Electrical Circuit-I

2nd Lecture

Ohm's Law

By:

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Ref: Robert L. Boylestad, *INTRODUCTORY CIRCUIT ANALYSIS*, Pearson Prentice Hall, Eleventh Edition, 2007

Ohm's Law

States that the voltage (v) across a resistor is directly proportional to the current (i) flowing through the resistor.

That is :

$$v \, \alpha \, i$$

Ohm define the constant of proportionality for a resistor to be the resistor (R)

$$V = I\,R$$

volts, V

R: is measured in the unit of Ohms, designated (Ω)

and

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

amperes, A

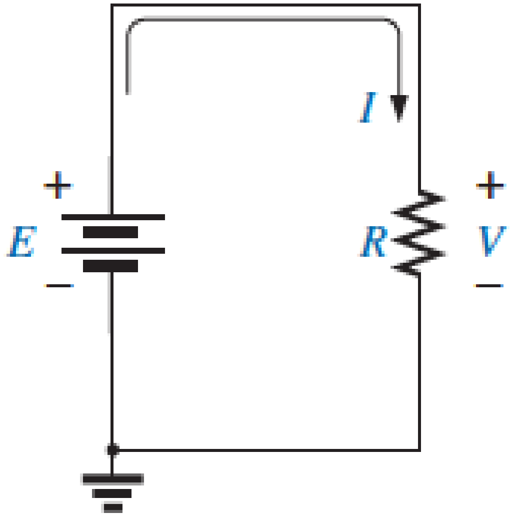
$$R = \frac{V}{I} = \frac{E}{I}$$

ohms, Ω

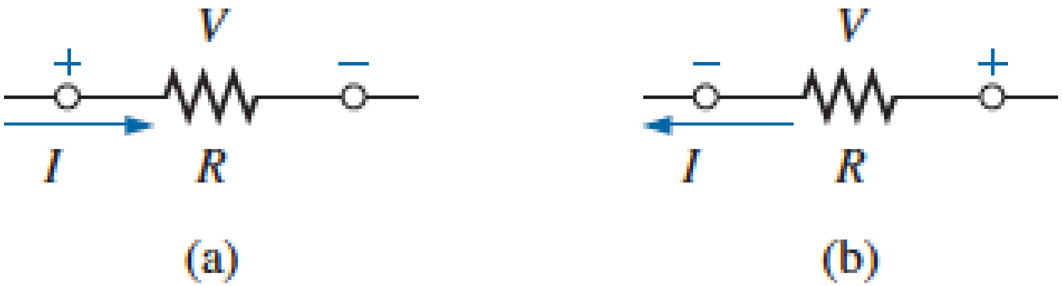
Ohm’s Law

The three quantities V, I, R are defined by the simple circuit

(Basic circuit)



- ***the symbol E is applied to all sources of voltage***
- ***the symbol V is applied to all voltage drops across components of the network.***
- ***For any resistor, in any network, the direction of current through a resistor will define the polarity of the voltage drop across the resistor***



***Example* (1)**

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

Solution:

$$I = \frac{V_R}{R} = \frac{E}{R} = \frac{9\text{ V}}{2.2\ \Omega} = \mathbf{4.09\ A}$$

***Example* (2)**

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

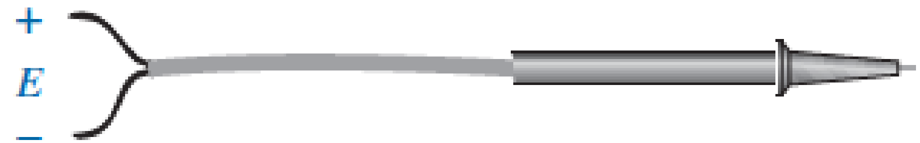
Solution:

$$R = \frac{V_R}{I} = \frac{E}{I} = \frac{120\text{ V}}{500 \times 10^{-3}\text{ A}} = \mathbf{240\ \Omega}$$

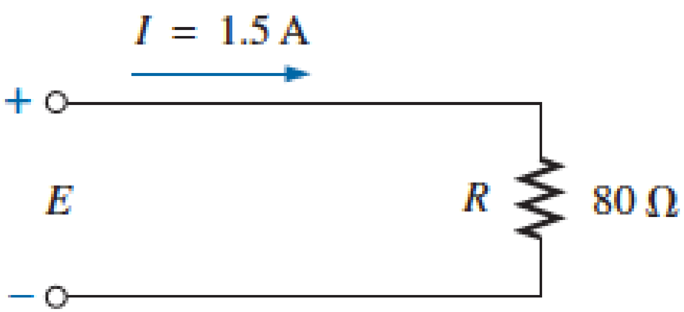
Example (3)

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

Solution:



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

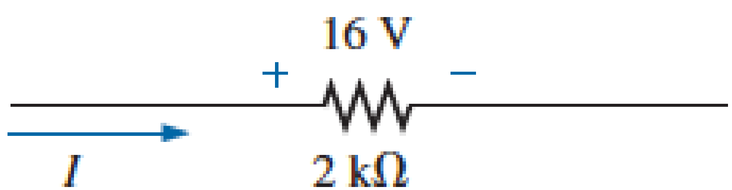


Example (4)

Calculate the current through the 2 kΩ resistor if the voltage drop across it is 16 V.

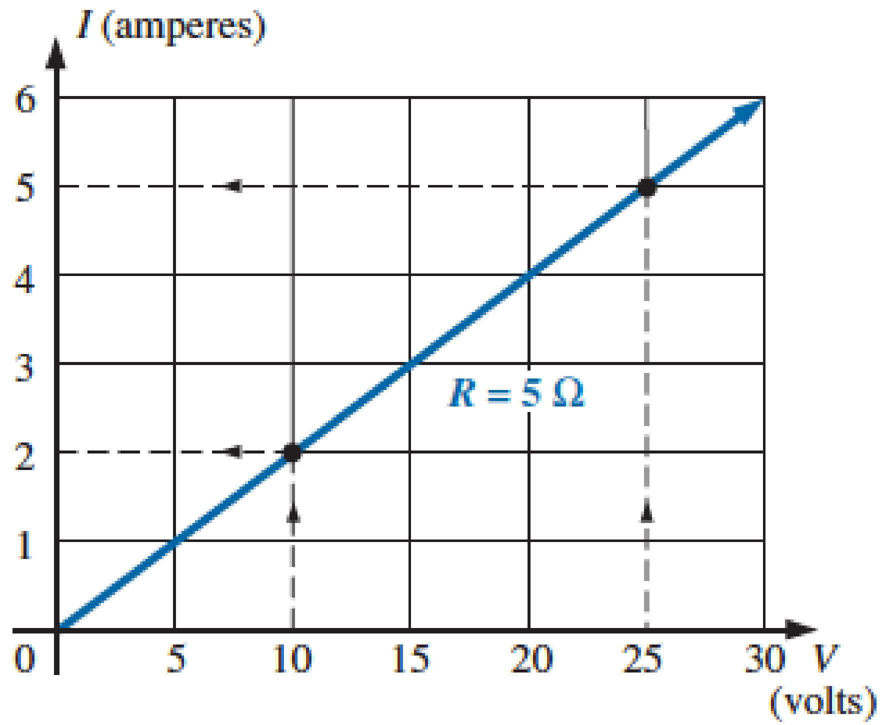
Solution:

$$I = \frac{V}{R} = \frac{16\ \text{V}}{2 \times 10^3\ \Omega} = \mathbf{8\ mA}$$



Plotting Ohm’s Law

$$R_{dc} = \frac{V}{I}$$



If we write Ohm’s law in the following manner and relate it to the basic straight-line equation

$$I = \frac{1}{R} \cdot E + 0$$

$$\downarrow \quad \downarrow \quad \downarrow \quad \downarrow$$

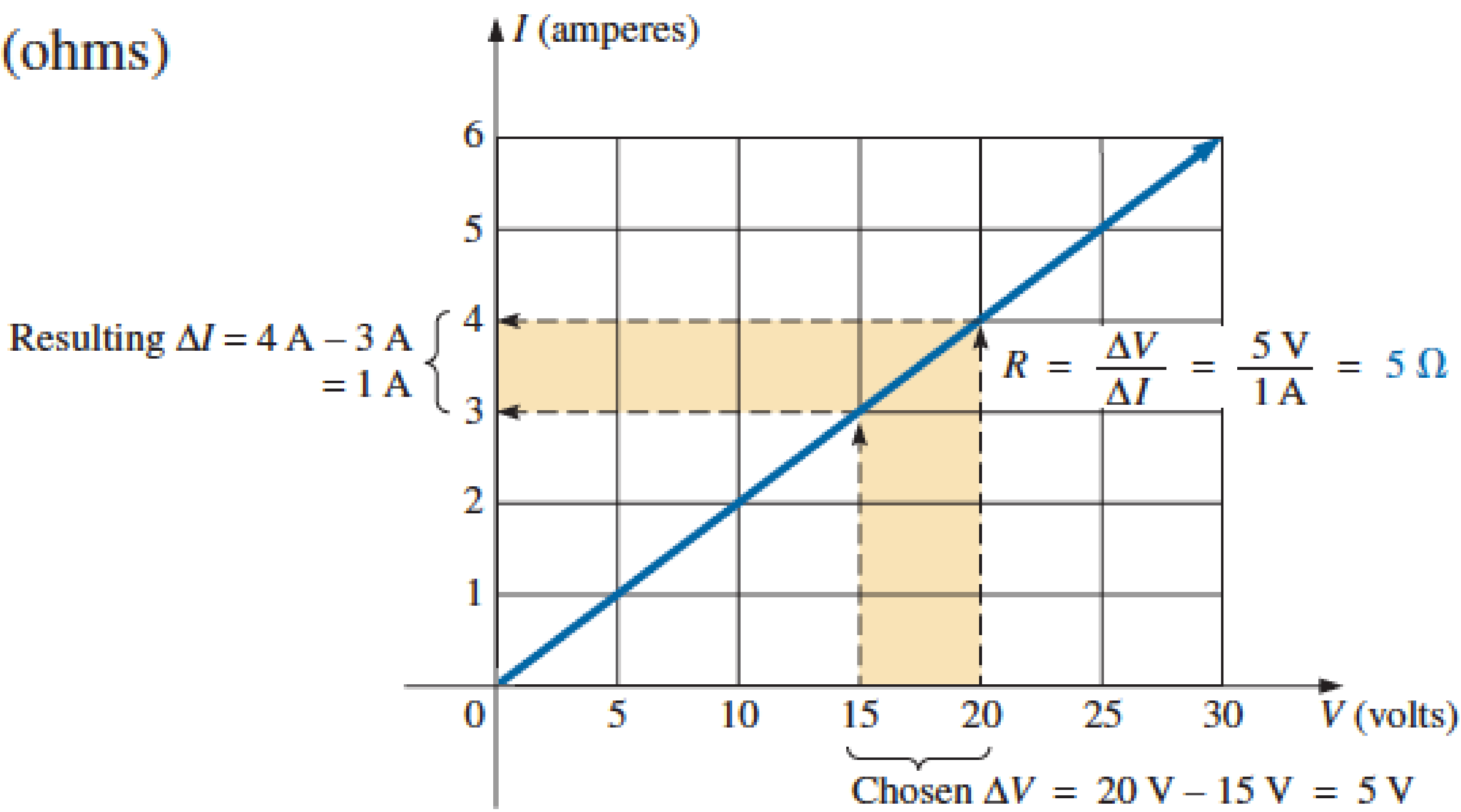
$$y = m \cdot x + b$$

Plotting Ohm's Law

we find that the slope is equal to 1 divided by the resistance value, as indicated by the following:

$$m = \text{slope} = \frac{\Delta y}{\Delta x} = \frac{\Delta I}{\Delta V} = \frac{1}{R}$$

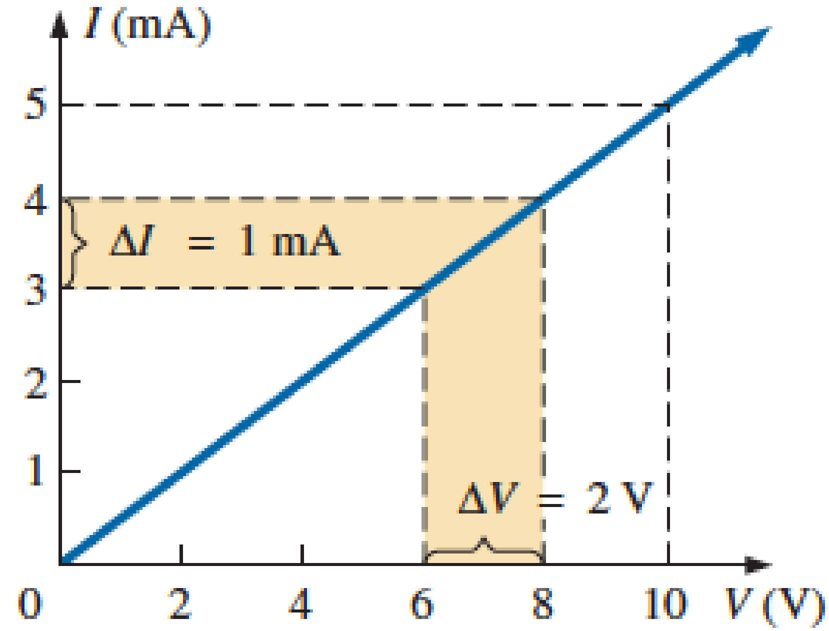
$$R = \frac{\Delta V}{\Delta I} \quad \text{(ohms)}$$



Example (5)

Determine the resistance associated with the curve in the figure below ? And compare results

Solution:



At $V = 6$ V, $I = 3$ mA, and

$$R_{dc} = \frac{V}{I} = \frac{6\text{ V}}{3\text{ mA}} = \mathbf{2\ k\Omega}$$

For the interval between 6 V and 8 V,

$$R = \frac{\Delta V}{\Delta I} = \frac{2\text{ V}}{1\text{ mA}} = \mathbf{2\ k\Omega}$$

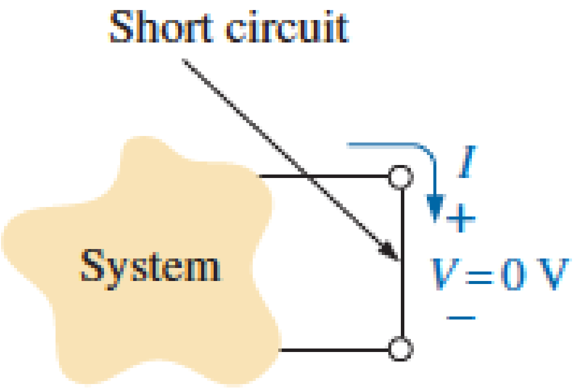
The results are equivalent.

Short Circuit

Is a circuit element with resistance approaching **zero**

R = 0 (for a short circuit)

V = I R = 0

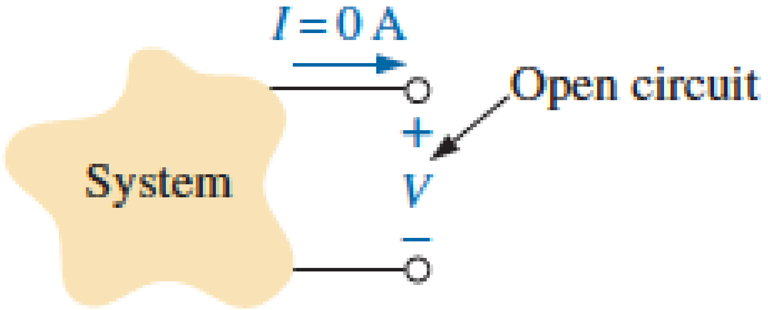


Open Circuit

Is a circuit element with resistance approaching **infinity**

R = ∞ (for a open circuit)

I = $\lim_{R\to\infty} \frac{V}{R} = 0$



Conductance

Is the ability of an element to conduct electric current; it is measured in Mho's (℧) or Siemens (S)

$$G = \frac{1}{R} = \frac{I}{V}$$

The SI unit of G

1 S = 1 ℧ = 1 A/V

Power

The power dissipated by resistor can be expressed in term of (P)

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

We should note two things:

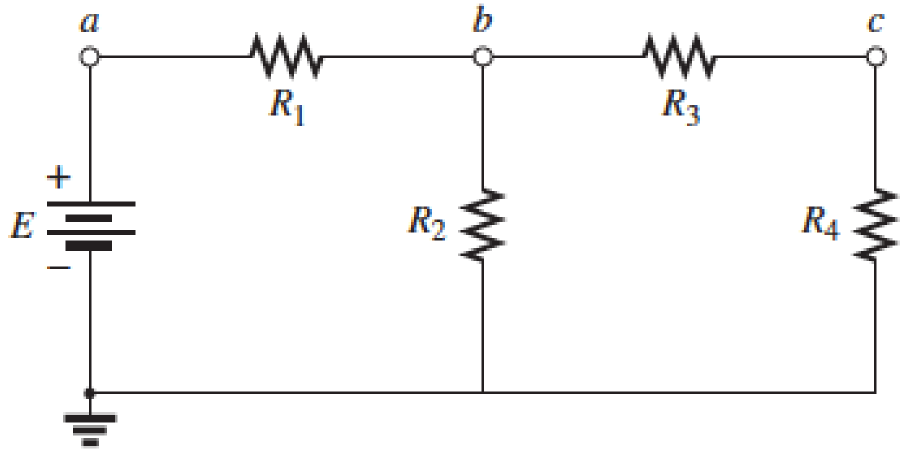
- The power dissipated in a resistor is nonlinear function of either current or voltage.
- Since R is positive quantities, the power dissipated in a resistor is always positive. Thus, a resistor always absorbs power from the circuit.

Branch

Branch represents a single element such as a voltage source or a resistor

Node

Node is the point of connection between two or more branches.



Loop

Loop is any closed path in a circuit.

A network with **(b)** branches, **(n)** nodes, and **(ℓ)** independent loops will satisfy the fundamental theorem of network topology:

$$b = \ell + n - 1$$