isaac Physics. You work it out.

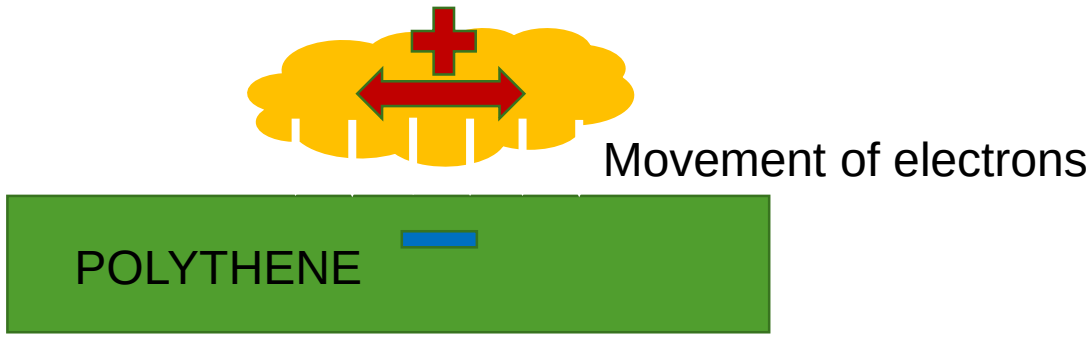
Electricity

GCSE overview

isaacphysics.org
https://isaacphysics.org/pages/remote_learning

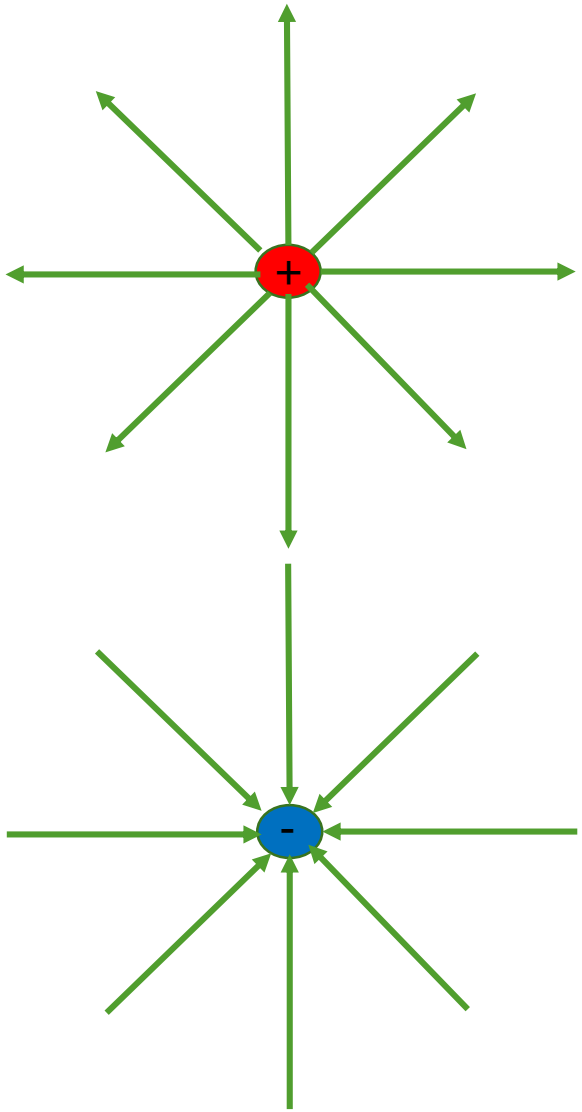
Electrostatics

- Electrons are negative & can move (the rest of the atom stays still)
- Friction allows some electrons to move from one object to another – charging by friction.
  - The object which loses electrons becomes positive.
  - The object which gains electrons becomes negative.



Electrostatics

- Electric field lines point in the direction a +ve charge would accelerate.
  - The closer the lines, the stronger the field
  - Electrons would accelerate the opposite way.
  - Example: Field outside a charged metal sphere.
  - If field is strong enough, it can pull electrons out of atoms, and speed them up so that they can knock electrons out of other atoms – this sudden flow of electrons is a spark.



Electrical quantities

Name	Symbol	Unit	Equations	Isaac chapter	Description (Pizza delivery analogy)
Charge	Q	coulomb (C)	Q=It	21	Electric stuff = motorcycles
Current through	I	amp (A)			Delivery rate of electric stuff = no of motorcycles sent each hour
Voltage (or pd) across	V	volt (V)	V = E/Q	26	Energy content of charge = no of pizzas on each motorcycle
Power	P	watt (W)	P = E/t P = IV P = I^2R	26 26 27	Delivery rate of energy = pizzas delivered each hour
Energy	E	joule (J)	E = Pt E= VIt	26	Number of pizzas delivered
Resistance	R	ohm (Ω)	V=IR Series: $R_t = R_1+R_2$	24	Obstruction to charge flow (‘voltage needed to push an amp’)

Energy can also be measured in kilowatt-hours (kWh) = Power in kW x Time in hours

Equation practice – fill in the gap

You know these		Work this out
Voltage = 6.0V	Current = 0.03A	Resistance
Voltage = 6.0V	Current = 0.03A	Power
Resistance = 300Ω	Current = 0.05A	Power
Charge = 150C	Time = 50s	Current
Current = 0.30A	Time = 3 minutes	Charge
Energy = 120J	Charge = 40C	Voltage
Current = 6A, Voltage = 12V	Time = 5 minutes	Energy

If electricity is 18p per kWh, how much does it cost to run a 3kW heater for 8 hours overnight?

Equation practice – fill in the gap

You know these		Work this out	Isaac chapter
Voltage = 6.0V	Current = 0.03A	Resistance R = V/I = 6/0.03 = 200Ω	24
Voltage = 6.0V	Current = 0.03A	Power P = IV = 0.03x6 = 0.18W	26
Resistance = 300Ω	Current = 0.05A	Power P = I^2R = 0.05^2x300 = 0.75W	27
Charge = 150C	Time = 50s	Current I = Q/t = 150/50 = 3.0A	22
Current = 0.30A	Time = 3 minutes	Charge Q = It = 0.30 x (3x60) = 54C	22
Energy = 120J	Charge = 40C	Voltage V = E/Q = 120/40 = 3.0V	26
Current = 6.0A Voltage = 12V	Time = 5 minutes	Energy E=VIt = 12 x 6.0 x (5x60) = 21 600J	26

If electricity is 18p per kWh, how much does it cost to run a 3kW heater for 8 hours overnight?

Energy = 3kW x 8 hours = 24kWh. Cost = 24 x 18p = 432p = £4.32

Circuit rules

Don’t forget: V=IR, P=IV

	in Parallel	in Series
Currents **THROUGH** components	add up to give battery current	all same as battery current
Voltage **ACROSS** components	all same as battery voltage	add up to give battery voltage
Resistance of combination	is smaller than resistance of smallest resistor	is the sum of the resistances

Current can split at junctions, and is NOT shared between components in series.

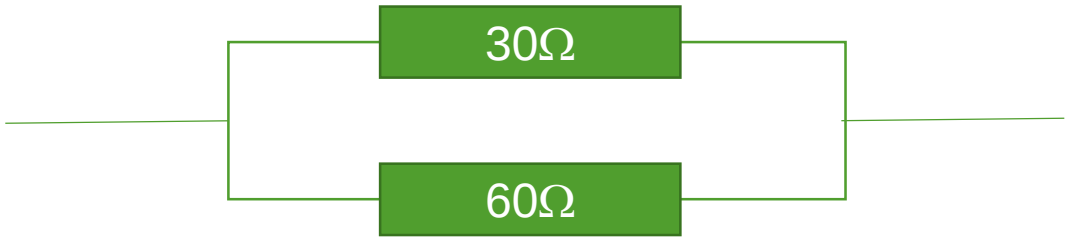
Voltage does NOT split at junctions, but is shared between components in series.
Two motorcycles approach a junction, each with six pizzas.
At the junction, one goes left, one goes right – they still have six pizzas each.

Current flowing out of a component = current flowing in.
Pizza delivery customers do not eat motorcycles.

Resistors

› **Resistors in Series – Add the resistances**

› **Resistors in Parallel – the overall resistance is less than the lower resistor**



Overall resistance = 20Ω

$(30^{-1} + 60^{-1})^{-1}$

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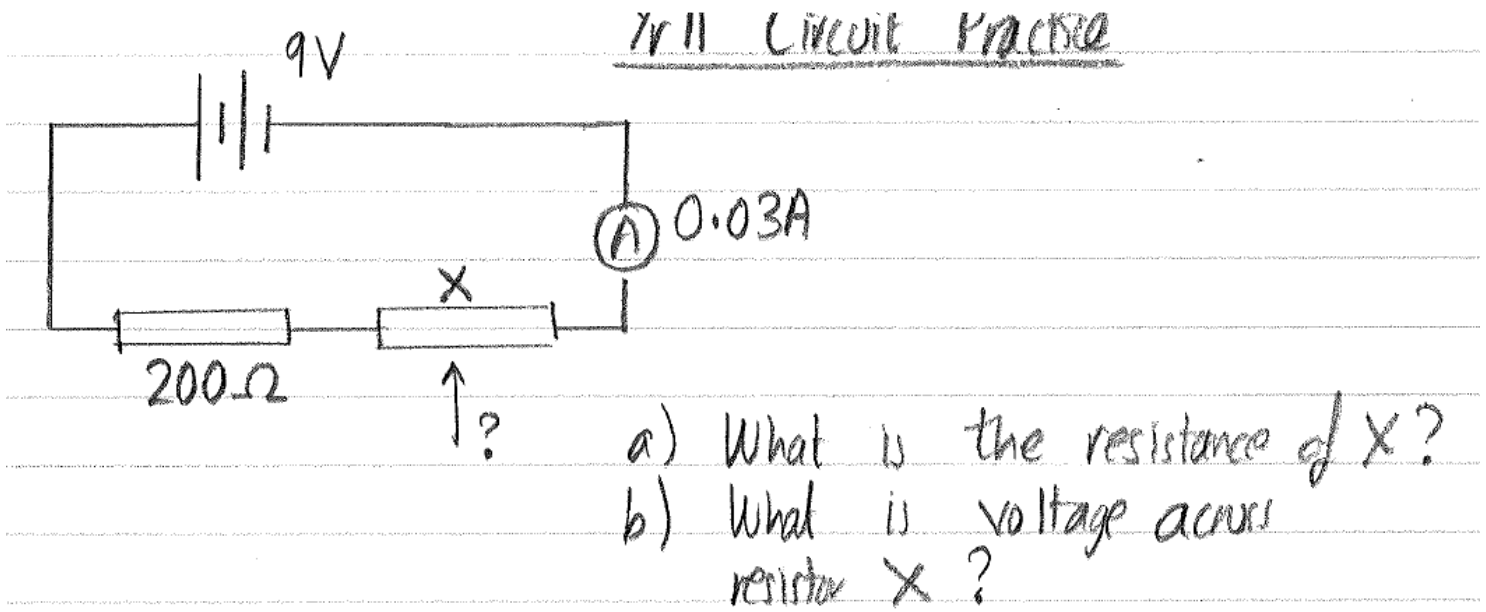

Isaac chapter 23, 24

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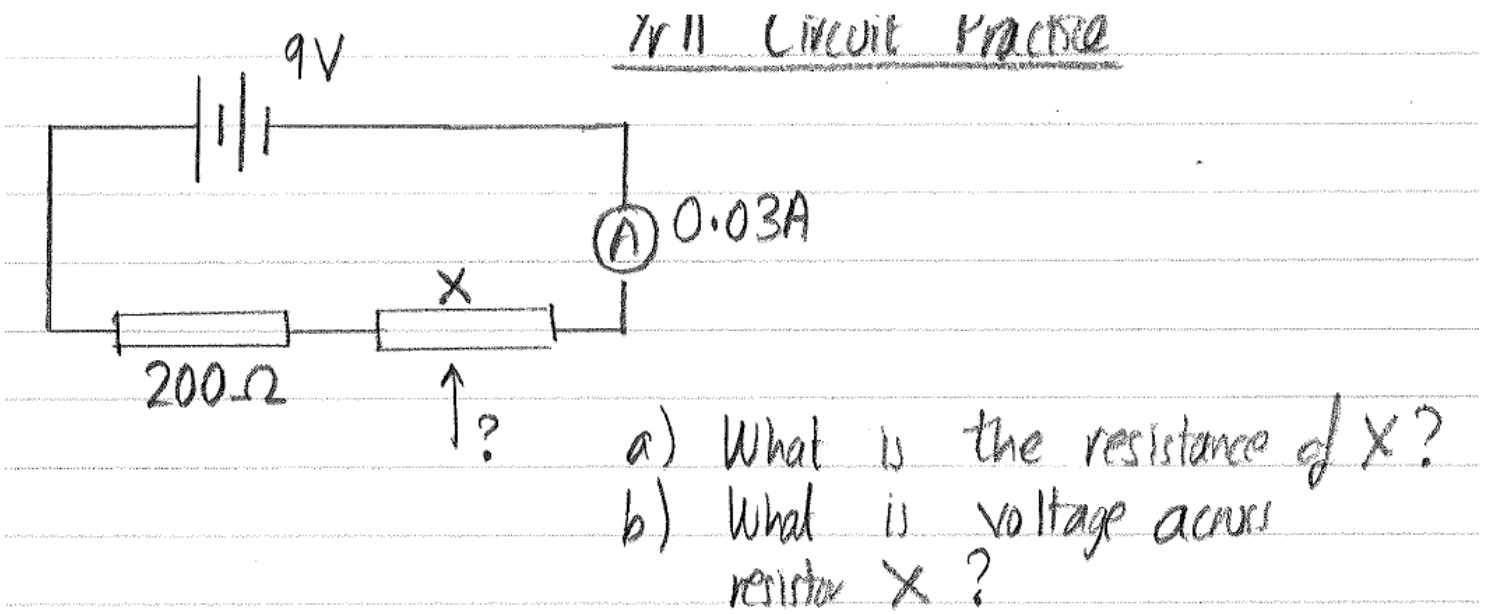

a) Resistance of whole circuit = V/I
= 9/0.03 = 300Ω,
so X+200Ω = 300Ω,
thus X=100Ω.

b) V=IR
=0.03x100 = 3V

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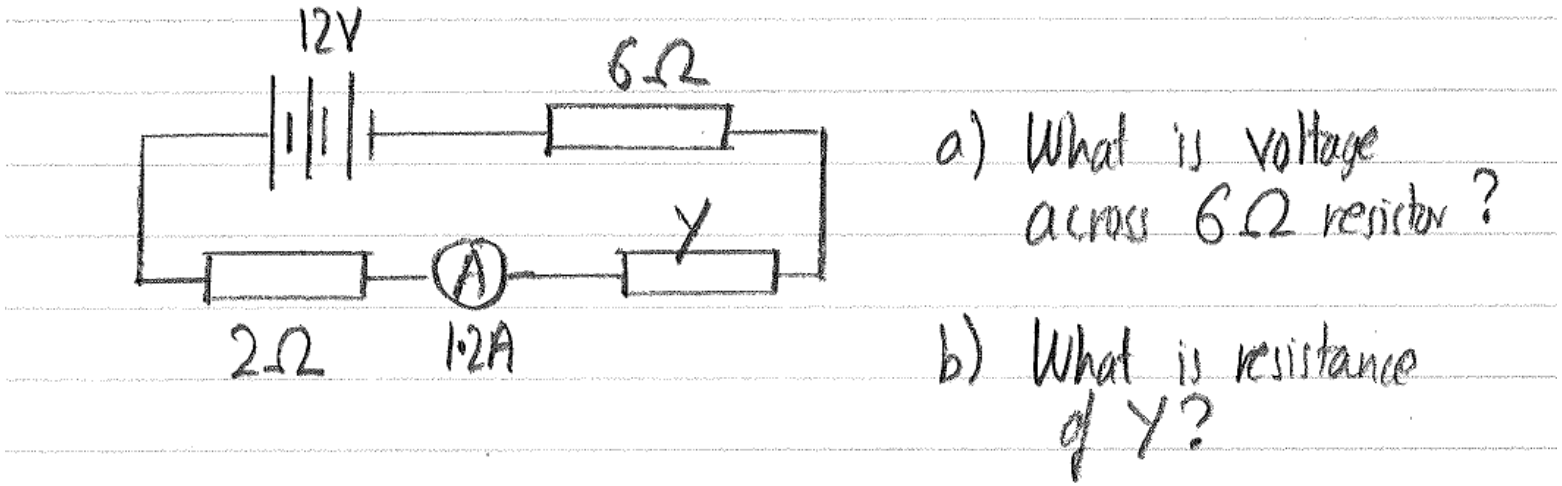

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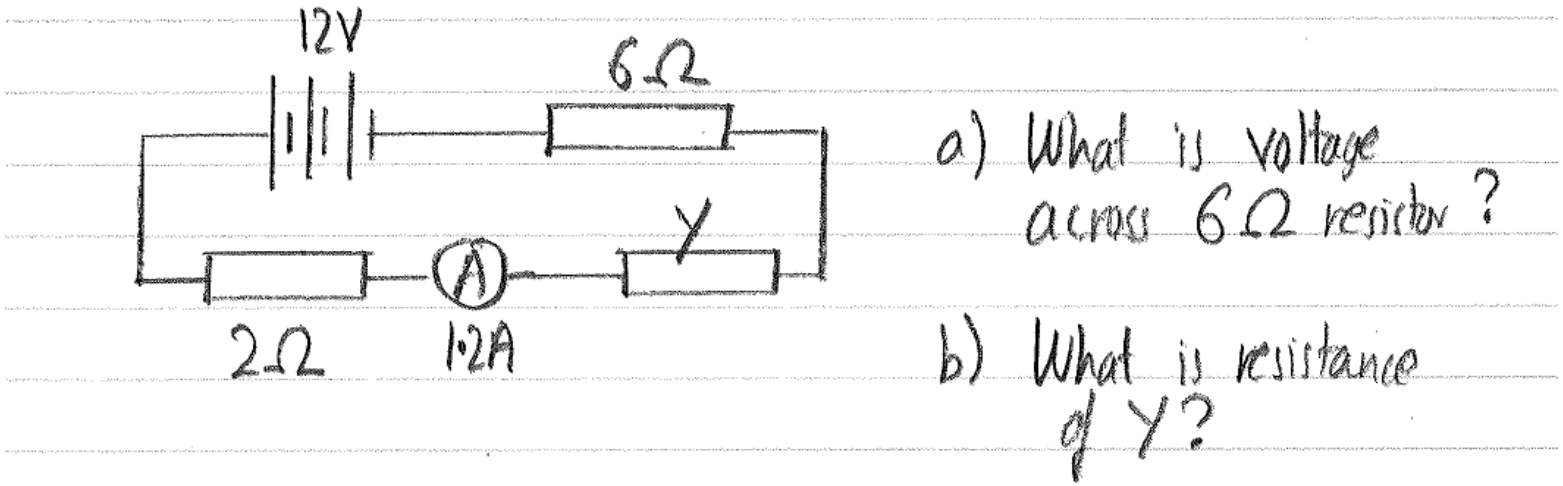

a) V = IR
= 1.2 x 6 = 7.2V

b) Resistance of whole circuit R = V/I
=12 / 1.2 = 10Ω
So, 6 + 2 + Y = 10
So Y=2Ω.

Don’t forget: V=IR, P=IV

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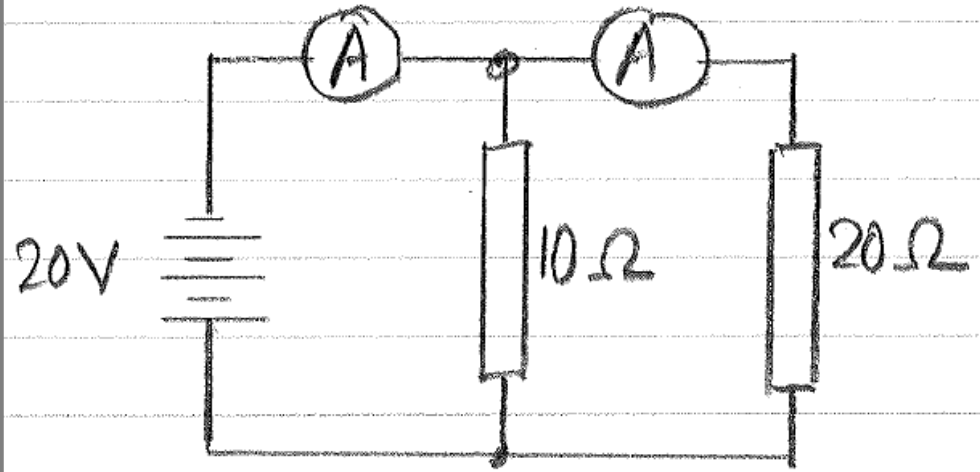

a) Calculate the current through each resistor

b) What will the ammeters read?

Isaac chapter 23, 24

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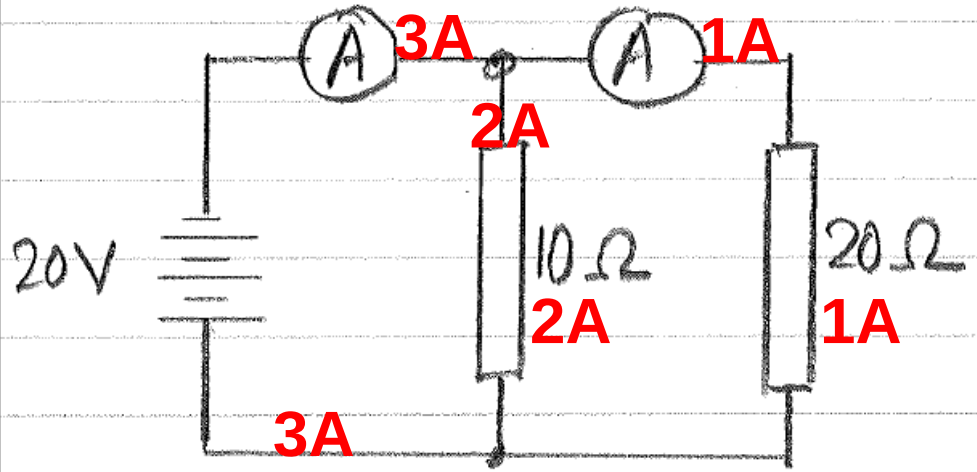


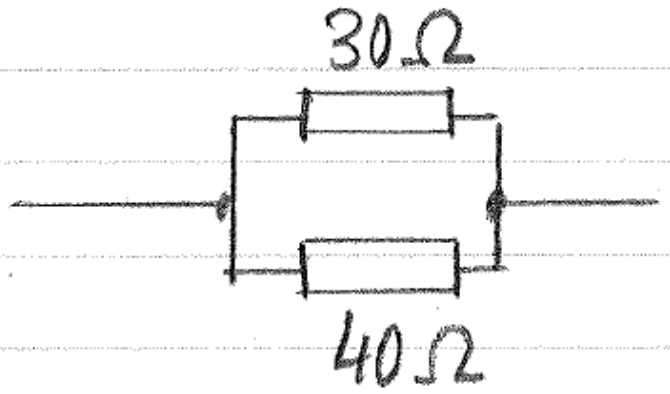
a) Calculate the current through each resistor

b) What will the ammeters read?

a) I = V/R
= 20 / 10 = 2A for left resistor
=20 / 20 = 1A for right resistor

b) Right ammeter = 1A
Left ammeter = 2A + 1A = 3A

A final test



Choose an answer:

the overall resistance is

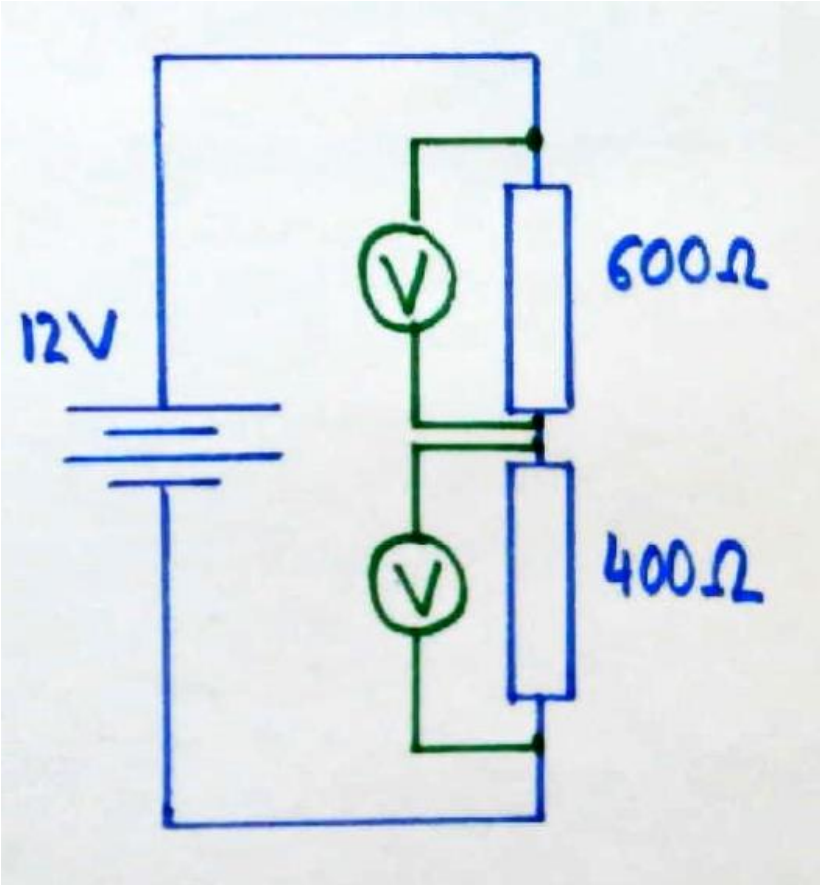
A more than 40 Ω

B between 30 Ω and 40 Ω

C exactly 30 Ω

D less than 30 Ω

Potential dividers



What are the voltages?

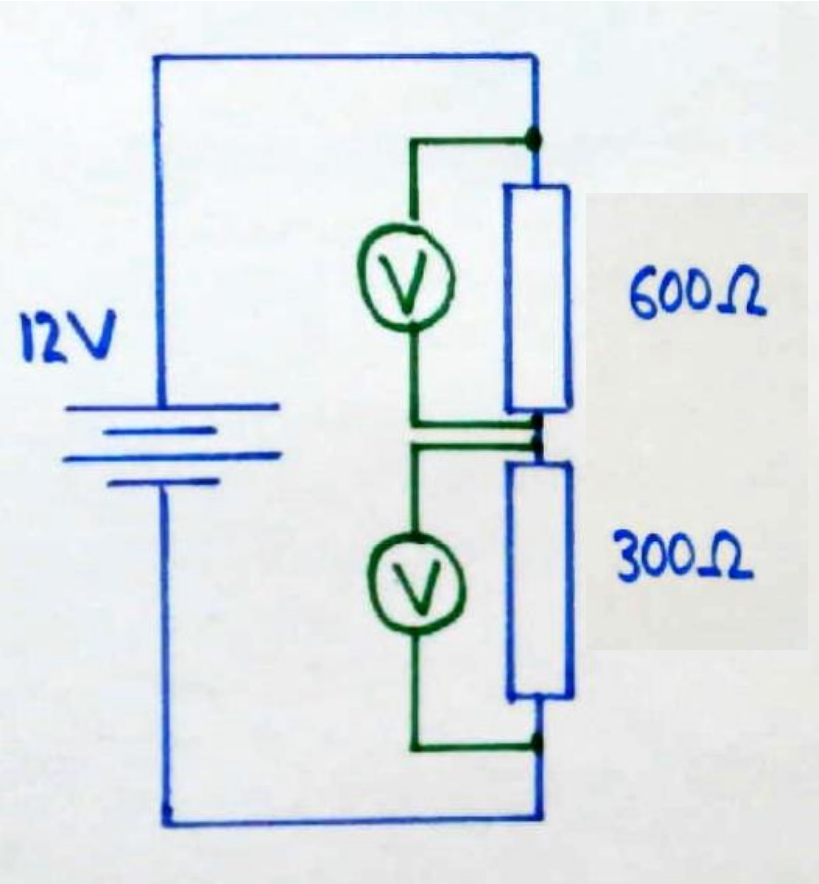
Method 1 –

Total resistance = 1000Ω
Top resistor has 600/1000=0.6 of the total
Top voltmeter = 12V x 0.6 = 7.2V

Method 2 –

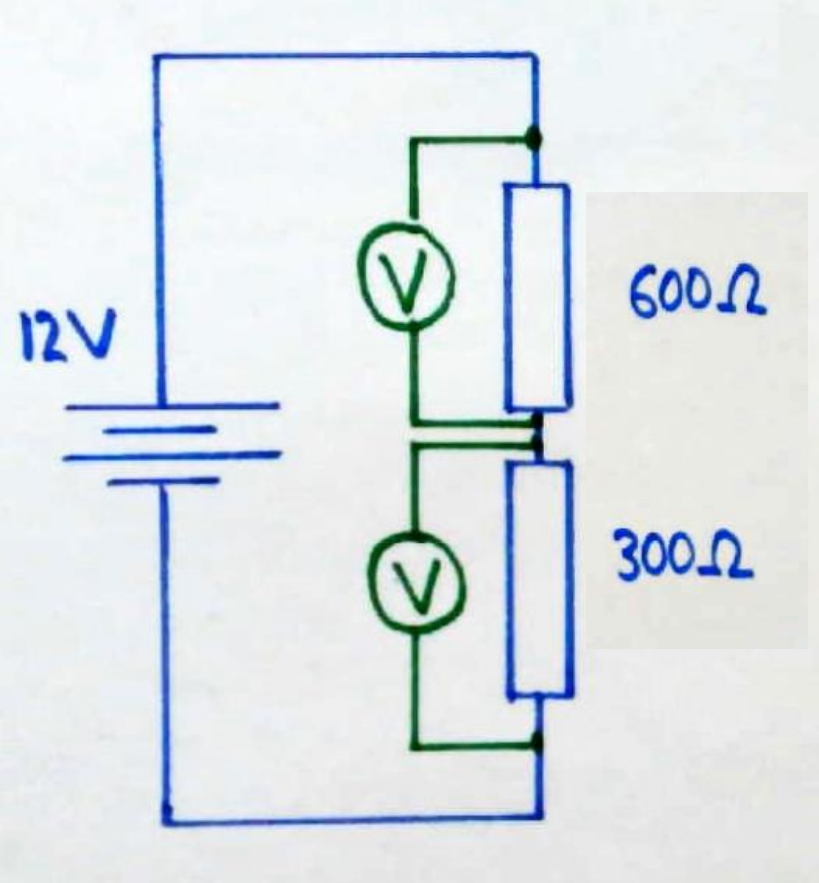
Total resistance = 1000Ω
Current = V/R = 12 / 1000 = 0.012A
Top voltmeter V = IR = 0.012 x 600 = 7.2V

Potential dividers



What are the voltages now?

Potential dividers



What are the voltages now?

Method 1 –

Total resistance = 900Ω

Top resistor has 600/900=2/3 of the total

Top voltmeter = 12V x 2/3 = 8.0V

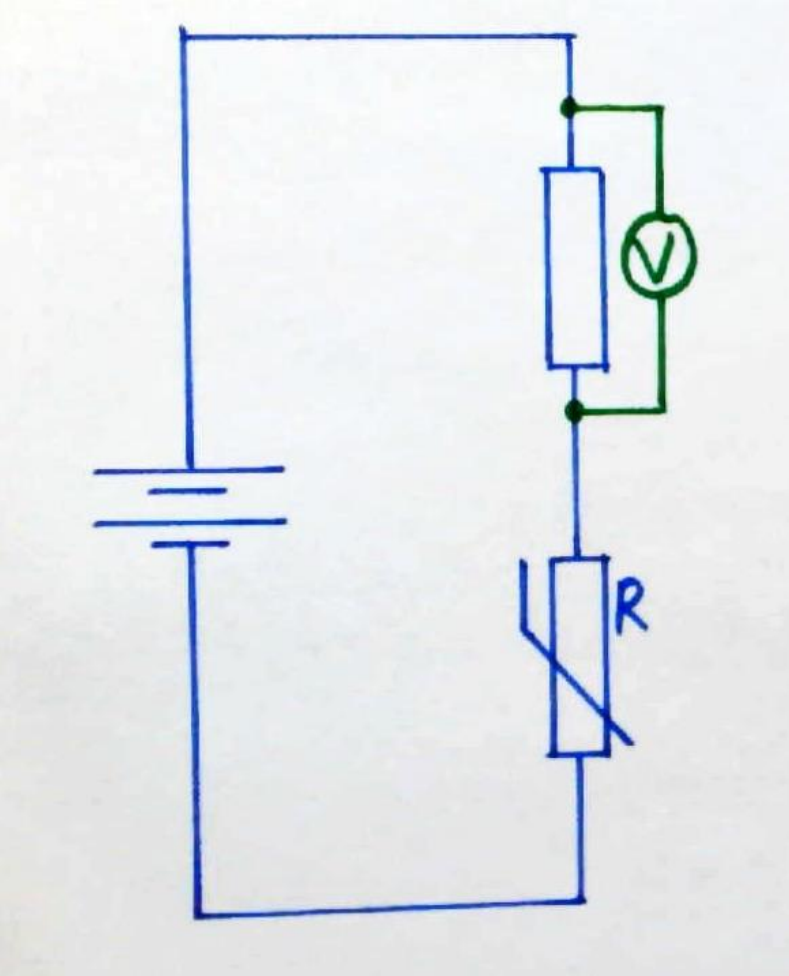
Method 2 –

Total resistance = 900Ω

Current = V/R = 12 / 900 = 0.013A

Top voltmeter V = IR = 0.013 x 600 = 8.0V

A measurement puzzle



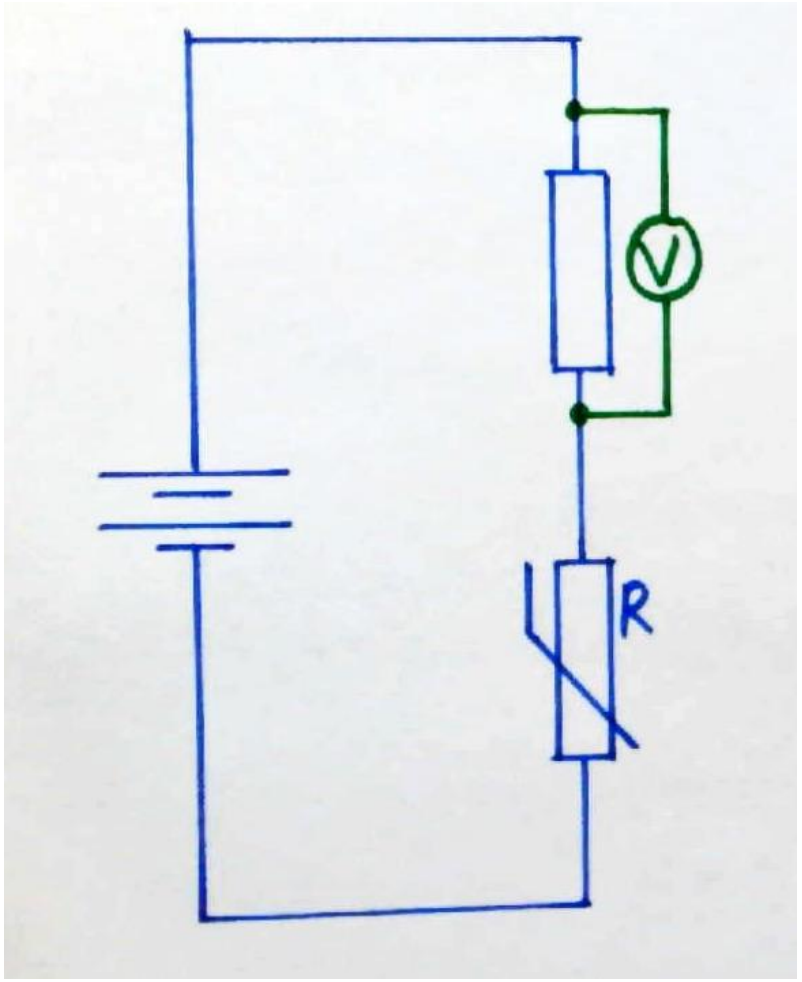
When R is heated

a) what happens to resistance R?

b) what happens to the current?

c) what happens to the voltmeter reading?

A measurement puzzle



When R is heated

a) what happens to resistance R?

Thermistor resistance DECREASES

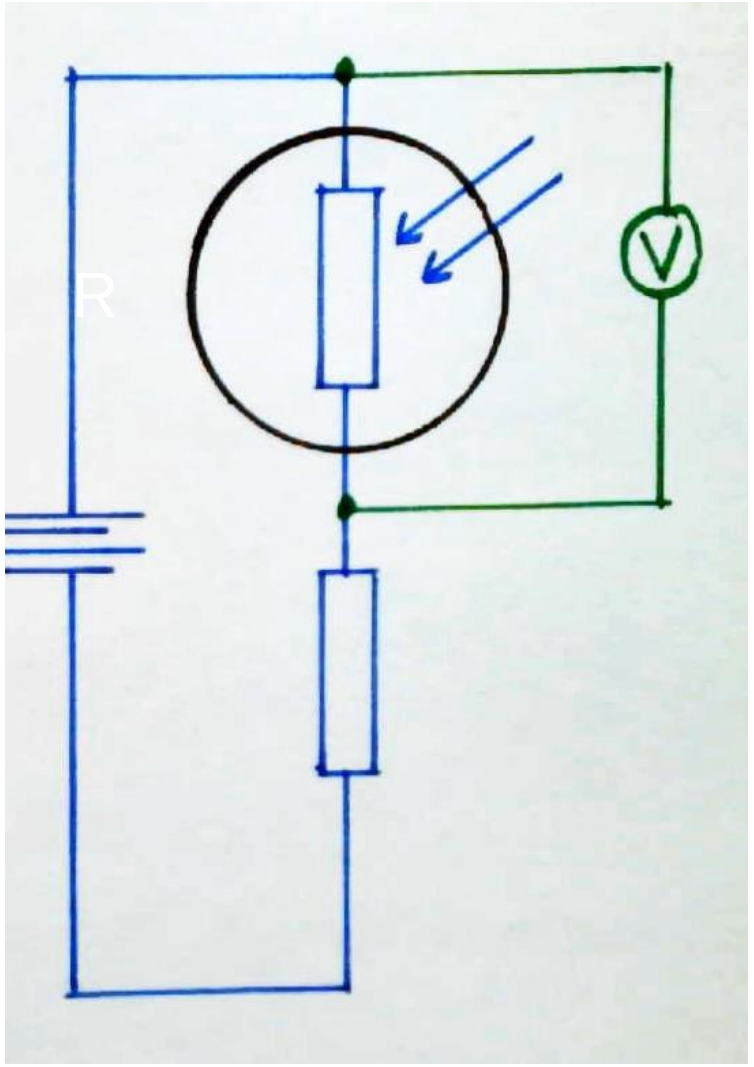
b) what happens to the current?

Less resistance, so MORE current

c) what happens to the voltmeter reading?

More current, so MORE voltage

A measurement puzzle



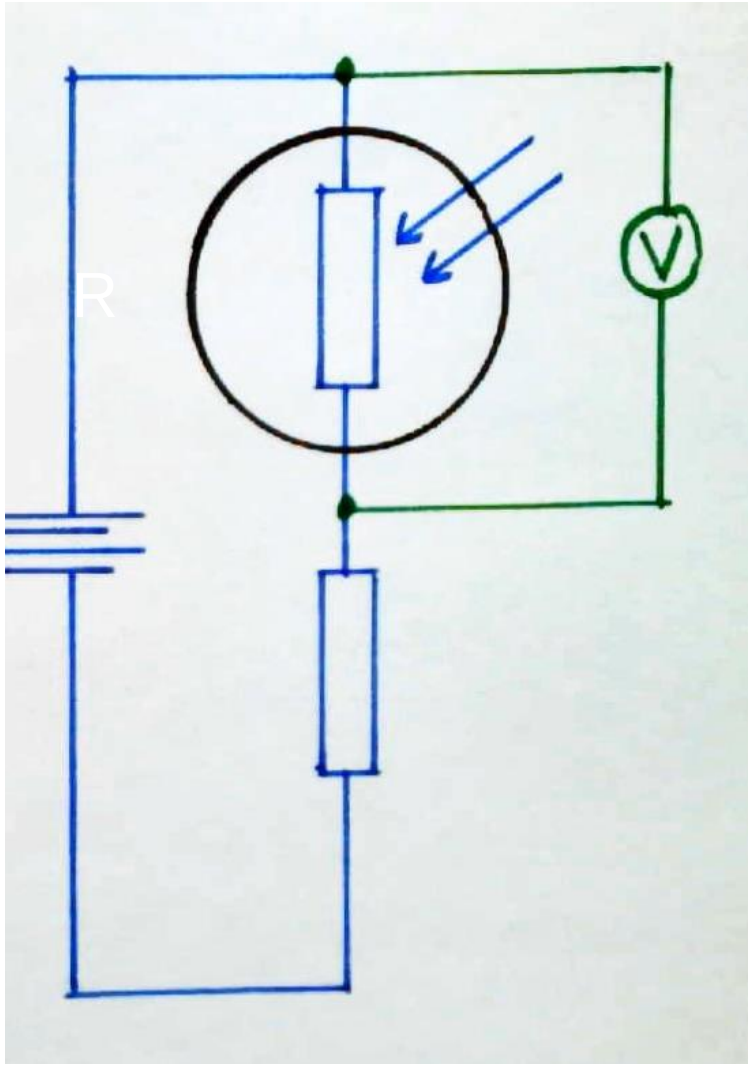
When R is covered up

a) What happens to the resistance R?

b) What happens to the current?

c) What happens to the voltmeter reading?

A measurement puzzle



When R is covered up

a) **What happens to the resistance R?**
LDR resistance increases in the dark

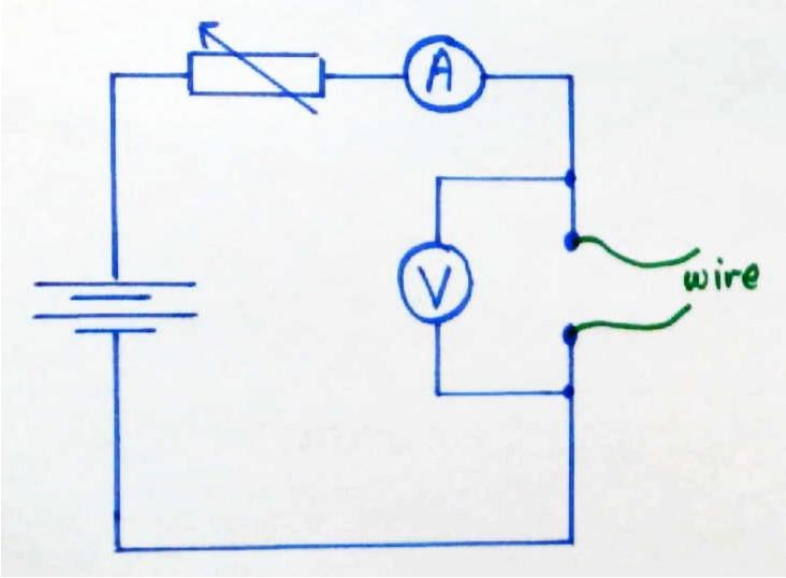
b) **What happens to the current?**
More resistance, so less current

c) **What happens to the voltmeter reading?**
LDR is larger share of total resistance, so voltmeter reading increases

Practical – resistance of wire

- Draw the circuit
- What would you plot?
- How do you determine resistance?
- You get poor results because you let the wire heat up – systematic/random?
- You get poor results because you use an ammeter with a RESOLUTION of 0.01A – systematic/random

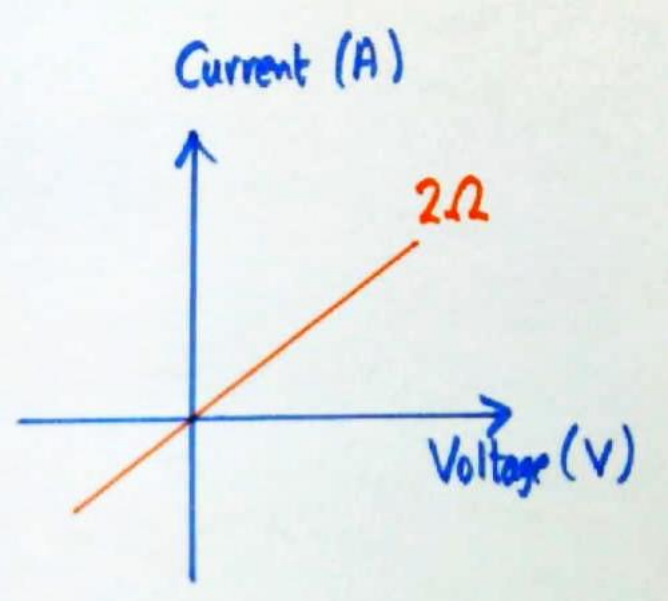
Practical – resistance of wire



- Draw the circuit
- What would you plot?
  Resistance/Ω ↑ vs Length/m →
- How do you determine resistance? R = V/I
- You get poor results because you let the wire heat up – systematic/random?
  Systematic – always causes resistance to be too high
- You get poor results because you use an ammeter with a RESOLUTION of 0.01A – systematic/random
  Random – sometimes over-read sometimes under-read

Practical - characteristics

- Measuring current through a component for different voltages
- What is the independent variable?
- What is the dependent variable?
- Draw the circuit
- What curves do you get for
  - a 2Ω resistor
  - a 4Ω resistor
  - a filament lamp (is it Ohmic?)
  - a diode



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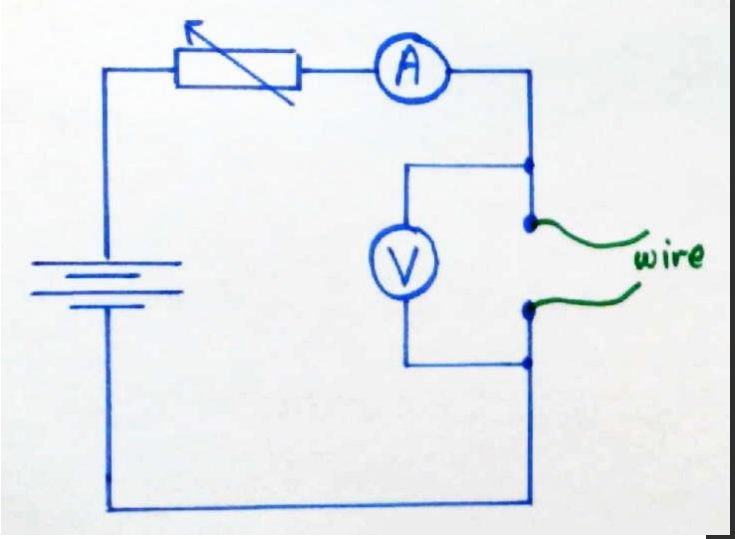

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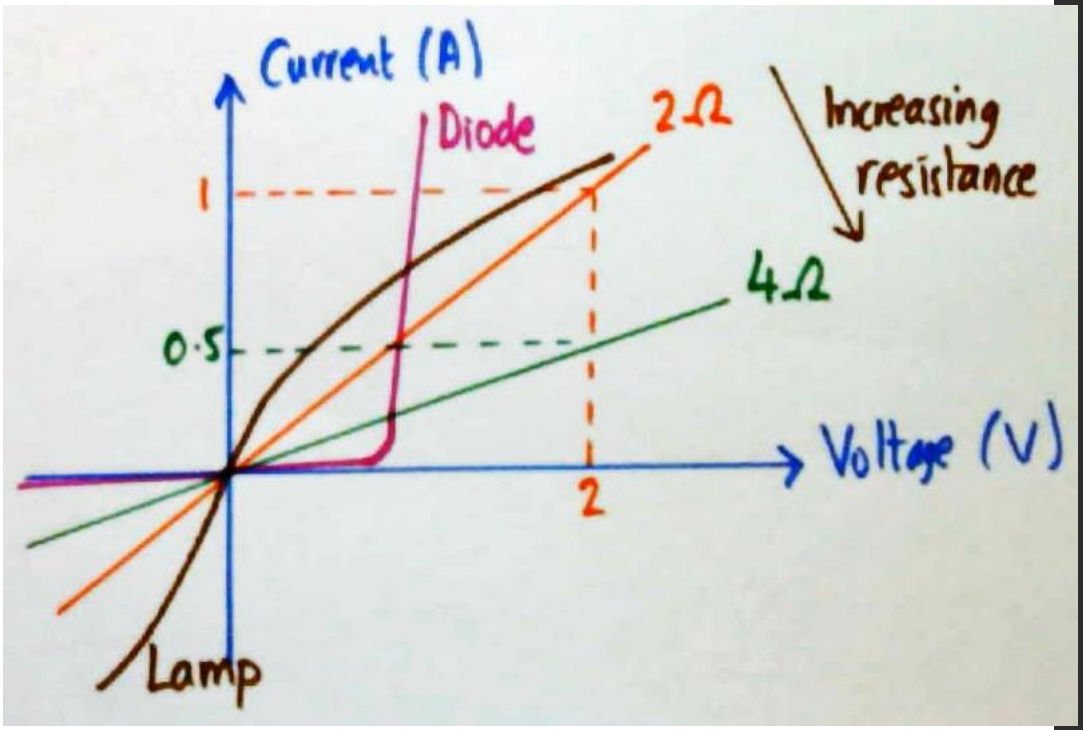
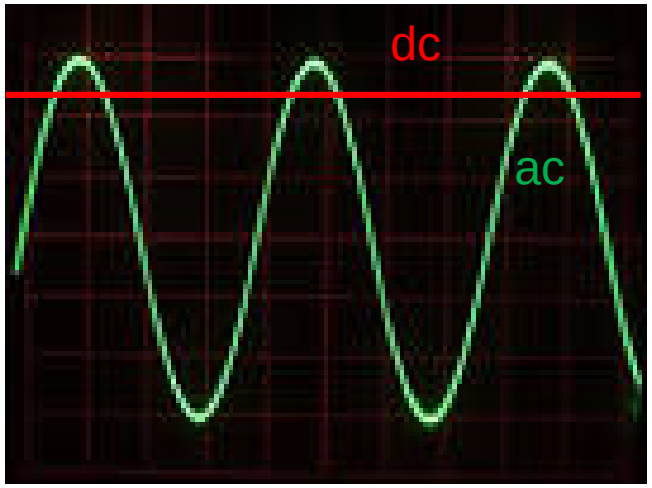
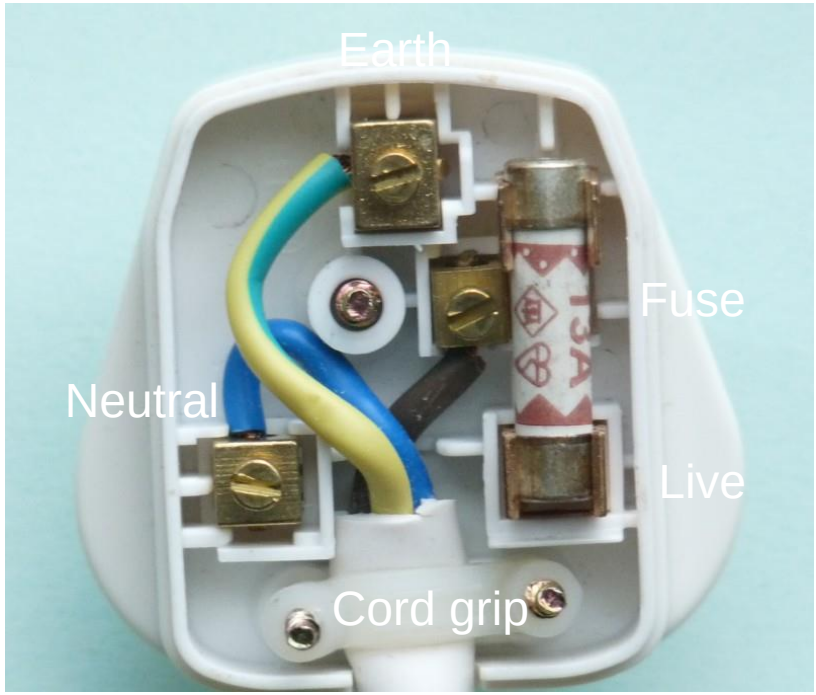


Electricity in the home

- Alternating current
  - Live = brown – voltage varies from -330 to +330V at 50Hz, we describe it as 230V
  - Neutral = blue – nearly 0V
  - Earth = green/yellow – 0V always
- Fuse has narrow wire which MELTS if current is too high (e.g. direct flow from live to earth)
- Plug fuses available in 3A, 5A, 13A values.
  - Choose the next one up
  - Choose the fuse for a 1000W floodlamp





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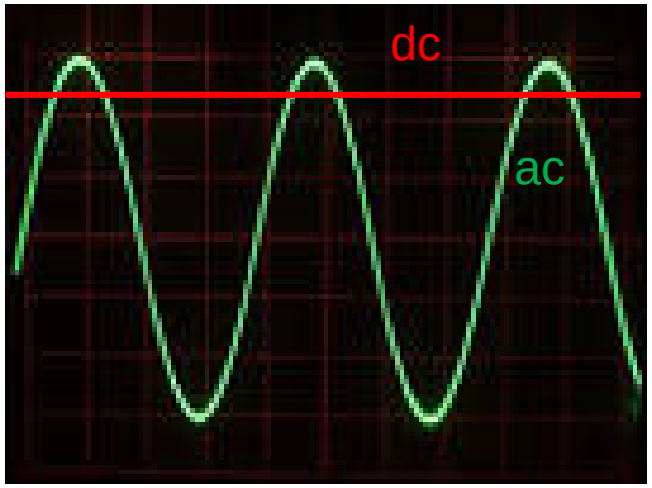
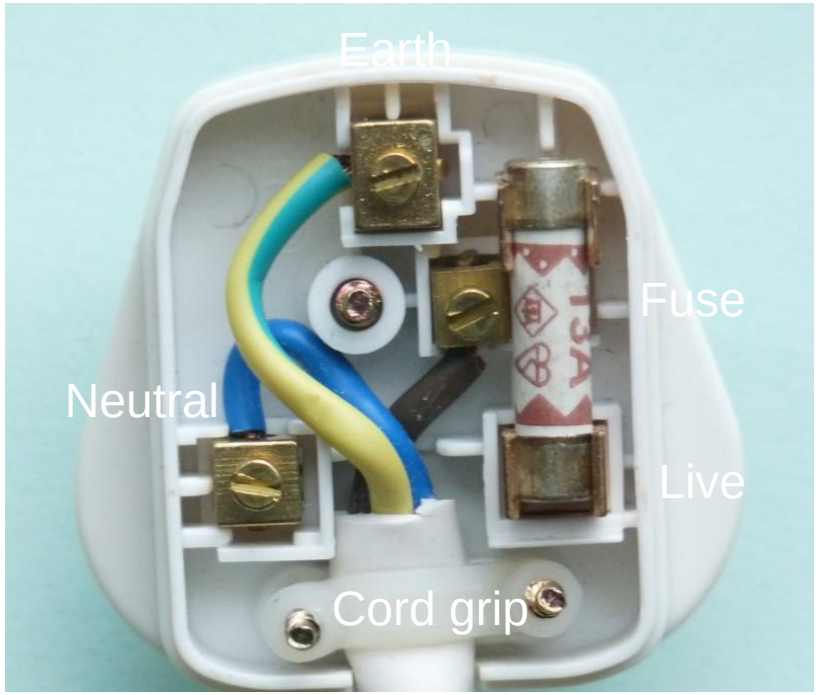
- Plug fuses available in 3A, 5A, 13A values.
  - Choose the next one up
  - Choose the fuse for a 1000W floodlamp
  - I = P/V = 1000 / 230 = 4.35A
  - Choose 5A fuse





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Consolidation Programme

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