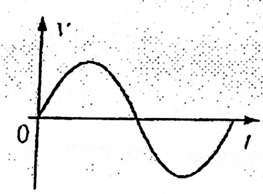
Current and Voltage

Charge: the electrical charge is an electrical property of atomic particles of which matter consists, measured in coulombs (C). The charge of an electron is ($-1.602\times10^{-19}\,C$).

Electrical current: is the rate of change of charge, measured in amperes (A). The current (I) is defined mathematically as:

$$\boxed{I=\frac{Q}{t}}$$

- Direct current (DC): is the current that remains constant with time. The symbol (I) is usually used to represent such a constant current.
- Alternating current (AC): is a current that is varying sinusoidally with time. A time varying current is represented by the symbol (i).



Sinusoidal

Voltage: the voltage (or potential difference) is the energy required to move a unit of charge through an element, measured in volts (V).

* For the voltage Vab, this mean that the potential of point a is higher than that of point b.

$$Vab=Va-Vb$$

Power: is the time rate of expending or absorbing energy, measured in watt (W).

$$P=\frac{w}{t}$$

Where P is the power in watt (W), w is the energy in joules (J), and t is the time in seconds (s).

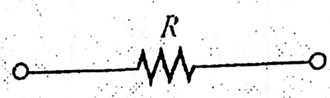
The power (P) is defined mathematically as:

$$\boxed{P=VI}$$

$$\boxed{P = \frac{V^2}{R}}$$

$$\boxed{P = I^2 R}$$

Resistance: the resistance R denotes the ability of an element to resist the flow of electrical current, it is measured in Ohms (Ω).



For the material, the resistance R depends of the physical dimensions as follows:

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

Where ρ is the receptivity of material.

Resistivity (ρ) of various materials in ohm-centimeters.

Silver	1.645×10^{-6}
Copper	1.723×10^{-6}
Gold	2.443×10^{-6}
Aluminum	2.825×10^{-6}
Tungsten	5.485×10^{-6}
Nickel	7.811×10^{-6}
Iron	12.299×10^{-6}
Tantalum	15.54×10^{-6}
Nichrome	99.72×10^{-6}
Tin oxide	250×10^{-6}
Carbon	3500×10^{-6}

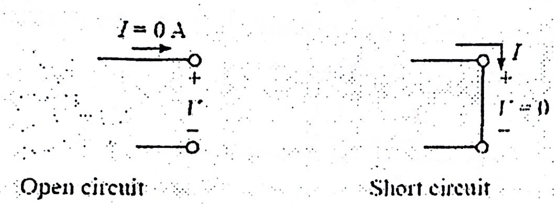
EXAMPLE: Determine the resistance of 30.48 m of copper telephone wire if the diameter is 0.032 cm.

Solution:

$$A = \frac{\pi d^2}{4} = \frac{(3.1416)(0.032\ \text{cm})^2}{4} = 8.04 \times 10^{-4}\ \text{cm}^2$$

$$R = \rho\frac{l}{A} = \frac{(1.723 \times 10^{-6}\ \Omega\cdot\text{cm})(3048\ \text{cm})}{8.04 \times 10^{-4}\ \text{cm}^2} \cong 6.5\ \Omega$$

- The resistance of a short circuit element is approaching zero.
- The resistance of an open circuit element is approaching infinity.



Conductance: the conductance can be explained as the ability of an element to conduct electrical current, it is measured in siemens (S).

$$\boxed{G = \frac{1}{R}} \qquad \boxed{G = \frac{A}{\rho l}}$$

OHM'S LAW: Ohm's low states that the voltage V across a resistor is directly proportional to the current I flowing through the resistor.

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

EXAMPLE: Determine the current resulting from the application of a 9-V battery across a network with a resistance of 2.2 Ω.

Solution:

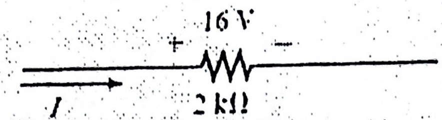
$$I = \frac{V}{R} = \frac{9V}{2.2\Omega} = 4.09\,A$$

EXAMPLE: Calculate the resistance of a 60-W bulb if a current of 500 mA results from an applied voltage of 120 V.

Solution:

$$R=\frac{V}{I}=\frac{120}{500\times10^{-3}}=240\Omega$$

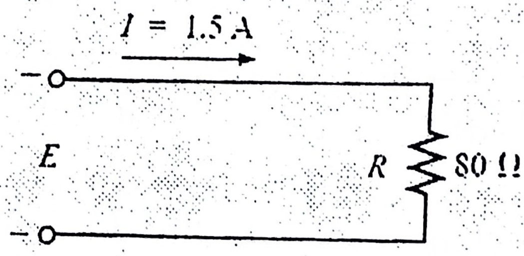
EXAMPLE: Calculate the current through the 2-kΩ resistor of Figure below if the voltage drop across it is 16 V.



Solution:

$$I=\frac{V}{R}=\frac{16\text{ V}}{2\times10^{3}\ \Omega}=8\text{ mA}$$

EXAMPLE: Calculate the voltage that must be applied across the soldering iron of Figure below to establish a current of 1.5 A through the iron if its internal resistance is 80Ω.



Solution:

$$E=IR=(1.5\text{ A})(80\ \Omega)=120\text{ V}$$

EXAMPLE: What is the power dissipated by a 5Ω resistor if the current is 4 A?

Solution:

$$P=I^2R=(4\text{ A})^2(5\ \Omega)=80\text{ W}$$

EXAMPLE: Determine the current through a 5-kΩ resistor when the power dissipated by the element is 20 mW.

Solution:

$$I=\sqrt{\frac{P}{R}}=\sqrt{\frac{20\times10^{-3}\text{ W}}{5\times10^{3}\ \Omega}}=\sqrt{4\times10^{-6}}=2\times10^{-3}\text{ A}$$

$$=2\text{ mA}$$