Electricity

2015 AQA A-Level Physics

Core content

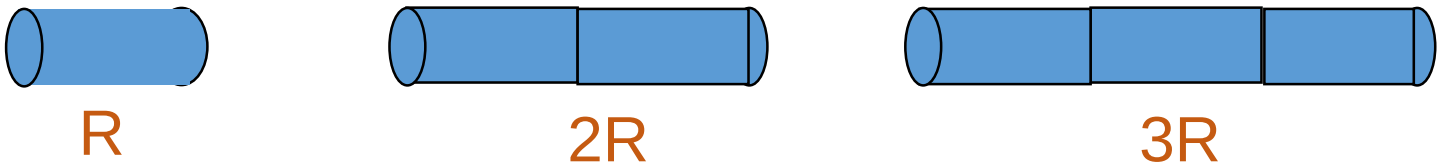
Resistivity and Superconductivity

Physics Tutor Online

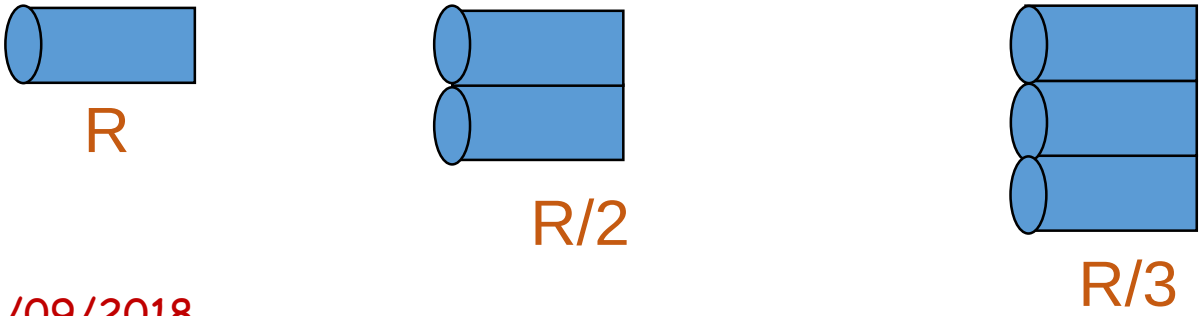
Factors affecting the resistance of a wire

The resistance of a wire depends on 3 things: the length of the wire, the width of the wire and what the wire is made of:

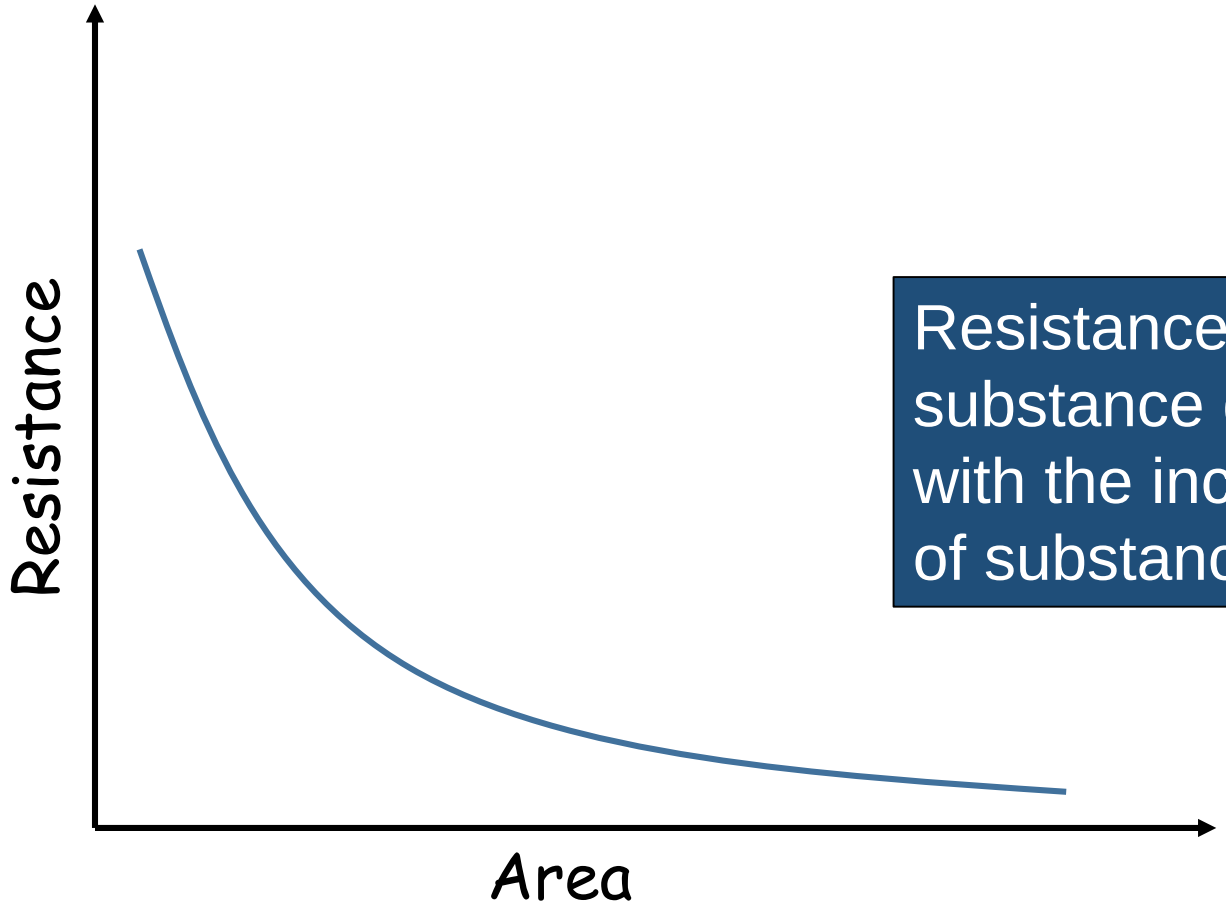
1) Length – Resistance is proportional to length



2) Area – Resistance is inversely proportional to area

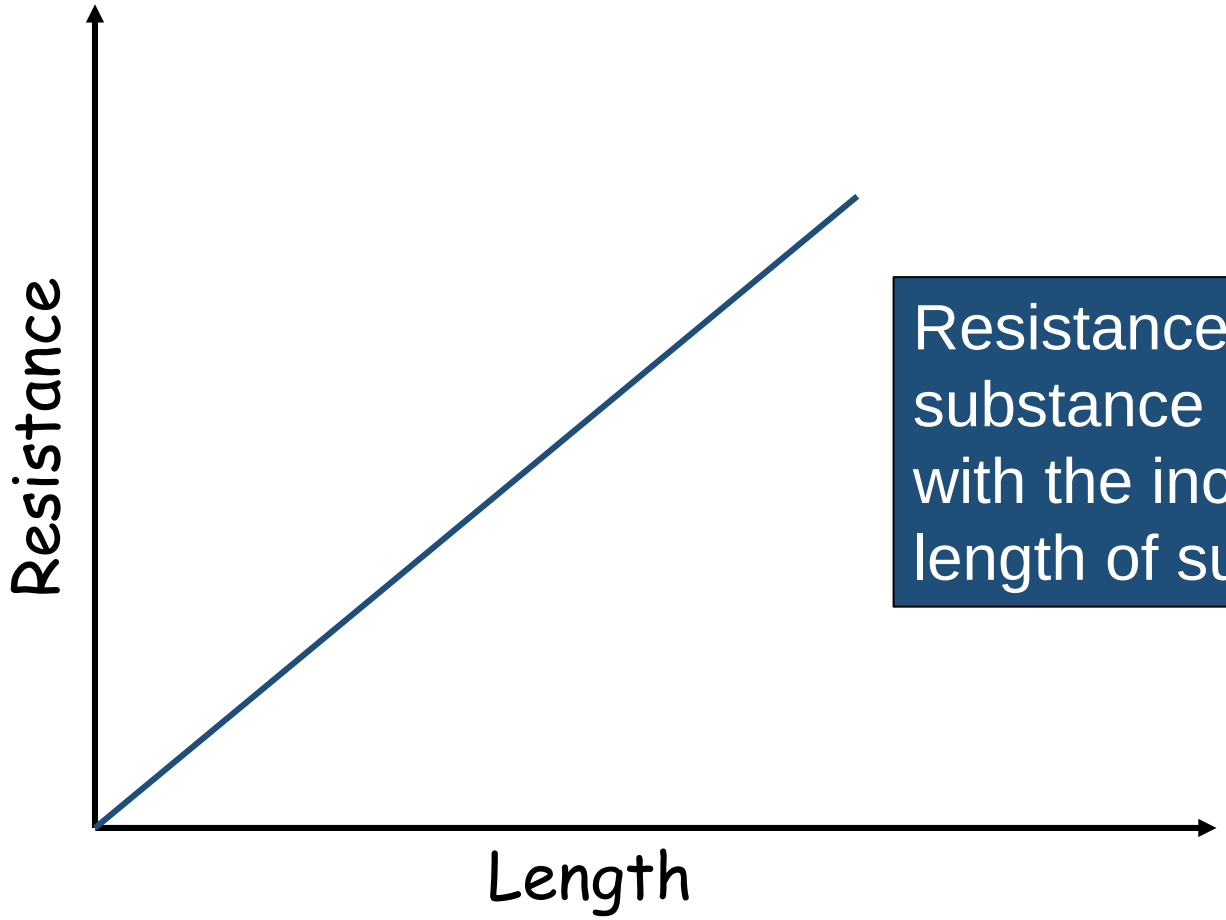


Resistance vs area graph



Resistance of a substance decreases with the increase in area of substance.

Resistance vs length graph



Resistance of a substance increases with the increase in length of substance.

Resistivity

The resistance of a wire depends on 3 things: the length of the wire, the width of the wire and what the wire is made of:

$$\text{Resistance} = \frac{\text{resistivity x length}}{\text{area}} \qquad R = \frac{\rho L}{A}$$

Units of resistivity:

$$\rho = \frac{R\,A}{L}$$

$$= \frac{\Omega \times m^2}{m}$$

$$= \Omega m$$

Resistivity

The resistance of a wire depends on 3 things: the length of the wire, the width of the wire and what the wire is made of:

$$\text{Resistance} = \frac{\text{resistivity x length}}{\text{area}} \qquad R = \frac{\rho L}{A}$$

Calculate the following:

1) The resistance of a wire of length 150cm, area 3.0mm^2 and resistivity 1.7x10^{-8} Ωm

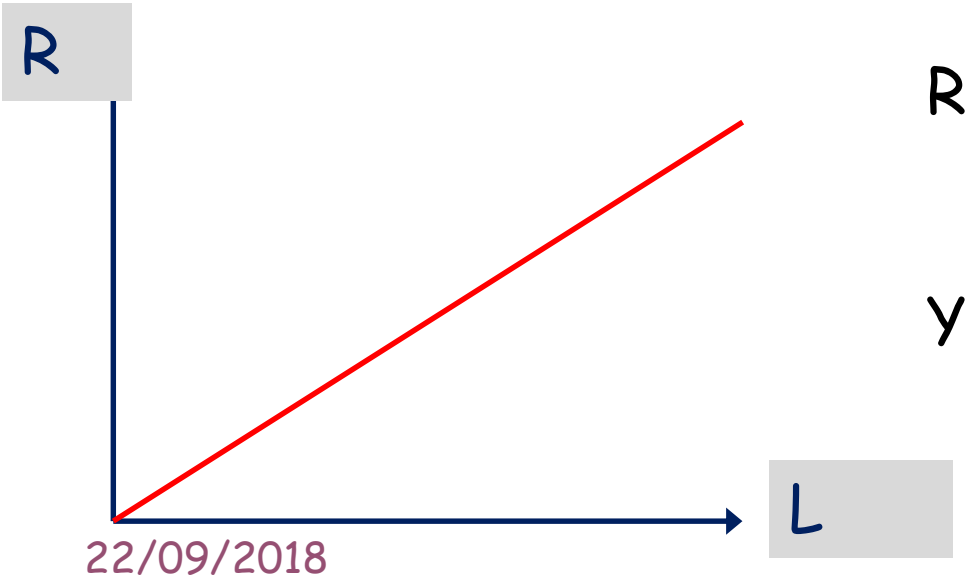
2) The length of an iron wire of resistance 80 Ohm, area 4mm^2 and resistivity 1x10^{-7} Ωm

3) A wire has a resistance of 6Ω. If the wire is 15m long and area 6mm^2 what is the resistivity of the wire?

Required Practical 5: Determining the Resistivity of a wire

Length/m	Resistance/Ω

Diameter of wire/m	
1	
2	
3	
Ave	



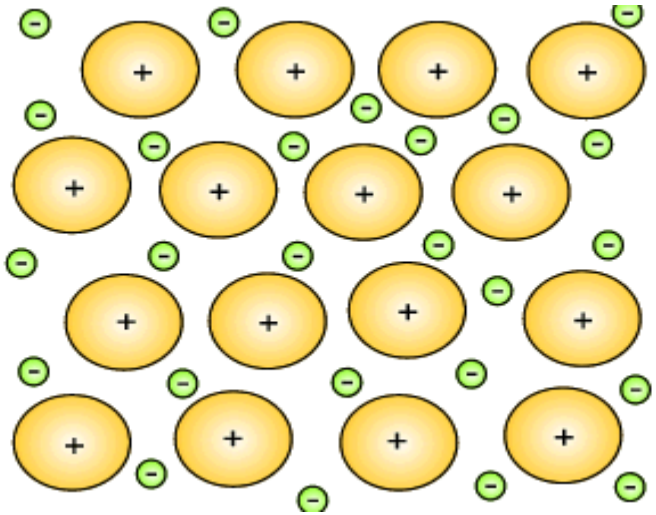
$$R = \frac{\rho L}{A}$$

$$y = mx + c$$

gradient = $\frac{\rho}{A}$

Inside a metal

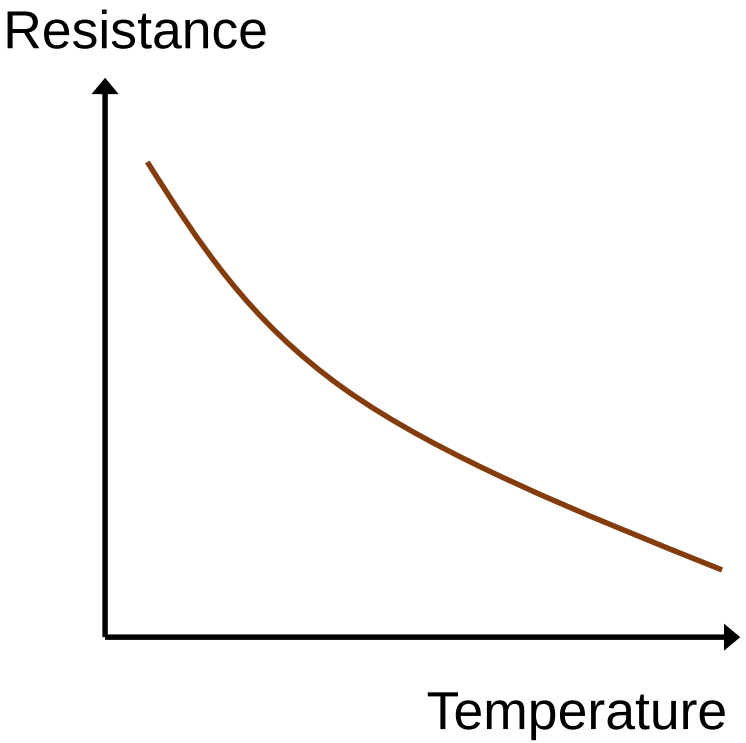
Inside a metal there is a ‘sea of electrons’ free to move through the material. Their movement is hindered by collisions with the ions in the lattice structure



At normal temperatures, with no current flowing, electrons hurtle around continuously. They collide with ions but because their movement is random there is no net energy transfer. Their average positions do not change.

Thermistors

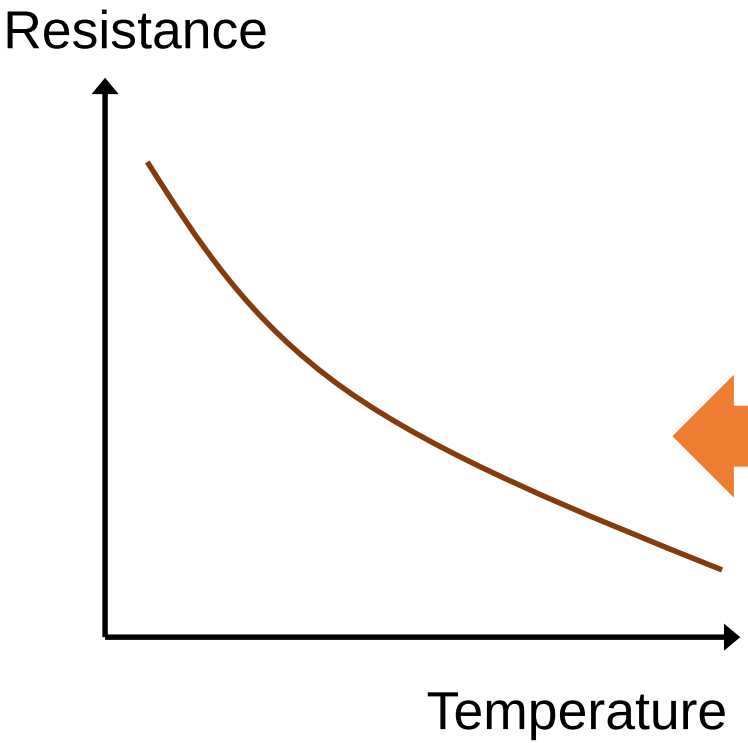
Thermistor – resistance DECREASES when temperature INCREASES



Explain why…….

Thermistors

Thermistor – resistance DECREASES when temperature INCREASES

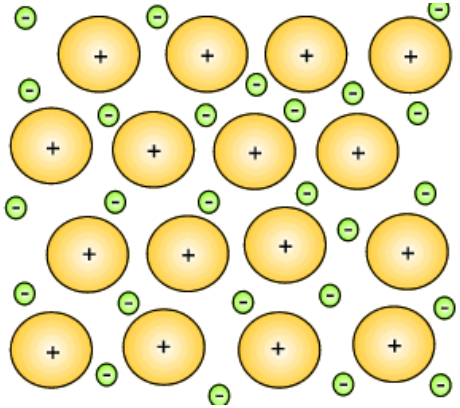


The resistivity of semiconductors tends to decrease as temperature rises because there is an increase in the number of mobile charge carriers.

The graph shows the resistance falling with temperature. This is a ntc thermistor (negative temperature coefficient)

How resistivity changes with temperature

Increasing the temperature of a metal will increase the _____ of the ions. This will increase the _____ of the metal and decrease the current because it lowers the ____ _____.



In a thermistor, the number of charge carriers is small but _____ with temperature. Increasing the temperature of the thermistor lowers the _____ and _____ the current

Words – thermistor, resistivity, vibrations, drift speed, increases, semiconductor

Superconductivity

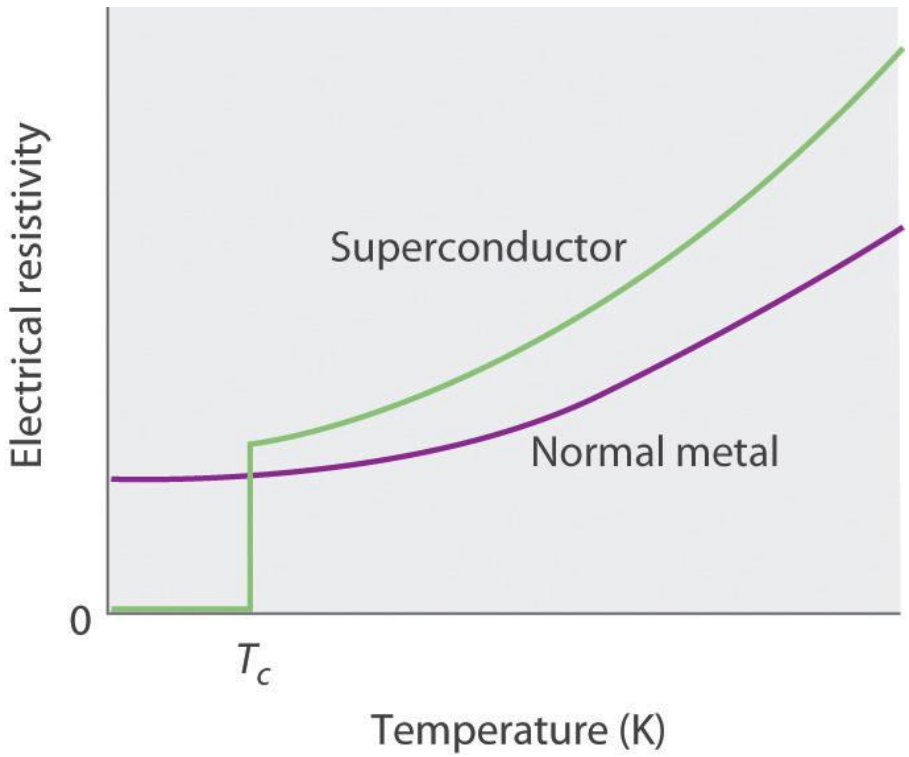
Superconductivity is a property of certain materials which have zero resistivity at and below a critical temperature

The critical temperature depends on the material

For mercury, the critical temperature is 4.2K

At and below 4.2K, mercury becomes a superconductor – it has no electrical resistance whatsoever!

Superconductivity



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Applications of Superconductivity

Superconductors can be used to produce strong magnetic fields

In MRI scanners, large coils of a superconducting material (niobium titanite) are kept cool (below 4K) using liquid helium

The coils and helium are thermally sealed and should stay at below 4K for the operating lifetime of the scanner (10 years)

Applications of Superconductivity

Superconductors can be used to produce magnetic levitation

Powerful electromagnets with superconducting windings can create a magnetic field strong enough to suspend a train above the track, greatly reducing friction!

The Shanghai Transrapid is one of just 2 Maglev trains
It is the fastest commercial train with a top speed of 430kmh^{-1}

Applications of Superconductivity

Superconductors can reduce energy loss in the production of electrical power

The world's first superconducting power transmission cable came into use in 2014 in Germany

The cable is cooled by liquid nitrogen. It carries a large current with very small energy losses