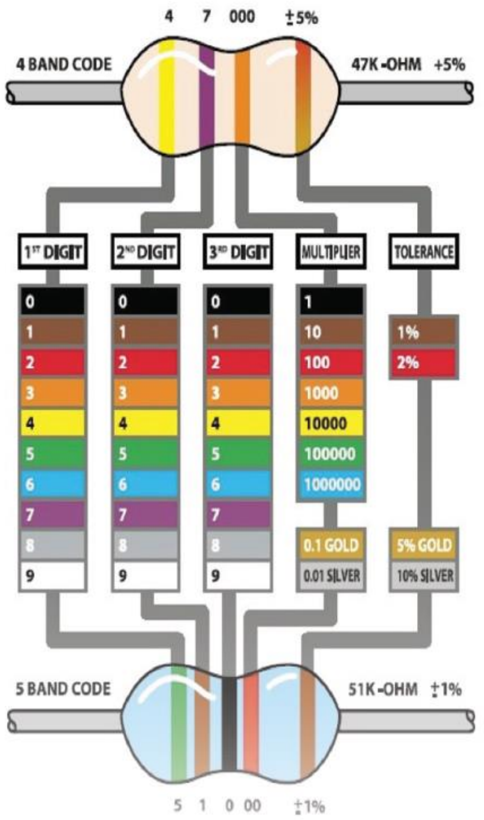
Current and Resistance



Chapter 9 :

Current and Resistance

1. Electric Current
2. Ohm›s Law
3. Electric Power
4. Connecting resistors

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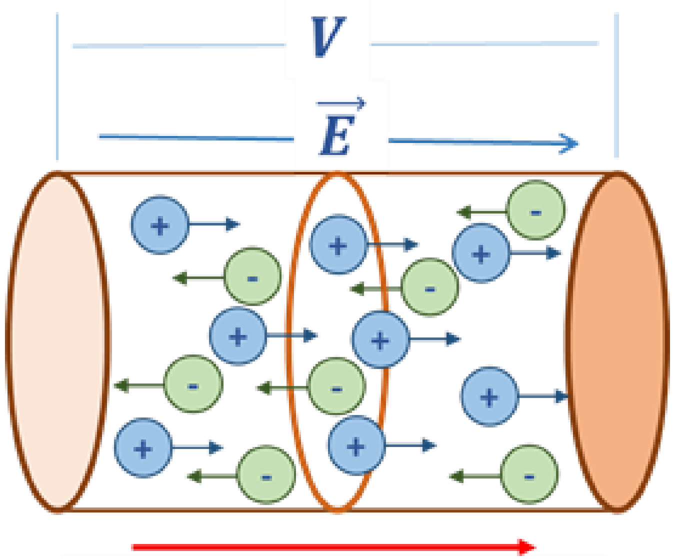
1. Electric Current

The electric current is defined as the rate of flow of negative charges of the conductor. The unit of the electric current is ampere A

$$I = \frac{dq}{dt} \qquad\qquad I = n\,e\,v\,A$$



Example: 9.1

How much the electrical current is generated by the passage of an electrical charge of 10 C in a 50-ms time period .

Solution

$$I = \frac{\Delta q}{\Delta t} = \frac{10}{50 \times 10^{-3}} = 200A$$

1. Electric Current

The density of the electric current (J) is defined as the amount electric current of passing through the vertical unit area of the conductor cross-section.

The unit of the density of the electric current is A/m^2

$$J = \frac{I}{A} \qquad\qquad J = n\,e\,v$$

Example: 9.2

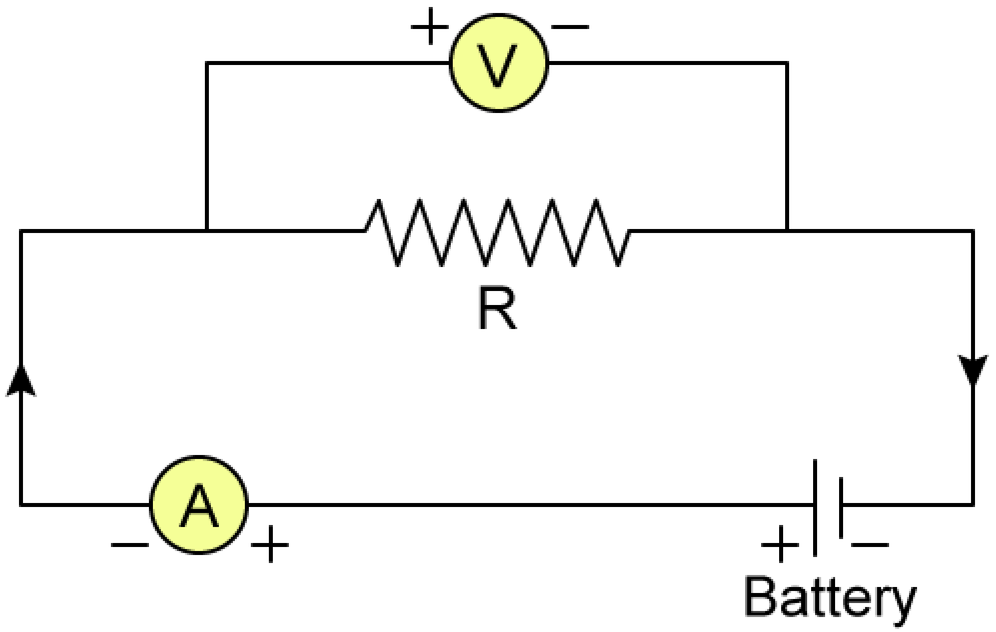
How much the density of the electric current is generated by the passage of an electrical current of 2 A in a 0.1 cm cross-section area of the conductor.

Solution

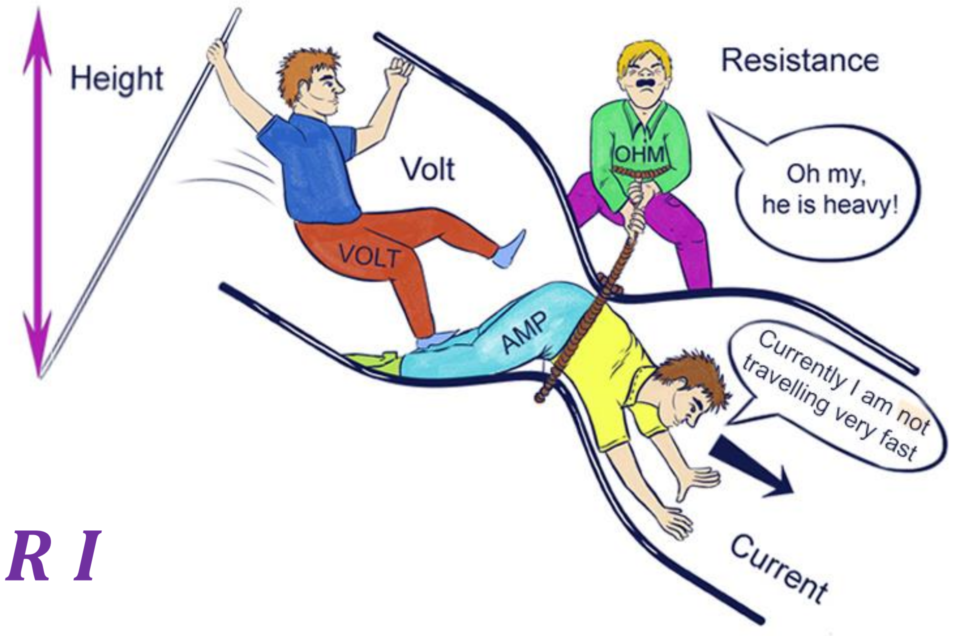
$$J = \frac{I}{A} = \frac{2}{0.1 \times 10^{-2}} = 2000\ \frac{A}{m^2}$$

2. Ohm's Law

Ohm law state that the voltage difference between the two ends of a conductor is proportional to the intensity of the electrical current passing through it, when its temperature is constant.



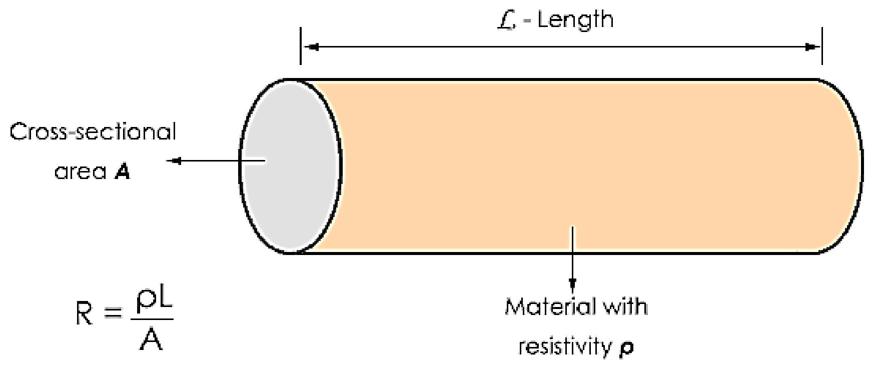
$$V = R\,I$$



2. Ohm's Law

The electrical resistance R is directly proportional to the length of the conductor and inversely proportional to the area of the conductor cross section.

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



Where **ρ** is the **specific resistance** of the material corresponds to another quantity called **electrical conductivity σ**.

$$\rho = \frac{1}{\sigma}$$

The electrical resistance is measured by the ohm Ω.

2. Ohm's Law

Example: 9.5

Nickel chrome alloy wire1 m long, 0.2 mm diameter, and its quality resistance $1 \times 10^{-6}\ \Omega \cdot m$

a. Calculate the resistance of the wire.

b. If the voltage difference of 20 V between the ends of the wire is affected. How much current is passing?

Solution

a. $R = \rho \frac{\ell}{A} = \rho \frac{\ell}{\pi\, r^2}$

$$= (1 \times 10^{-6}) \frac{1}{\pi (0.2 \times 10^{-3})^2} = 7.96\ \Omega$$

b. $\mathrm{I} = \frac{V}{R}$

$$= \frac{20}{7.96} = 2.5\ A$$

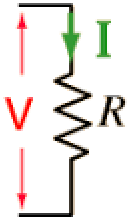
3. Electric Power

Electrical power P is the energy or work done to transfer electrical charges in a conductor per unit time.

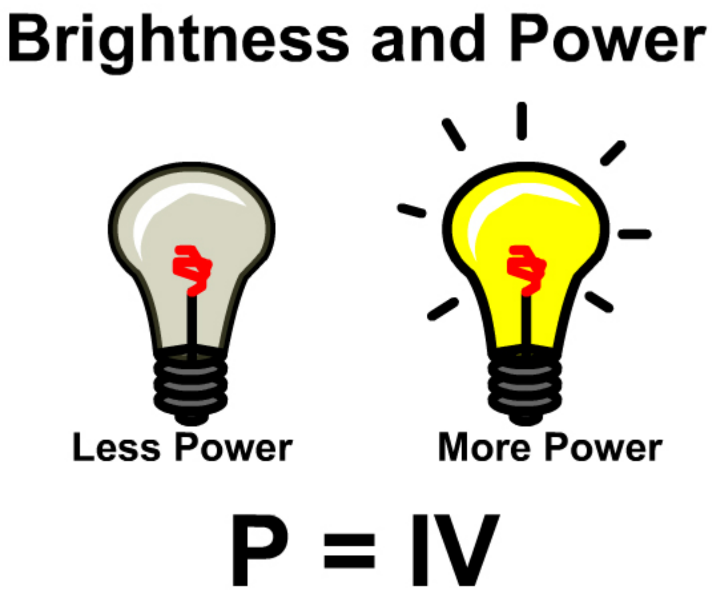
$$P = V\,I$$

The electrical power is measured by the watt.

$$1\ watt = \frac{1\ J}{1\ sec}$$



$$P = VI = \frac{V^2}{R} = I^2 R$$



3. Electric Power

Example: 9.6

nickel chrome heater has an 8 Ω resistant, works on a 120 V voltage. Find the current and electrical power that passes through the heater wire.

Solution

We find the strength of the current first:

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

$$= \frac{120}{8} = 15 \text{ A}$$

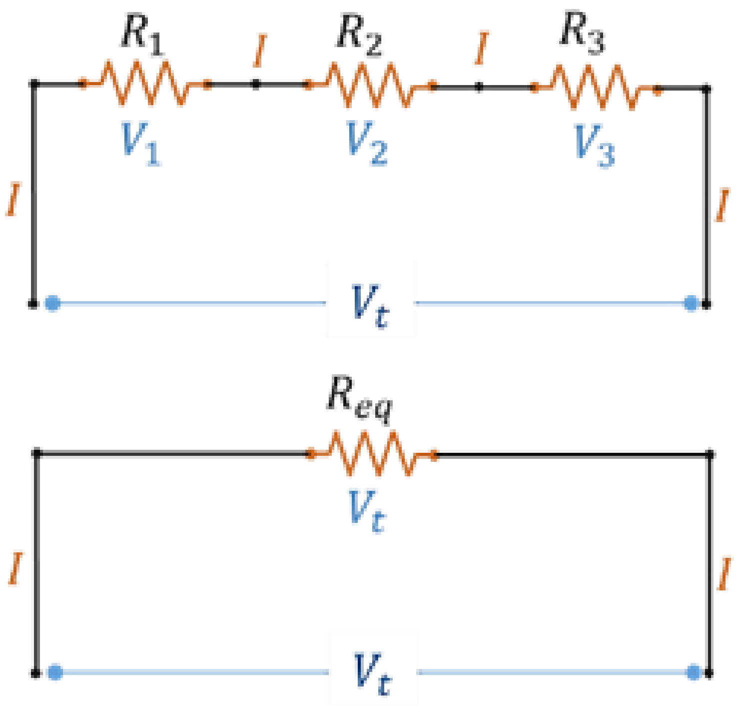
Then we compensate in the Law of power as follows:

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

$$= \frac{(120)^2}{8} = 1800 \text{ Watt}$$

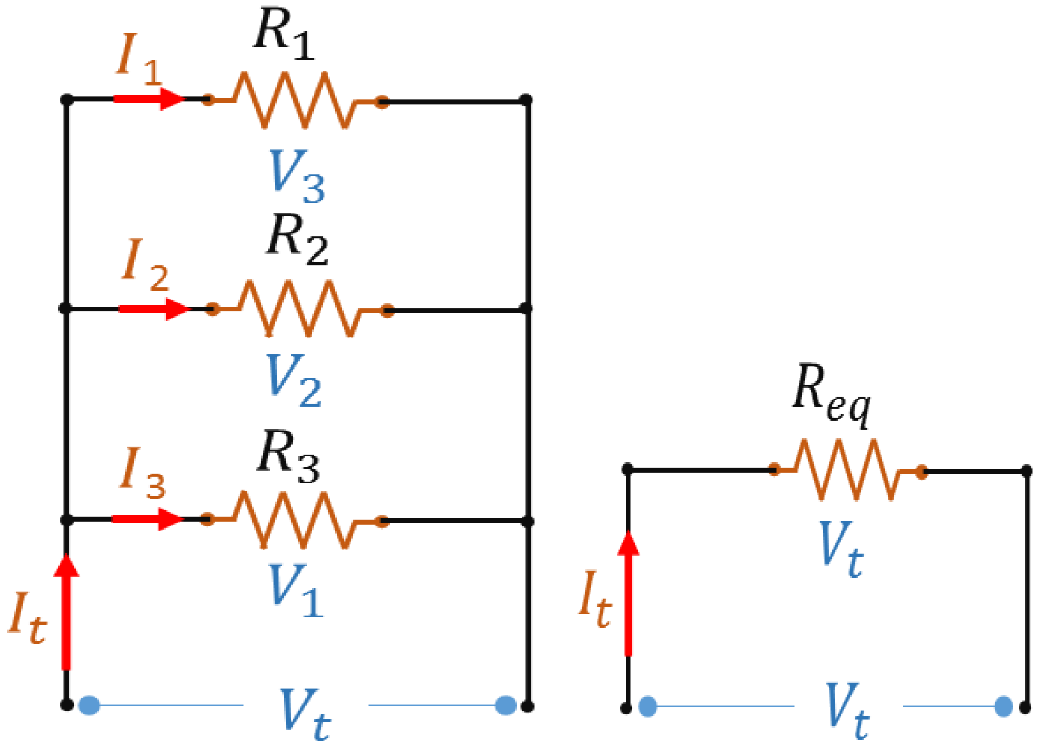
4. Connecting resistors

Connecting resistors in series



$$R_{eq} = R_1 + R_2 + R_3$$

Connecting resistors in parallel



$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

4. Connecting resistors

Example: 9.7

Three resistances amounting to 18 Ω, 12 Ω, 6 Ω connected in series, how much of the equivalent resistance?

Solution

$$R_{equ} = R_1 + R_2 + R_3$$

$$= 18 + 12 + 6 = 36\Omega$$

4. Connecting resistors

Example: 9.8

Three resistances amounting to 18 Ω, 12 Ω, 6 Ω connected in parrlel, how much of the equivalent resistance?

Solution

$$\frac{1}{R_{equ}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

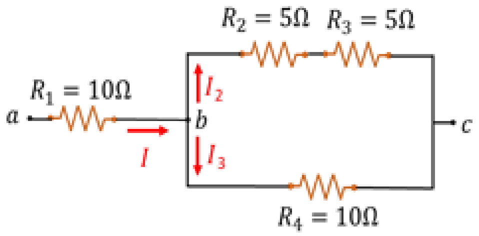
$$= \frac{1}{18} + \frac{1}{12} + \frac{1}{6} = \frac{11}{36}$$

$$R_{equ} = 3.3\ \Omega$$

4. Connecting resistors

Example: 9.9

Four resistant conducting as in the Figure.



a. Find the equivalent resistance between the points a and c?

b. How much of the current in each resistance if a total voltage difference of 15 V is applied between points a and c?

Solution

a. Equivalent resistance:

Resistance (R_{23}) equivalent to R_3 and R_2 is equal to

$$R_{23} = R_2 + R_3$$
$$= 5\Omega + 5\Omega = 10\Omega$$

Resistance (R_{234}) equivalent to R_4 and R_3 and R_2 is equal to

$$\frac{1}{R_{234}} = \frac{1}{R_{23}} + \frac{1}{R_4}$$
$$= \frac{1}{10} + \frac{1}{10} = \frac{1+1}{10} = \frac{2}{10}$$
$$R_{234} = 5\Omega$$

Resistance (R_{ac}) equivalent to R_4 and R_3 and R_2 and R_1 between the two points a and c

$$R_{ac} = R_1 + R_{234}$$
$$= 10 + 5 = 15\Omega$$

b. Total current I in the resistance system:

$$I = \frac{V}{R}$$
$$= \frac{15V}{15\Omega} = 1A$$