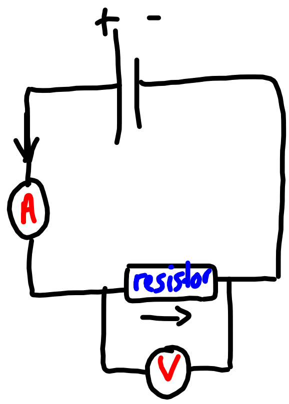
Resistor

- impedes the flow of charge.
- work is done; charges lose potential energy -> thermal; so there is a potential difference across the resistor.



If the pot. diff across the resistor is V then each coulomb of charge passing through it loses V joules of its electrical potential energy

(if the potential diff. is 100V, then 1C of charge loses 100J of pot. energy.)

If the current through the resistor is I then I coulombs of charge pass through every second

(If the current is 5.0A, then 5.0C pass through the resistor in 1 second)

Resistance

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

scalar quantity

units: VA^{-1} Ω ohm (Ω)

* NOTE that this is NOT a statement of ohm's Law

Example

A potential difference of 12V exists across a resistor and the current through the resistor is 3.0A. Determine the resistance of the resistor.

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

$$R = \frac{12V}{3.0A}$$

$$R = 4.0\,\Omega$$

Example

A small heating element has a resistance of 100 Ω and 5.0V is applied across it. Determine the amount of charge which flows through the element in 1.0 minutes and the power that it develops in that time.

find the current: $R = \frac{V}{I}$

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

$$I = \frac{5.0\cancel{V}}{100\,\Omega} \quad \cancel{V}A^{-1}$$

$$I = 0.050\,A$$

change in 1 min: $I = \frac{\Delta q}{\Delta t}$

$$\Delta q = I\Delta t$$

$$\Delta q = 0.050A\,(60s)$$

$$\Delta q = 3.0\,C$$

Recall: $\Delta E = qV$ $\left(V = \frac{\Delta E}{q}\right)$

$$\Delta E = I(\Delta t)V$$

now $P = \frac{\Delta E}{\Delta t}$

$$P = \frac{I(\cancel{\Delta t})V}{\cancel{\Delta t}}$$

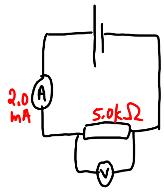
$$P = IV$$

$$P = (0.050A)(5.0V)$$

$$P = 0.25W$$

Example

In the circuit shown, the ammeter reads 2.0mA and the resistance of the resistor is 5.0 kΩ. What is the reading on the voltmeter?



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

$$V = IR$$

$$V = (2.0 \times 10^{-3}A)(5.0 \times 10^{3}\,\Omega) \quad VA^{-1}$$

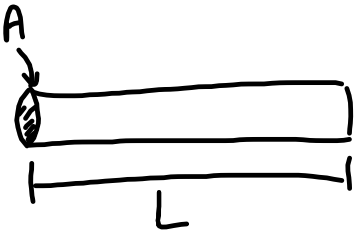
$$V = 10 \times 10^{0}\,V$$

$$V = 10\,V$$

Resistivity

$R \propto L$

$R \propto \frac{1}{A}$



ρ rho

depends on the nature of the material used.

$R \propto \frac{L}{A}$

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

where ρ is the constant of proportionality (depends on the material)

ρ is called the resistivity of the material that the conductor is made of.

- scalar; units are $\Omega\,m$

Definition of resistivity (see handout)

↳ resistance of the material 1m long with a cross sectional area of $1m^2$

$$\rho = \frac{RA}{L}$$

where R is the resistance (Ω)

A is the cross sectional area (m^2) ($A = \pi r^2$)

L is the length (m)

Example

The resistivity of constantan is $4.9 \times 10^{-7}\ \Omega m$. Calculate the length of constantan resistance wire which has a resistance of $5.0\ \Omega$ and a radius of 0.12 mm.

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

$$L = \frac{RA}{\rho} \qquad A = \pi r^2$$

$$L = \frac{(5.0\ \cancel{\Omega})(\pi)(0.12 \times 10^{-3}\ m)^2}{4.9 \times 10^{-7}\ \cancel{\Omega} m}$$

$$L = 0.46\ m$$

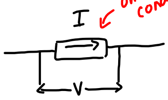
The resistivity is a small value since the resistance is is small and a small Area (radius)

$$\rho = \frac{RA}{L}$$

For a particular material, if the radius of the wire is increased, the the resistance decreases for the same length.

Ohm's Law

"ohmic conductor"



$$\underbrace{I \propto V}_{\text{true If}}$$

- ohmic conductor
- temperature is constant

ohmic conductor → metallic conductors + most resistors

non-ohmic conductor → filment lamps, ionic solutions + semi conductor devices such as diodes

Ohm's Law and Resistance

For an ohmic conductor at constant temperature:

$$I \propto V$$

and recall our definition of resistance: $R = \frac{V}{I}$

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

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

$\frac{1}{R}$ is the constant of proportionality for $I \propto V$

For an ohmic conductor at constant temp:

ohm's Law or ($I \propto V$) → $I = \frac{V}{R}$

or $V = IR$ (← not a statement of ohm's Law)