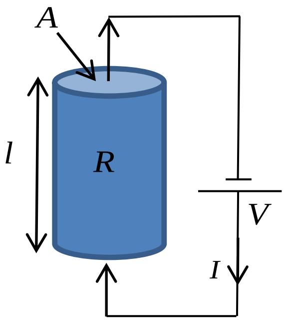
Ohm's law and electrical resistance

Resistance is defined to be the ratio of voltage dropped (or *potential difference*) to current flow through an electrical component. For many passive components this will be a constant, i.e. the graph of voltage against current will be linear, with resistance being the gradient. Such components are called *Ohmic*.



A cylindrical passive resistor of cross-section A and length l will have resistance R in terms of these geometrical parameters and the *resistivity* ρ of the material.

$$\boxed{R = \frac{\rho l}{A}}$$

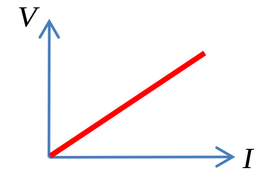
Ohm's Law

$$\boxed{V = IR}$$

Voltage / volts
Energy per unit charge lost across a conductor of resistance R

Current / amps
Rate of flow of charge through resistor R

Resistance /ohms (Ω)



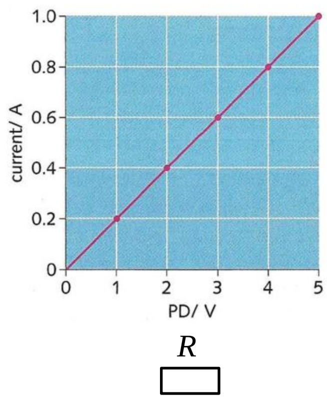
Georg Ohm
1789-1854

Resistivity of various materials

Copper $\rho = 1.68 \times 10^{-8}\ \Omega\text{m}$
Aluminium $\rho = 2.82 \times 10^{-8}\ \Omega\text{m}$
Gold $\rho = 2.44 \times 10^{-8}\ \Omega\text{m}$
Iron $\rho = 1.00 \times 10^{-7}\ \Omega\text{m}$
Sea water $\rho = 2.00 \times 10^{-1}\ \Omega\text{m}$
Glass $\rho = 10^{11} - 10^{15}\ \Omega\text{m}$
Hard rubber $\rho = 10^{13}\ \Omega\text{m}$
Dry wood $\rho = 10^{14} - 10^{16}\ \Omega\text{m}$
Air $\rho = 1.3 - 3.3 \times 10^{16}\ \Omega\text{m}$

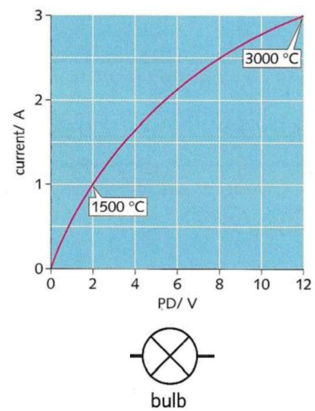
Typical resistivity values/ Ωm	
Constantan	49×10^{-8}
Manganin	44×10^{-8}
Nichrome	100×10^{-8}
Tungsten	55×10^{-8}

Fixed passive resistor



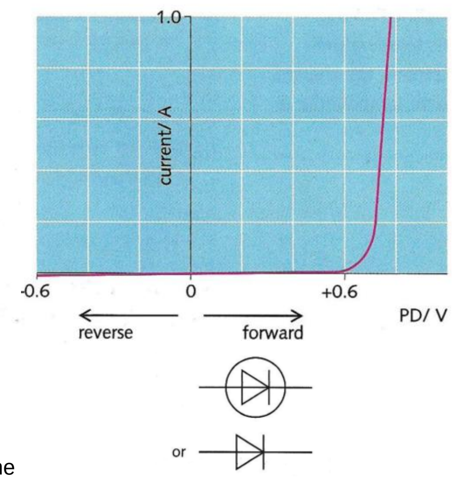
The gradient of this graph is constant since resistance is constant

Filament bulb

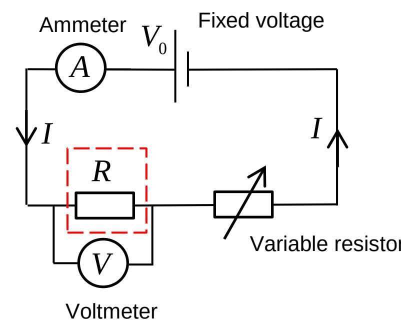


As the more current passes through a bulb it heats up. The increased random motion impedes the free flow of electrons which therefore increases resistance.

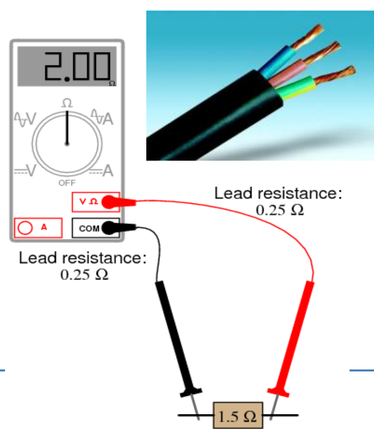
Semiconductor diode

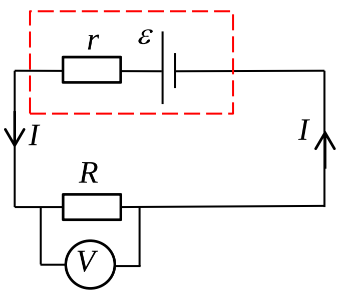


Very little current passes through a diode until a threshold voltage is reached After this point the diode resistance is very low i.e. a small voltage increase will result in significant increases in current.



Schematic of experimental setup for measuring the I,V curve of an electrical component. The most efficient way to do this via a *potential divider*. i.e. have a *fixed* supply voltage and then vary the potential across the device by *varying* the resistance of a passive resistor in series. Careful choice of the variable resistance range should be made to result in a significant change in I and V.





Real voltage supplies will **have internal resistance** r. The 'electromotive force' (EMF) (i.e. the actual supply voltage ε) will differ from the actual voltage V across components in a series loop

$$\boxed{V = \frac{R}{R+r}\varepsilon, \quad \varepsilon = I\left(R+r\right)}$$

An **ammeter** is a current measuring device. Since it is placed in series it should have very little resistance so not to result in a significant voltage drop across it.

A **voltmeter** is a voltage measuring device. This is placed in parallel with a component and has a *high internal resistance* to prevent it drawing much current.