Fundamental units

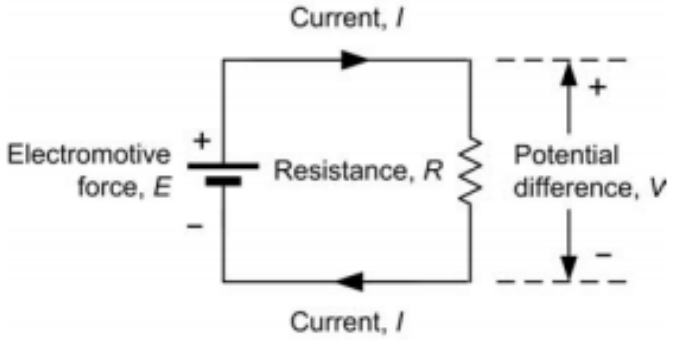
You will already know that the units that we now use to describe such things as length, mass and time are standardized within the International System of Units. This **SI system** is based upon **fundamental units**

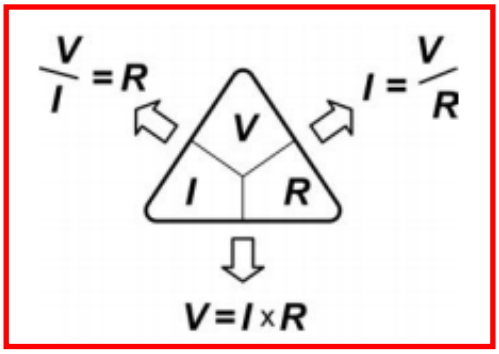
Quantity	Unit	Abbreviation	Equivalent (in terms of fundamental units)
Current	ampere	A	
Length	metre	M	
mass	Kilogram	Kg	
Temperature	Kelvin	K	
Time	second	s	
capacitance	Farad	As/v	
charge	coulomb	c	As
Energy	joule	J	Nm
Frequency	Herz	Hz	1/s
Inductance	Henry	H	Vs/A
Potential	volt	v	W/A
Power	watt	w	J/s
Resistance	Ohm	Ω	v/A

Ohm's Law

$$V / I = \text{a constant} = R$$

where **V** is the potential difference (or voltage drop) in Volts (V), **I** is the current in Amperes (A), and **R** is the resistance in Ohms (Ω) (as shown in Fig below). The formula may be arranged to make V, I or R the subject, as follows





Example 1

A 12 Ω resistor is connected to a 6V battery. What current will flow in the resistor?

Solution

Here we must use $I = V / R$ (where V = 6 V and R = 12 Ω):

$I = V / R$ = 6 V / 12 Ω = 0.5 A (or 500 mA)

Example 2

A current of 100 mA flows in a 56 Ω resistor. What voltage drop (potential difference) will be developed across the resistor?

Solution

Here we must use $V = I \cdot R$ and ensure that we work in units of Volts (V), Amperes (A) and Ohms (Ω).

$$V = I \cdot R = 0.1 \text{ A} \cdot 56 \text{ Ω} = 5.6 \text{ V}$$

(Note that 100 mA is the same as 0.1 A.) This calculation shows that a p.d. of 5.6 V will be developed across the resistor.

Example 3

A voltage drop of 15 V appears across a resistor in which a current of 1 mA flows. What is the value of the resistance?

Solution

$$R = V / I = 15 \text{ V} / 0.001 \text{ A} = 15{,}000 \text{ Ω} = 15 \text{ kΩ}$$

Note that it is often more convenient to work in units of mA and V which will produce an answer directly in kΩ

Energy and power

In electrical circuits, energy is supplied by batteries or generators. It may also be stored in components such as capacitors and inductors. Electrical energy is converted into various other forms of energy by components such as resistors (producing heat), loudspeakers (producing sound energy) and light emitting diodes (producing light). The unit of energy is the Joule (J). Power is the rate of use of energy and it is measured in Watts (W). A power of 1W results from energy being used at the rate of 1 J per second. Thus:

$$P = W / t$$

where P is the power in Watts (W), W is the energy in Joules (J), and t is the time in seconds (s).

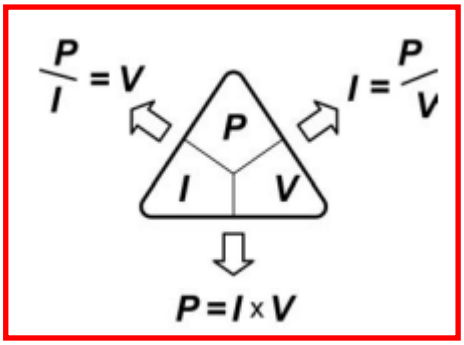
The power in a circuit is equivalent to the product of voltage and current. Hence:

$$P = I \times V$$

where P is the power in Watts (W), I is the current in Amperes (A), and V is the voltage in Volts (V).

The formula may be arranged to make P, I or the subject, as follows:

$$P = I \times P,\ I = P / V \textbf{ and } V = P / I$$



The relationship, $P = I \times V$, may be combined with that which results from Ohm's Law ($V = I \times R$) **to** produce two further relationships.

First, substituting for **V** gives: $P = I \times (I \times R) = I^2 R$

Secondly, substituting for **I** *gives:* $P = (V / R) \times V = V^2/R$

Example 4

A current of 1.5 A is drawn from a 3 V battery. What power is supplied?

Solution

Here we must use $P = I \cdot V$ (where I = 1.5 A and V = 3 V). $P = I \cdot V$ = 1.5 A · 3 V = 4.5 W

Hence a power of 4.5 W is supplied.

Example 5

A voltage drop of 4 V appears across a resistor of 100 Ω. What power is dissipated in the resistor?

Solution

Here we use $P = V^2 / R$ (where V = 4 V and R = 100 Ω).

$$P = V^2 / R = (4 \text{ V} \cdot 4 \text{ V}) / 100 \text{ Ω} = 0.16 \text{ W}$$

Hence the resistor dissipates a power of 0.16 W (or 160 mW)

Example 6

A current of 20 mA flows in a 1 kΩ resistor. What power is dissipated in the resistor?

Solution

Here we use $P = I^2 \cdot R$ but, to make life a little easier, we will work in mA and kΩ (in which case the answer will be in mW).

$$P = I^2 \cdot R = (20 \text{ mA} \cdot 20 \text{ mA}) \cdot 1 \text{ kΩ} = 400 \text{ mW}$$

Thus a power of 400 mW is dissipated in the 1kΩ resistor.

Problems

(1): A resistor of 270 Ω is connected across a 9 V d.c. supply. What current will flow?

(2): A current of 56 μA flows in a 120 kΩ resistor. What voltage drop will appear across the resistor?

(3): A voltage drop of 13.2 V appears across a resistor when a current of 4 mA flows in it. What is the value of the resistor?

(4):A current of 25 mA flows in a 47 Ω resistor. What power is dissipated in the resistor?

(5):A 9 V battery supplies a circuit with a current of 75 mA. What power is consumed by the circuit?

(6):A resistor of 150 Ω is rated at 0.5 W. What is the maximum current that can be applied to the resistor without exceeding its rating?