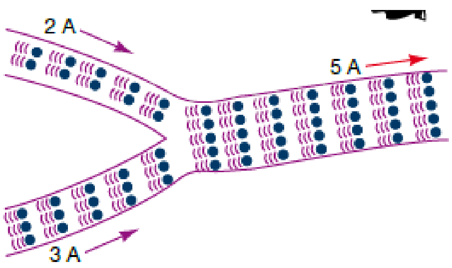
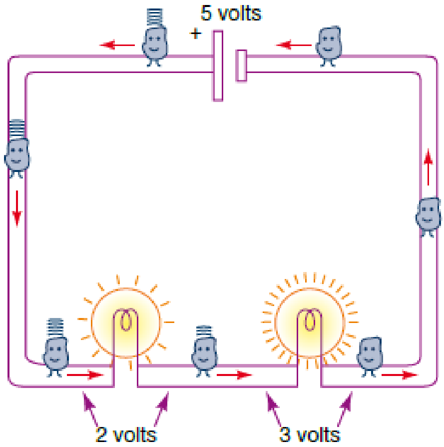
E.7 Circuit Rules

There are two rules for electric circuits, known as Kirchoff's laws. They relate to the conservation of charge and conservation of energy.

In any electric circuit the sum of all currents flowing into any point is equal to the sum of the currents flowing out of it.
For example, if at a junction of three wires there is 2 A flowing in on one wire and 3 A flowing in on another, then there must be a current of 5 A flowing out on the third.



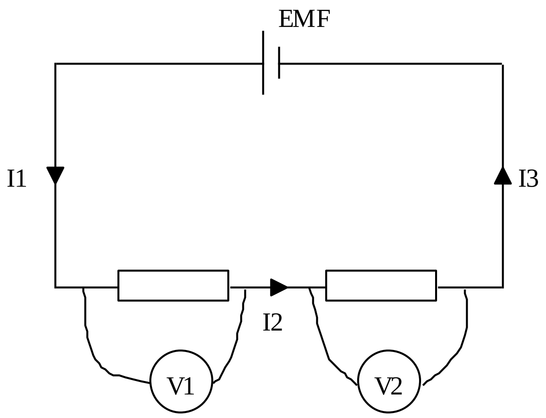
The total potential drop around a closed circuit must be equal to the total EMF in the circuit. In a torch, for example, if the battery supplies an EMF of 3.0 V and we measure a 2.8 V p.d. across the bulb, there must be a 0.2 V drop somewhere else in the circuit.



E.8 Voltage and Current in a Circuit

E.8.1 Series Circuits

Video: Hewitt Drew it – Voltage drop



$I_1 = I_2 = I_3$ In series circuits the current remains the same

$V_1 + V_2 = E.M.F.$ In series potential differences add up

In a series circuit , the current leaves the battery, travels around the loop of the circuit passing through each circuit element. As the charges move through each circuit element they transfer/transform potential (energy) until they arrive back at the battery terminal with no electrical energy left. In a series circuit the current is the same throughout the circuit.

We can say that the sum of the energies transferred in the circuit = the energy supplied by the battery.

i.e. $EMF = V_1 + V_2 + V_3 + \ldots\ldots\ldots$

from Ohm's law $V = I R$

we get $I R_T = I R_1 + I R_2 + I R_3 + \ldots\ldots\ldots\ldots$

since I is the same around the circuit

$I R_T = I (R_1 + R_2 + R_3 + \ldots\ldots\ldots\ldots)$

So $R_T = R_1 + R_2 + R_3 + \ldots\ldots\ldots\ldots$

Example

Two pieces of nichrome wire (as used in heater elements) have resistances of 10 Ω and 20 Ω.
a What current would flow through them, and what power will be produced in them, if they are separately connected to a 12 V battery?
b If they are connected in series what is their total resistance?
c When placed in series across the 12 V battery, what current will flow through them and what power will be produced?

Solution

a The current will be given by $I = V/R$, so for the two wires separately the currents will be 12/10 = 1.2 A and 12/20 = 0.6 A.
The power is found from $P = VI$ and so will be 12 × 1.2 = 14.4 W and 12 × 0.6 = 7.2 W, a total of 21.6 W.

b When connected in series the total resistance will be 10 + 20 = 30 Ω.

c The current that flows from the 12 V battery will be
$I = \frac{12}{30}$
= 0.4 A
The total power will be 12 × 0.4 = 4.8 W,