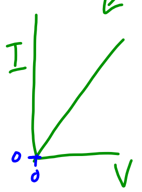
Recall: Ohm's Law is stated

$I \propto V$

$I = \frac{V}{R}$ ← rearrange: $R = \frac{V}{I}$

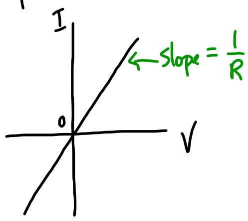
$I = \left(\frac{1}{R}\right) V$

↑ constant of proportionality

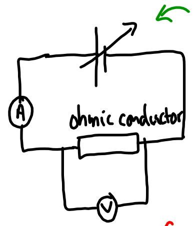


Plotting current against potential difference:

- independent variable is pot. diff | dependent variable is current



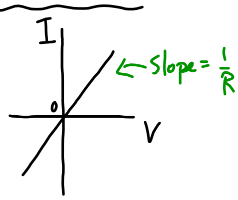
← variable potential difference



Circuit for verifying Ohm's Law.

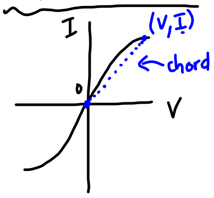
I-V characteristics of an ohmic resistor and a filament lamp

Ohmic behaviour



- ohmic conductor at constant temperature
- constant resistance

Non-ohmic behaviour



- filament lamp
- the resistance increases as the potential diff increases. (or current)

* The resistance is not the reciprocal of the slope to the tangent of the curve. It is simply the value of $\frac{V}{I}$ (non-ohmic)

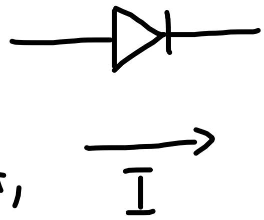
IF the behaviour is ohmic: slope $= \frac{1}{R}$

or $R = \frac{1}{\text{slope}}$

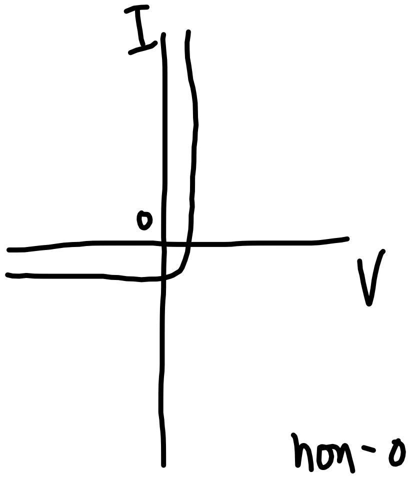
IF the behaviour is non-ohmic, then the slope of the chord drawn between the origin and (V, I) is $\frac{1}{R}$ or $R = \frac{1}{\text{slope (of chord)}}$

I-V characteristic of a diode

diode



A diode is a device which has a low resistance when current flows forwards through it, and a high resistance to current flowing in the opposite direction. => current essentially can only flow in one direction



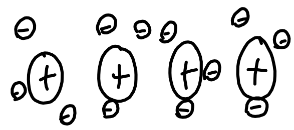
non-ohmic behaviour

Why does the resistance of a metal increase as the temperature increases?

— need to look at the free electron model of conduction in a metal.

Free Electron Model of a Metal

— one or two valence electrons



- free to move from one atom to the next along at conduction band

- think of a metal as a lattice of positive ions in a sea of negative electrons ⇒ electrons are free to move around ⇒ delocalized electrons.

- overall, the metal is electrically neutral

- apply a potential diffence to the conductor ⇒ electric field.

- the electric field applies a force on the electrons so that they migrate in the conduction band to the positive terminal.

- the positive ions are stationary (lattice)

- the motion of the electrons under the action of the electric field is slow (they collide with the positive ions) ⇒ net drift of electrons toward the + terminal

- drift velocity is about 1mm per second

- the electron drift is superimposed on the rapid thermal motion of the electrons. (much greater than the drift velocity)

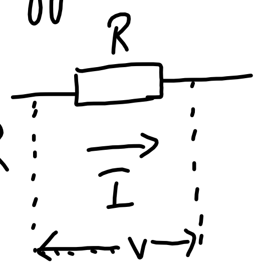
- even though the drift velocity is low, the electrons all start to drift towards the positive terminal at the same time when the circuit is closed.

- when the metal's temperature increases, the the random thermal motion of the electrons increases, thereby impeding the slow drift of the electrons towards the positive terminal.

⇒ increase the temperature of the resistor ⇒ increases the resistance.

Power dissipation in a resistor

For resistor, power refers to the rate at which electrical energy is converted to thermal energy.



When a current I flows through a resistor of resistance R due to a potential difference V, then the power dissipated is:

$$P = \frac{\Delta E_p}{\Delta t}$$

← loss in electrical potential energy of the charge Δq in time Δt

Recall: $\Delta E_p = \Delta q V$

$$P = \frac{\Delta q V}{\Delta t}$$

$$P = IV$$

Recall: $R = \frac{V}{I}$ → $I = \frac{V}{R}$, → $V = IR$

$$P = I(IR)$$

$$P = I^2 R$$

$$P = \left(\frac{V}{R}\right)V$$

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

Summary:

$$P = \frac{\Delta E_p}{\Delta t} = \frac{\Delta W}{\Delta t}$$

$$P = IV$$

$$P = I^2 R$$

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