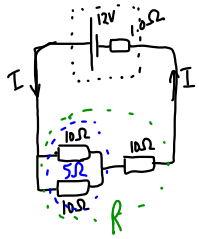
Resistance

Series: $R = R_1 + R_2 + R_3 + \ldots + R_n$ (increase R)

Parallel: $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots + \frac{1}{R_n}$ (decrease R)

Example

A cell of emf 12V and an internal resistance 1.0Ω is connected to three resistors each of resistance 10Ω. The first and second of these resistors are connected in parallel and they are connected in series with the third resistor.



Calculate:

a) the current in each resistor

b) potential diff. across each resistor

c) power in each resistor

First find the equivalent resistance of the 3x 10Ω resistors:

Two in parallel: $\frac{1}{R} = \frac{1}{10\Omega} + \frac{1}{10\Omega}$

$\frac{1}{R} = \frac{2}{10\Omega}$

$R = 5\Omega$

Now that "resistor" (two in parallel) is in series with 10Ω

$R = R_1 + R_2$

$R = 5\Omega + 10\Omega$

$R = 15\Omega$

Using: $\mathcal{E} = I(R + r)$

$I = \frac{\mathcal{E}}{(R+r)}$

$I = \frac{12V}{(15\Omega + 1.0\Omega)}$

$I = \frac{12V}{16\Omega}$

$I = 0.75A$ ← current in the series resistor

∴ current in the parallel resistors is split equally

0.375A

(b)

$V = IR$

$V = (0.75A)(10\Omega)$

$V = 7.5V$ ← the resistor in series.

$V = (0.375A)(10\Omega)$

$V = 3.75V$ ← the resistors in parallel.

(c) $P = I^2R$

$P = (0.75A)^2(10\Omega)$

$P = 5.6\ W$ ← the resistor in series

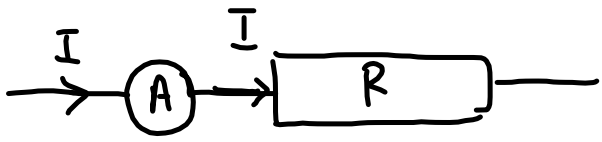
$P = (0.375A)^2(10\Omega)$

$P = 1.4\ W$ ← the resistors in parallel

Measurement of current with an ammeter

- an ammeter measures the amount of charge passing through it per second.
- it must be placed in series so that the current also passes through it
- the ammeter MUST NOT affect the current that is being measured.
- the resistance of the ammeter must be very small

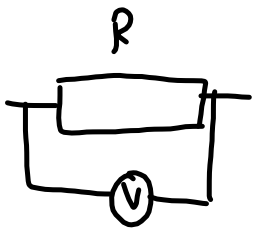
An ideal ammeter has zero resistance



The ammeter must be placed in series and have negligible resistance.

Measurement of Potential Difference with a Voltmeter:

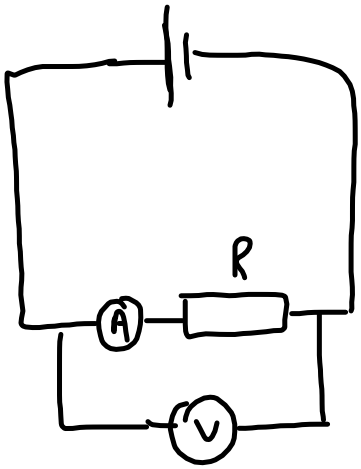
- the voltmeter measures the difference in energy per unit charge on either side of the resistor.
- it must be placed parallel with the resistor so that it can sense the difference in energy per unit charge on either side of it.
- the voltmeter must not draw current from the resistor!
- the resistance of the voltmeter must be very large



an ideal voltmeter has infinite resistance

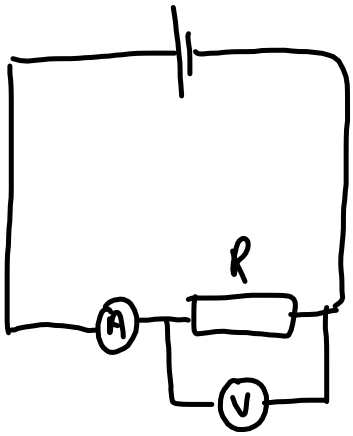
We want negligible current passing through the voltmeter in comparison to the resistor and the voltmeter is connected in parallel

Simultaneous measurement of current + potential difference.
(through resistor) (across resistor)



This is suitable if a less than perfect voltmeter is used.

Current passing through it doesn't affect the ammeter reading



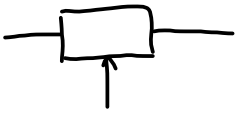
This is suitable if a less than perfect ammeter is used.

The pot. diff across it doesn't affect the voltmeter reading.

Either circuit is acceptable if both meters are perfect!

The potential divider

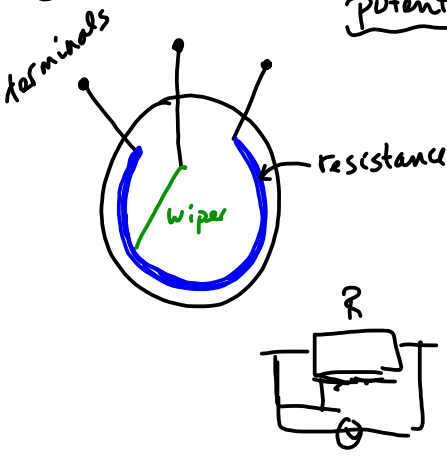
- a potential divider circuit is a circuit which divides a fixed input potential into an output potential which can be varied continuously from zero up to a maximum equal to the input potential
- devices that require a continuously variable voltage make use of a potential divider (i.e. volume control)



circuit symbol for rheostat or potentiometer

used to create a potential divider circuit.

Construction of rheostat and potentiometer:



- current enters at one of the end terminals + exits the other
- as it passes through the resistance wire a pot diff is set up from the point of entry.
- a wiper or slider contacts the resistance wire
- a pot diff. exists between the point of contact and the point of entry of the current.
- the potential difference can be continuously varied by moving the wiper from the point of entry of current (where the pot diff. is zero) to the point of exit of the current (the pot. diff is then equal to the pot diff across the potentiometer)