is a circuit that has only one path that the current can take.

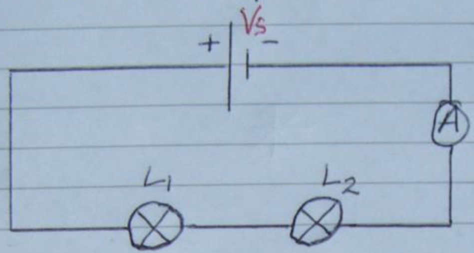


If a third identical lamp L_3 is added then all three lamps get dimmer.

Ammeters

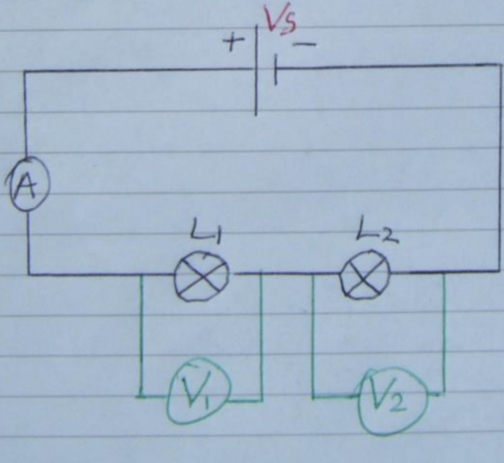
They are used to measure the electrical current in Amperes.

Ammeters are connected in series with the components in a circuit.



NB The ammeter can be placed at any point in series in the circuit.

Voltmeters



$V_S = V_1 + V_2$

Voltmeters are used to measure the voltage across a component and they are connected in parallel.

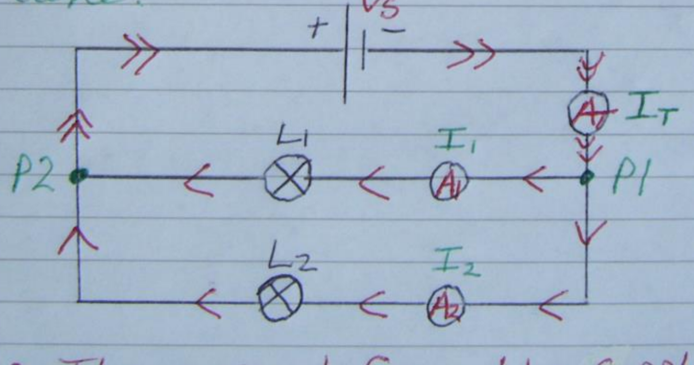
Summary of Series Circuits

- The current measured is the same at any point in a series circuit.
- The supply voltage is split between each of the components in a series circuit.

Parallel Circuits

In a series circuit we said that it had only one path for current to take.

In a parallel circuit the current will have two or more paths to take.



- The current from the supply Vs passes through the ammeter —A_T— until it reaches P1.
- At P_1 the current splits up into 2 different paths ie —A_1— and —A_2—

- The 2 currents then join back together at P_2 and then go back to the supply.

$$A_T = A_1 + A_2$$

ie $$I_T = I_1 + I_2$$

In a purely parallel circuit the voltage across each branch is the same as the voltage supply.

ie $$V_S = V_{L_1} = V_{L_2}$$

Summary of parallel Circuits

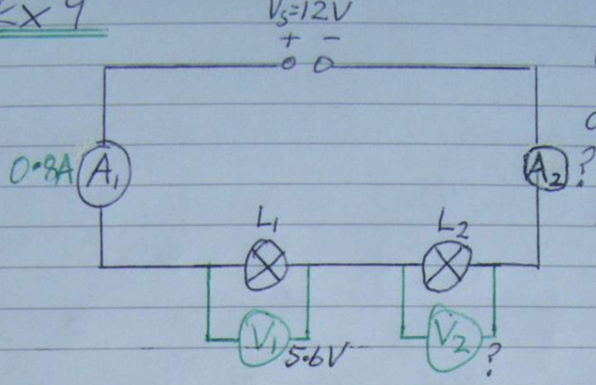
- The current from the supply splits up between each of the branches in a parallel circuit.
- The voltage across each branch in a parallel circuit is the same as the supply voltage.

KEY POINTS

- Current passes through and Voltage is dropped across a component.
- SERIES CIRCUIT ⇒ CURRENT → SAME + VOLTAGE → SPLITS
- PARALLEL CIRCUIT ⇒ CURRENT → SPLITS + VOLTAGE → SAME

Ex 9

Q



Calculate or find:

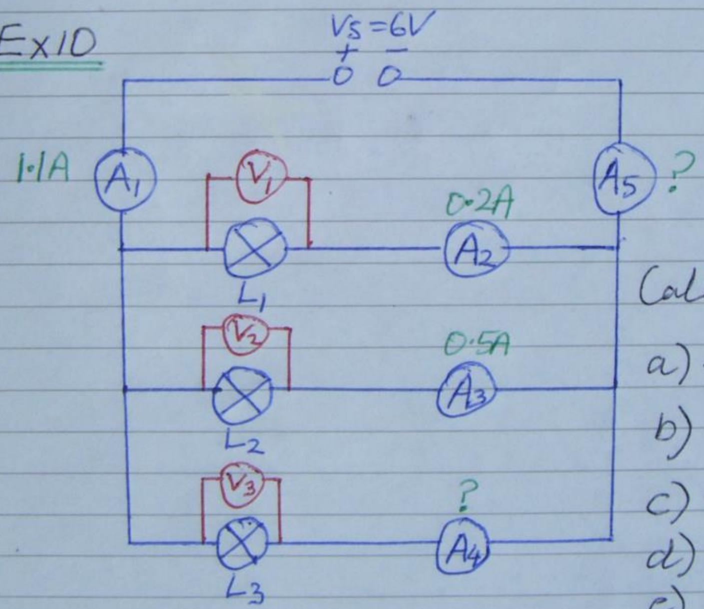
a) A2 = ?

b) V2 = ?

A a) A2 = **0·8A** ⇒ Series → Current same

b) V2 = 12V − 5·6V = **6·4V** ⇒ Series ⇒ Voltage splits

Ex 10



Calculate or find:

a) A4 = ?

b) A5 = ?

c) V1 = ?

d) V2 = ?

e) V3 = ?

a) A4 = 1·1 − (0·2 + 0·5) = **0·4A**

b) A5 = A1 = **1·1A**

c) and d) and e) = **6V** (Same as Vs)

Ohms Law

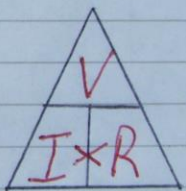
A resistor is a component which opposes the flow of current in a circuit.

ie The greater the resistance the smaller the current.

Ohms Law is the most commonly used electrical equation in Physics.

$$V = IR$$

- V → Voltage / potential difference (Volts) → (V)
- I → Current (Amperes) → (A)
- R → Resistance (Ohms) → (Ω)



1/ $V = IR$ 2/ $I = \frac{V}{R}$ 3/ $R = \frac{V}{I}$

Ex11

Calculate the Voltage dropped across a $2.5k\Omega$ resistor if a current of 150mA flows through it.

$V = ?$
$I = 150mA = 150 \times 10^{-3} A$
$R = 2.5k\Omega = 2.5 \times 10^{3} \Omega$

$V = IR = 150 \times 10^{-3} \times 2.5 \times 10^{3}$

$\Rightarrow V = 375V$

Ex12

A voltage of 60mV is dropped across a resistor R.
Calculate the resistance of resistor R if a current of 300μA passes through it.

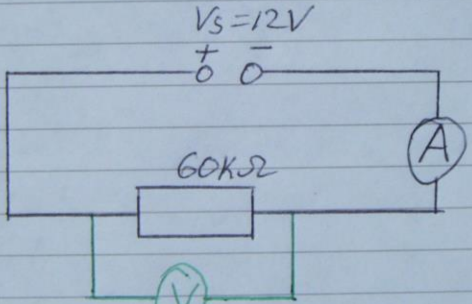
$V = 60mV = 60\times10^{-3}V$
$I = 300\mu A = 300\times10^{-6}A$
$R = ?$

$R = \frac{V}{I}$

$\Rightarrow R = \frac{60\times10^{-3}}{300\times10^{-6}}$

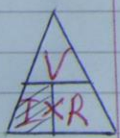
$\Rightarrow R = 200\Omega$

Ex13



Calculate the current reading on the ammeter —(A)—.

- —(V)— = 12V ⇒ All of the supply voltage is dropped across the resistor.



- —(A)— = ?

$V = 12V$
$I = ?$
$R = 60k\Omega = 60\times10^{3}\Omega$

$I = \frac{V}{R} = \frac{12}{60\times10^{3}} = 2\times10^{-4}A$

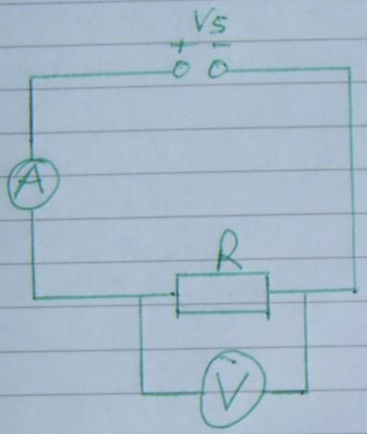
Instruments to measure Resistance

An unknown Resistance R can be measured using

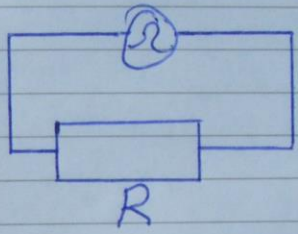
- An ammeter and Voltmeter method

  OR

- An Ohmmeter method.



$R = \dfrac{\text{Reading on (V)}}{\text{Reading on (A)}}$



The resistance can be read straight off the Ohmmeter
* No power supply or battery required here!!

Multimeters

Multimeters can be used to measure

- Current
- Voltage
- Resistance.

Using a multimeter to measure Current, Voltage and Resistance.

DC CURRENT

TERMINALS
- COM
- 10A DC

RANGE SCALE
- 10A ===

DC VOLTAGE

TERMINALS
- COM
- VΩ mA

RANGE SCALE
- 20V ===

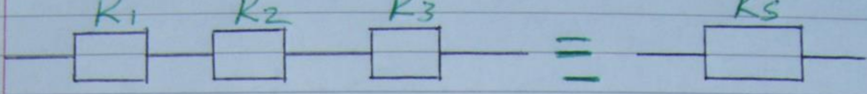
RESISTANCE

TERMINALS
- COM
- VΩ mA

RANGE SCALE
- 200Ω (OR HIGHER!!)

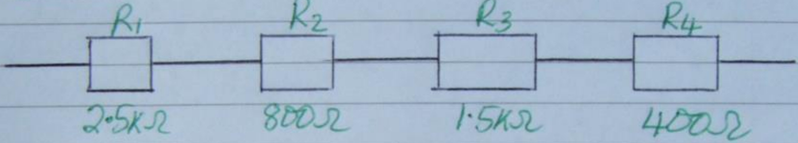
Resistors connected in series.

This involves resistors connected in-line with one another.



$$* \quad R_S = R_1 + R_2 + R_3 + \ldots \quad *$$

Ex14

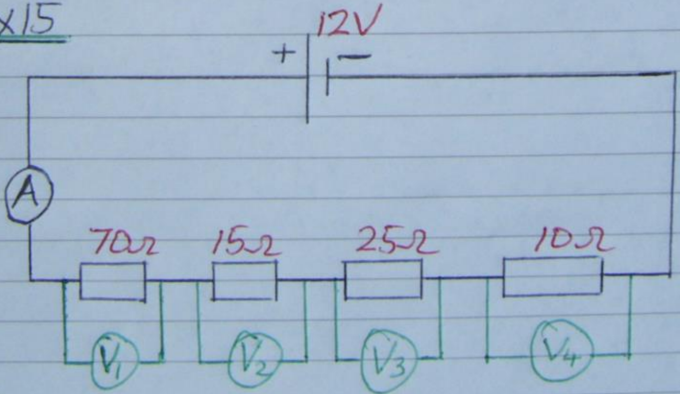


Calculate the total resistance in series.

$R_S = R_1 + R_2 + R_3 + R_4 = 2500 + 800 + 1500 + 400$

$\Rightarrow R_S = \underline{5200\,\Omega}$ or $\underline{5{\cdot}2\,k\Omega}$

Ex15



Calculate or find:

Q a) Total resistance in series

b) Reading on the ammeter

c) Readings on 1) —(V_1)—

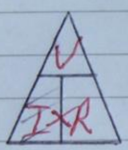
2) —(V_2)—

3) —(V_3)—

4) —(V_4)—

A a) $R_S = R_1 + R_2 + R_3 + R_4 = 70 + 15 + 25 + 10 = \underline{\underline{120\,\Omega}}$

b) $V = 12V$
$I = ?$
$R = 120\,\Omega$



$I = \frac{V}{R} = \frac{12}{120} = \underline{\underline{0.1A}}$

c) 1) $V_1 = IR_1 = 0.1 \times 70 = \underline{\underline{7V}}$

2) $V_2 = IR_2 = 0.1 \times 15 = \underline{\underline{1.5V}}$

3) $V_3 = IR_3 = 0.1 \times 25 = \underline{\underline{2.5V}}$

4) $V_4 = IR_4 = 0.1 \times 10 = \underline{\underline{1V}}$

(Check, $V_S = V_1 + V_2 + V_3 + V_4$

$\Rightarrow 12V = 7V + 1.5V + 2.5V + 1V$!!)

* When more resistors are added in series then the total resistance in series increases. *

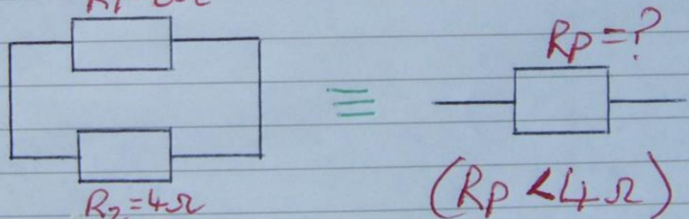
Resistors connected in parallel

This involves resistors connected across one another.

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

Ex16

Q



A

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{6} + \frac{1}{4} = 6^{-1} + 4^{-1}$$

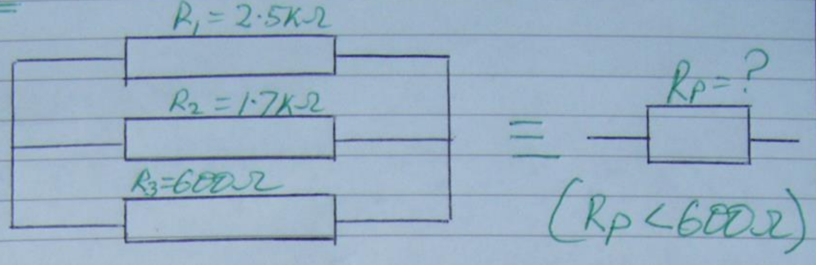
$$\Rightarrow \frac{1}{R_P} = \frac{5}{12} \Rightarrow \frac{R_P}{1} = \frac{12}{5} \Rightarrow R_P = 2.4\Omega$$

OR $$\frac{1}{R_P} = 0.4167 \Rightarrow \frac{R_P}{1} = \frac{1}{0.4167} \Rightarrow R_P = 2.4\Omega$$

(Resistance usually measured to 1dp)

Ex17

Q



A

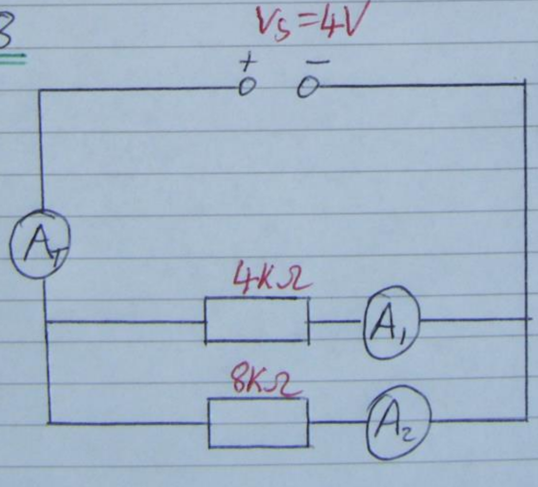
$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{2500} + \frac{1}{1700} + \frac{1}{600}$$

$$\Rightarrow \frac{1}{R_P} = 2500^{-1} + 1700^{-1} + 600^{-1} = \frac{677}{255000}$$

$$\Rightarrow \frac{1}{R_P} = 2.655 \times 10^{-3} \Rightarrow \frac{R_P}{1} = \frac{1}{2.655 \times 10^{-3}}$$

$$\Rightarrow R_P = 376.7\Omega \approx 377\Omega$$

Ex18



Calculate or find:

a) R_P

b) Reading on A_T

c) i) Reading on A_1

ii) Reading on A_2

Q a) $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{4000} + \frac{1}{8000}$

$\Rightarrow \frac{1}{R_P} = 4000^{-1} + 8000^{-1} = \frac{3}{8000} = 3.75 \times 10^{-4}$

$\Rightarrow \frac{R_P}{1} = \frac{1}{3.75 \times 10^{-4}} \Rightarrow R_P = 2667\,\Omega$

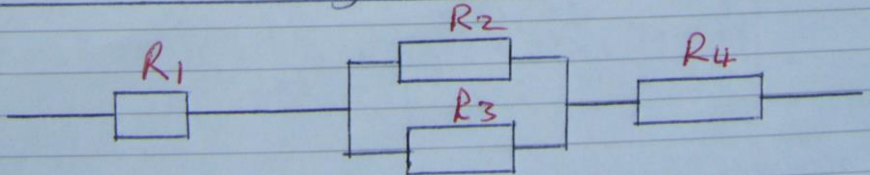
b) $I_T = \frac{V_S}{R_P} = \frac{4}{2667} = 1.5 \times 10^{-3}\,A$

c) i) $I_1 = \frac{V_S}{R_1} = \frac{4}{4000} = 1 \times 10^{-3}\,A$

ii) $I_2 = \frac{V_S}{R_2} = \frac{4}{8000} = 5 \times 10^{-4}\,A \; (0.5 \times 10^{-3}\,A)$

(Check $I_T = I_1 + I_2 \Rightarrow 1.5 \times 10^{-3} = 1 \times 10^{-3} + 0.5 \times 10^{-3}$) ✓ OK!!

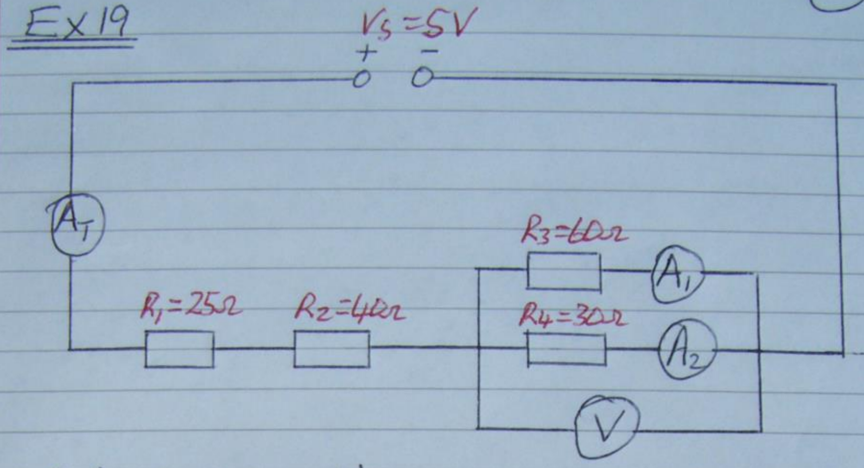
Resistors in series and parallel connected together



$R_S = R_1 + R_4$, $\frac{1}{R_P} = \frac{1}{R_2} + \frac{1}{R_3}$

$\Rightarrow$ * $\boxed{R_T = R_S + R_P}$ * Not in DB!!

Ex 19



Q Calculate or find:

a) R_S b) R_P c) R_T d) Reading on A_T

e) Readings on i) A_1 ii) A_2

f) Reading on V

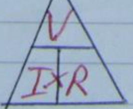
A a) $R_S = R_1 + R_2 = 25 + 40 = 65\Omega$

b) $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{60} + \frac{1}{30} = 60^{-1} + 30^{-1}$

$\Rightarrow \frac{1}{R_P} = \frac{1}{20} \Rightarrow \frac{R_P}{1} = \frac{20}{1} \Rightarrow R_P = 20\Omega$

c) $R_T = R_S + R_P = 65 + 20 = 85\Omega$

d) $V_S = 5V$
$I = ?$
$R_T = 85\Omega$



$I = \frac{V}{R} = \frac{5}{85} = 0.06A$

e) i) $-(A_1)- = ?$, $V = IR_p = 0.06 \times 20 = 1.2V$

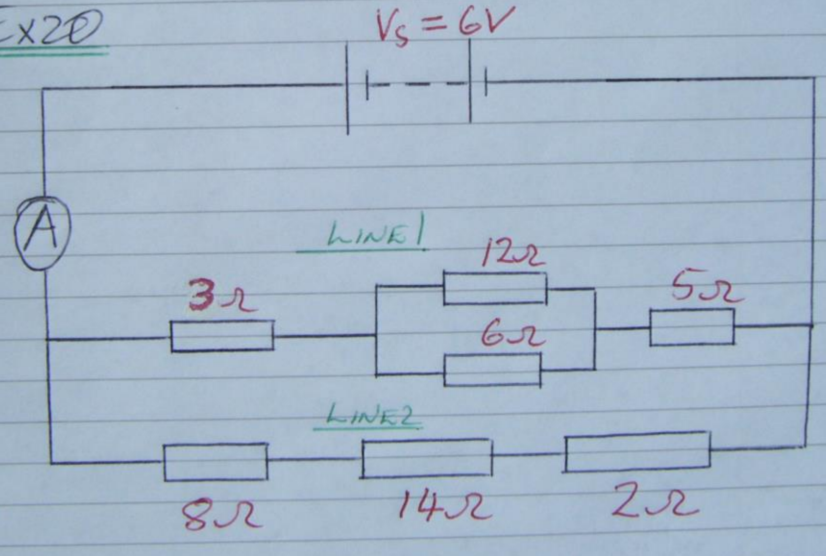
$\Rightarrow I_1 = \frac{V_p}{R_1} = \frac{1.2}{60} = 0.02A$

ii) $-(A_2)- = ?$ $V = IR_p$ again!!

$\Rightarrow I_2 = \frac{V_p}{R_2} = \frac{1.2}{30} = 0.04A$

f) The voltage dropped across each branch in a parallel circuit is the same. $\therefore$ $-(V)- = 1.2V$

Ex20



Q Calculate or find:

a) Total resistance, R_T in the circuit

b) Reading on the ammeter $-(A)-$.

<u>Line 1</u>

A a) $R_T = R_S + R_P$

• $R_S = 3\Omega + 5\Omega = 8\Omega$

• $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{12} + \frac{1}{6} = 12^{-1} + 6^{-1} = \frac{1}{4}$

$\Rightarrow \frac{R_P}{1} = \frac{4}{1} \Rightarrow R_P = 4\Omega$

$R_T = R_S + R_P = 8 + 4 = 12\Omega$

<u>Line 2</u>

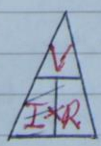
$R_S = 8\Omega + 14\Omega + 2\Omega = 24\Omega$

COMBINATION OF LINE 1 AND LINE 2

$\frac{1}{R_P} = \frac{1}{12} + \frac{1}{24} = 12^{-1} + 24^{-1} = \frac{1}{8}$

$\Rightarrow \frac{R_P}{1} = \frac{8}{1} \Rightarrow R_P = 8\Omega$

b) $V_S = 6V$
$I = ?$
$R = 8\Omega$



$I = \frac{V_S}{R} = \frac{6}{8} = 0.75A$

Resistance Wires

The resistance of a wire depends on :

- Thickness of the wire
- Length of the wire
- Type of material of the wire

Think of a wire like a road, and the cars driving along the road like charges moving through the wire.

Conclusion

A large current will be obtained when a wire is thick and short.

ie More cars will be able to travel from A to B along a road if:

- The road is short in length
- The road has multiple lanes like a motorway. (Thicker road).

mains Voltage ↖ mains frequency ↓

Mains supply (230V ac) (50Hz)

The mains supply is split into different domestic circuits.
Each of these domestic circuits have a mains fuse OR miniature circuit Breaker (MCB). These devices protect the mains wiring.

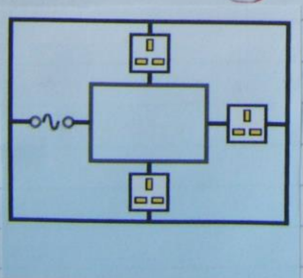
The two most common types of circuit are:

- Lighting Circuit
- Power Ring circuits

Lighting Circuit

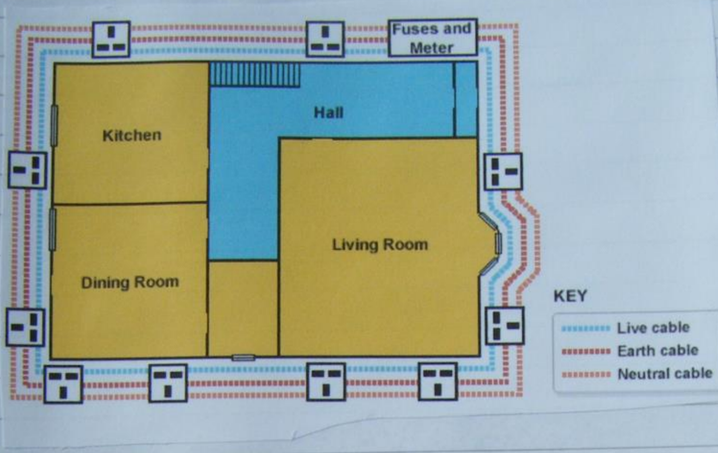
The lamps are wired in parallel so that they can be switched on independantly of each other.
Each lamp will operate at 230V with the power of the lamp determining how bright it is.

Power Ring Circuit



The power sockets in your homes are wired in a special 'Loop parallel circuit' called a power ring circuit

Power ring circuit wiring in a house



A power ring mains circuit gives two paths for current to take. This effectively halves the current flowing through the cables.

The cable will not heat up as much, so thinner cable can be used, which cuts costs.

Comparison of lighting circuit and Power Ring Circuit

Lighting Circuit	Power Ring Circuit
• Supplies fixed lights	• Supplies power sockets
• Uses 5A fuse	• Uses 30A fuse
• Uses thinner cable	• Uses thicker cable
• Parallel Circuit	• 'Loop' parallel Circuit

Calculating 'Electricity' Bills

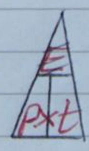
The Electricity suppliers use a unit called kilowatt hours (KWh) to measure the electrical energy used.

Why not Joules?

The number of Joules used would be far too large.

eg   1KWh = ? Joules.

E = ?
P = 1KW = 1000W
t = 1h = 60x60 = 3600s



E = Pt
⇒ E = 1000 x 3600
⇒ E = 3,600,000J

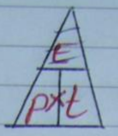
ie   1KWh = 3,600,000J

1KWh = 1 unit ≈ 15p per unit.

Ex21

Q/ How much would it cost to switch on a 70W LED TV for 12 hours.

A) $E = ?$
$P = 70W = \frac{70}{1000} = 0.07kW$
$t = 12$ hours



$E = Pt = 0.07 \times 12 = 0.84kWh$.

$0.84kWh = 0.84$ units

1 unit = 15p ∴ 0.84 units = $0.84 \times 15p$

$= \underline{12.6p}$

Ex22

A LHS pupil has a marathon session on his Playstation, which has a power rating of 200 Watts.

Q) If the session costs 21p in electrical energy, then calculate or find:

a) How many units of electrical energy he used if it costs 15p per unit?

b) How long the session lasted?

A) a) 15p → 1 unit ∴ 21p → $\frac{21}{15} = \underline{1.4 \text{ units}}$

b) $E = 1.4kWh$
$P = 200W = 0.2kW$
$t = ?$

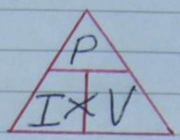
$t = \frac{E}{P} = \frac{1.4}{0.2} = \underline{7 \text{ hours}}$

The three Electrical Power Equations

1) Power, Current and Voltage

$$P = I V$$

P — Power (W)
I — Current (A)
V — Voltage (V)

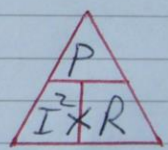


i) $P = IV$ ii) $I = \frac{P}{V}$ iii) $V = \frac{P}{I}$

2) Power, Current and Resistance

$$P = I^2 R$$

P — Power (W)
I^2 — {Current (A)}^{2}
R — Resistance (Ω)



i) $P = I^2 R$ ii) $I^2 = \frac{P}{R}$ iii) $R = \frac{P}{I^2}$

3) Power, Voltage and Resistance

$$P = \frac{V^2}{R}$$

P — Power (W)
V^2 — {Voltage (V)}^{2}
R — Resistance (Ω)

i) $P = \frac{V^2}{R}$ ii) $V^2 = PR$ iii) $R = \frac{V^2}{P}$

Ex23

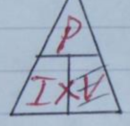
A resistor of power rating 10W has a current of 0.5A passing through it.

Q Calculate or find:

a) The Voltage dropped across the Resistor.

b) The Resistance of the Resistor.

A a) $P = 10W$
$I = 0.5A$
$V = ?$



$$V = \frac{P}{I} = \frac{10}{0.5} = 20V$$

b) $R = ?$ With plenty of information available, you can use

- $R = \frac{V}{I}$ OR • $R = \frac{P}{I^2}$ OR • $R = \frac{V^2}{P}$

$$R = \frac{V}{I} = \frac{20}{0.5} = 40\Omega$$

OR

$$R = \frac{P}{I^2} = \frac{10}{0.5} = 40\Omega$$

OR

$$R = \frac{V^2}{P} = \frac{20^2}{10} = 40\Omega$$

Ex 24.

A lamp of power rating 150W operates from a 230V mains supply.

Q Calculate or find:

a) Resistance of the lamp

b) Current passing through the lamp.

A a) $P = 150W$
$V = 230V$
$R = ?$

$R = \frac{V^2}{P} = \frac{230^2}{150}$

$\Rightarrow R = 353\Omega$

This part of the question can also be done in 2 parts!!

$P = IV$ then $V = IR$

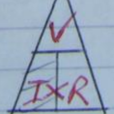
$\Rightarrow I = \frac{P}{V} = \frac{150}{230}$ $\quad R = \frac{V}{I} = \frac{230}{0.652}$

$\Rightarrow I = 0.652A$ $\quad R = 353\Omega$

↑

This then gives the answer to part b).

b) $V = 230V$
$I = ?$
$R = 353\Omega$



$I = \frac{V}{R} = \frac{230}{353} = 0.652A$

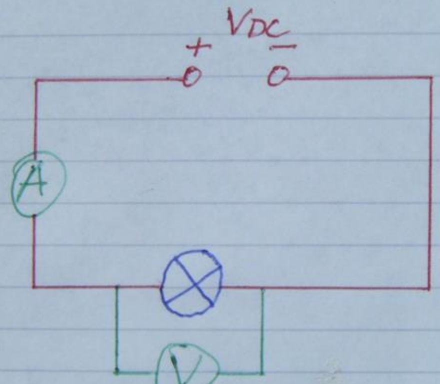
Ex25

Q a) Design a dc circuit diagram that can measure the power rating and the resistance of a lamp.

b) i) Explain how the power rating of the lamp is found.

ii) Explain how the resistance of the lamp is found.

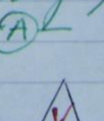
A a)



b) i) $P = IV$

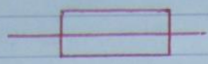
$\Rightarrow$ Power Rating of the lamp = Reading on (A) × Reading on (V)

ii) $V = IR \Rightarrow R = \frac{V}{I}$

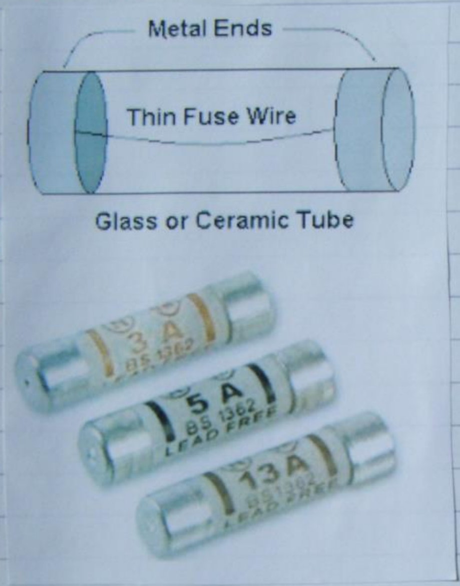


$\Rightarrow$ Resistance of the lamp = $\frac{\text{Reading on (V)}}{\text{Reading on (A)}}$

Fuses

Symbol  ⇐ Do not confuse with a resistor!

You will find a fuse inside a plug for any appliance.



The purpose of a fuse is to protect the wiring from overheating and possibly causing a fire in the appliance, when a fault develops.

⇒ Fuses have different ratings such as 3A, 5A and 13A in the diagram.

As a rough 'rule of thumb':

Appliances with power rating < 700W use a 3A fuse.

Appliances with a power rating > 700W use a 13A fuse.

You can show by calculation which fuse rating to use in the plug of an appliance using the power equations. ($P=IV$, $P=I^2R$, $P=\frac{V^2}{R}$)

Ex 26

An electric fire of power rating 1.15 kW is connected to the mains supply.

Q

a) Calculate the current that the electric fire draws from the mains supply.

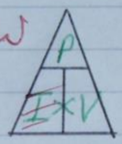
b) Explain from the calculation in a) whether a 3A or a 13A fuse is used in the plug.

A

a) $P = 1.15\,kW = 1.15 \times 10^3\,W$

$I = ?$

$V = 230V$ (mains)



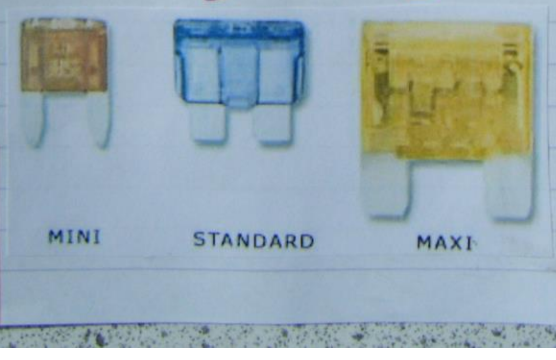
$I = \frac{P}{V} = \frac{1.15 \times 10^3}{230}$

$I = 5A$

b) A 13A fuse is required as the current in the appliance is greater than 3A.

Fuses in cars

Modern cars use a lot of fuses of different types.
All calculations are based on the battery voltage = 12V.



Three different types of car fuses.