Conductance is the ability of an element to conduct electric current; it is measured in mhos (℧) or siemens (S).

$$G = \frac{1}{R} = \frac{i}{v}$$

A branch represents a single element such as a voltage source or a resistor.

A node is the point of connection between two or more branches.

A loop is any closed path in a circuit.

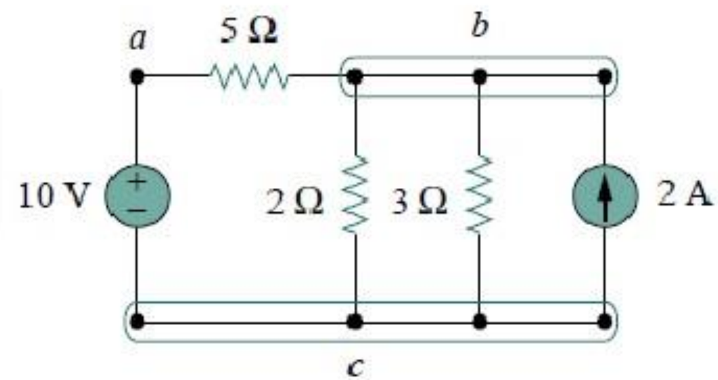


Figure 2.10 Nodes, branches, and loops.

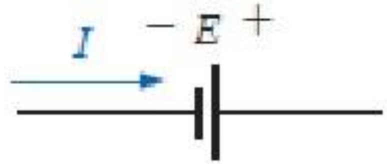


FIG. 5.2

Defining the direction of conventional flow for single-source dc circuits.

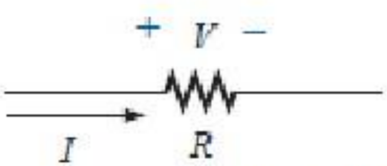


FIG. 5.3

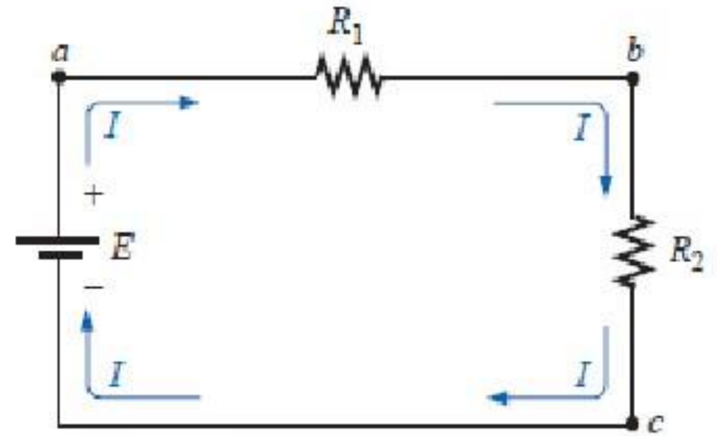
Defining the polarity resulting from a conventional current I through a resistive element.

By following the direction of conventional flow, we notice that there is a rise in potential across the battery (- to +), and a drop in potential across the resistor (+ to -).

Series Circuit

Two elements are in series if

1. *They have only one terminal in common (i.e., one lead of one is connected to only one lead of the other).*
2. *The common point between the two elements is not connected to another current-carrying element.*



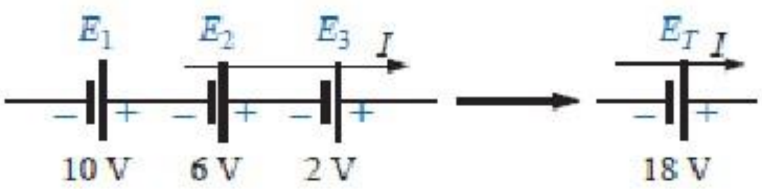
(a) Series circuit

The current is the same through series elements.

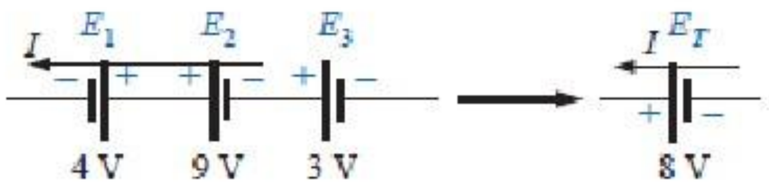
The total power delivered to a resistive circuit is equal to the total power dissipated by the resistive elements.

VOLTAGE SOURCES IN SERIES

$$E_T = E_1 + E_2 + E_3 = 10\text{ V} + 6\text{ V} + 2\text{ V} = 18\text{ V}$$

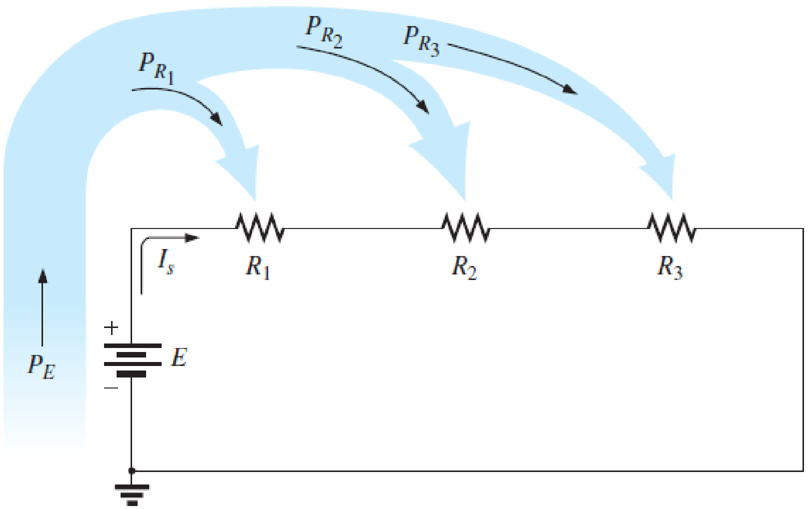


$$E_T = E_2 + E_3 - E_1 = 9\text{ V} + 3\text{ V} - 4\text{ V} = 8\text{ V}$$



Power distribution in a Series Circuit

- The power applied by the dc supply must equal that dissipated by the resistive elements.



$$P_E = P_{R_1} + P_{R_2} + P_{R_3}$$

$$P_1 = V_1 I_1 = I_1^2 R_1 = \frac{V_1^2}{R_1}$$

- In a series configuration, maximum power is delivered to the largest resistor.

KIRCHHOFF'S VOLTAGE LAW

Kirchhoff's voltage law (KVL) states that the algebraic sum of all voltages around a closed path (or loop) is zero.

$$v_2 + v_3 + v_5 = v_1 + v_4$$

$$\sum_{m=1}^{M} v_m = 0$$

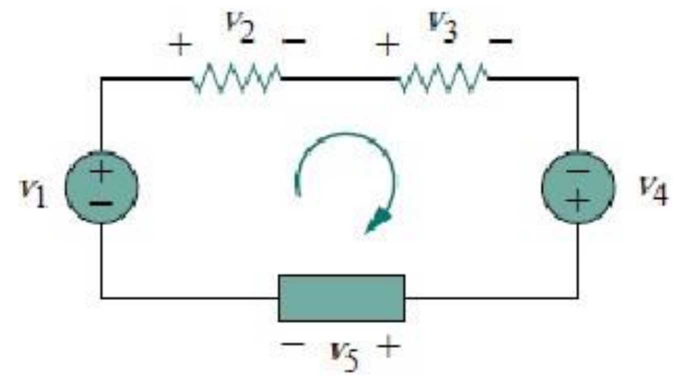


Figure 2.19 A single-loop circuit illustrating KVL.

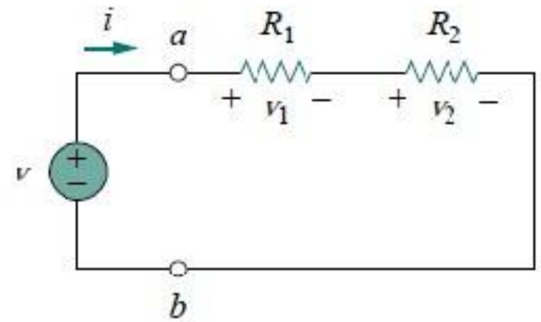
KVL can be applied in two ways: by taking either a clockwise or a counterclockwise trip around the loop. Either way, the algebraic sum of voltages around the loop is zero.

$$\boxed{\text{Sum of voltage drops} = \text{Sum of voltage rises}}$$

SERIES RESISTORS AND VOLTAGE DIVISION

$$v_1 = iR_1, \qquad v_2 = iR_2$$

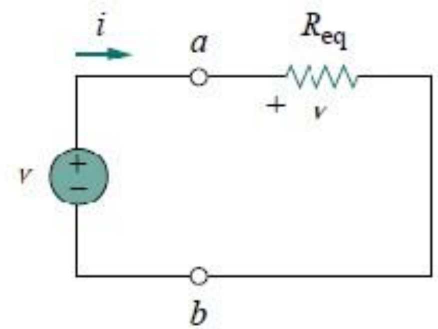
If we apply KVL to the loop (moving in the clockwise direction).



$$-v + v_1 + v_2 = 0$$

$$v = v_1 + v_2 = i(R_1 + R_2)$$

$$i = \frac{v}{R_1 + R_2}$$



$$v = iR_{eq}$$

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

The total resistance of a series circuit is the sum of the resistance levels.

$$v_1 = \frac{R_1}{R_1 + R_2} v, \qquad v_2 = \frac{R_2}{R_1 + R_2} v$$

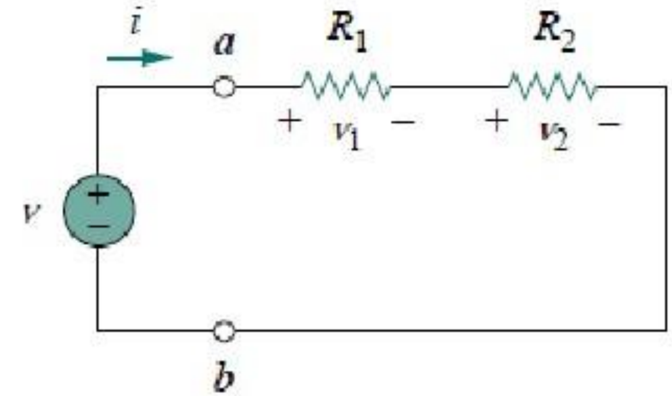


Figure 2.29 A single-loop circuit with two resistors in series.

Notice that the source voltage v is divided among the resistors in direct proportion to their resistances; the larger the resistance, the larger the voltage drop. This is called the *principle of voltage division*, and the circuit in Fig. 2.29 is called a *voltage divider*. In general, if a voltage divider has N resistors ($R_1, R_2, \ldots, R_N$) in series with the source voltage v, the nth resistor (R_n) will have a voltage drop of

$$v_n = \frac{R_n}{R_1 + R_2 + \cdots + R_N} v \tag{2.32}$$

Voltage Regulation

A measure of how close a supply will come to ideal conditions.

$$\text{Voltage regulation } (VR)\% = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100\%$$

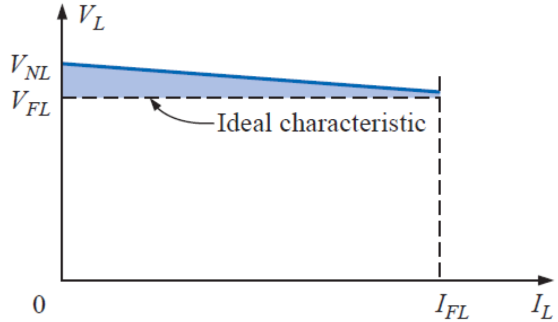


FIG. 5.56
Defining voltage regulation.

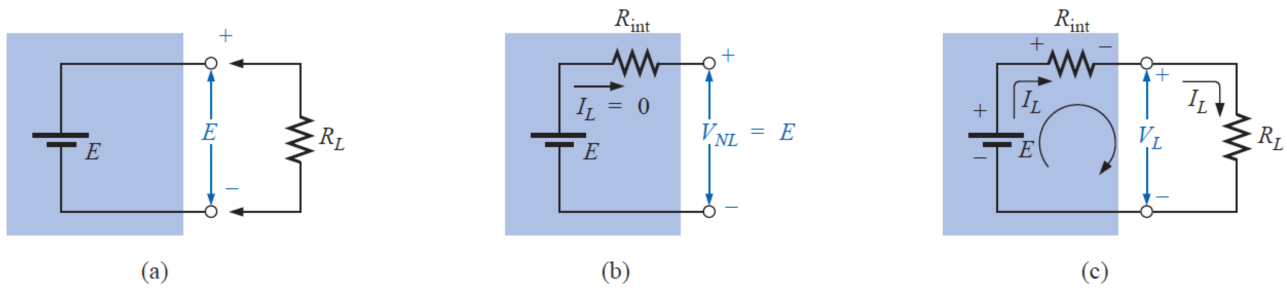
For ideal conditions, $V_{FL} = V_{NL}$ and $VR\% = 0$. Therefore, *the smaller the voltage regulation, the less the variation in terminal voltage with change in load.*

$$VR\% = \frac{R_{\text{int}}}{R_L} \times 100\%$$

In other words, the smaller the internal resistance for the same load, the smaller the regulation and the more ideal the output.

Internal Resistance of Voltage Sources

Every source of voltage have some internal resistance.



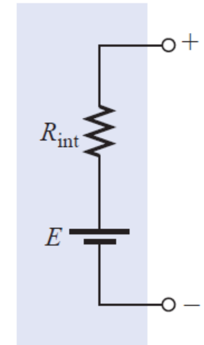


FIG. 5.52

Voltage source: (a) ideal, $R_{int} = 0\ \Omega$; (b) determining V_{NL}; (c) determining R_{int}.

$$E - I_L R_{\text{int}} - V_L = 0$$

$$E = V_{NL}$$

$$V_{NL} - I_L R_{\text{int}} - V_L = 0$$

$$\boxed{V_L = V_{NL} - I_L R_{\text{int}}}$$

$$R_{\text{int}} = \frac{V_{NL} - V_L}{I_L} = \frac{V_{NL}}{I_L} - \frac{I_L R_L}{I_L}$$

$$\boxed{R_{\text{int}} = \frac{V_{NL}}{I_L} - R_L}$$

$I_L V_L$	$=$	$I_L V_{NL}$	$-$	$I_L^2 R_{\text{int}}$
Power to load		Power output by battery		Power loss in the form of heat

LOADING EFFECTS OF INSTRUMENTS

- Any ammeter connected in a series circuit will introduce resistance to the series combination that will affect the current and voltages of the configuration.
- For ammeters, the higher the maximum value of the current for a particular scale, the smaller will the internal resistance be.

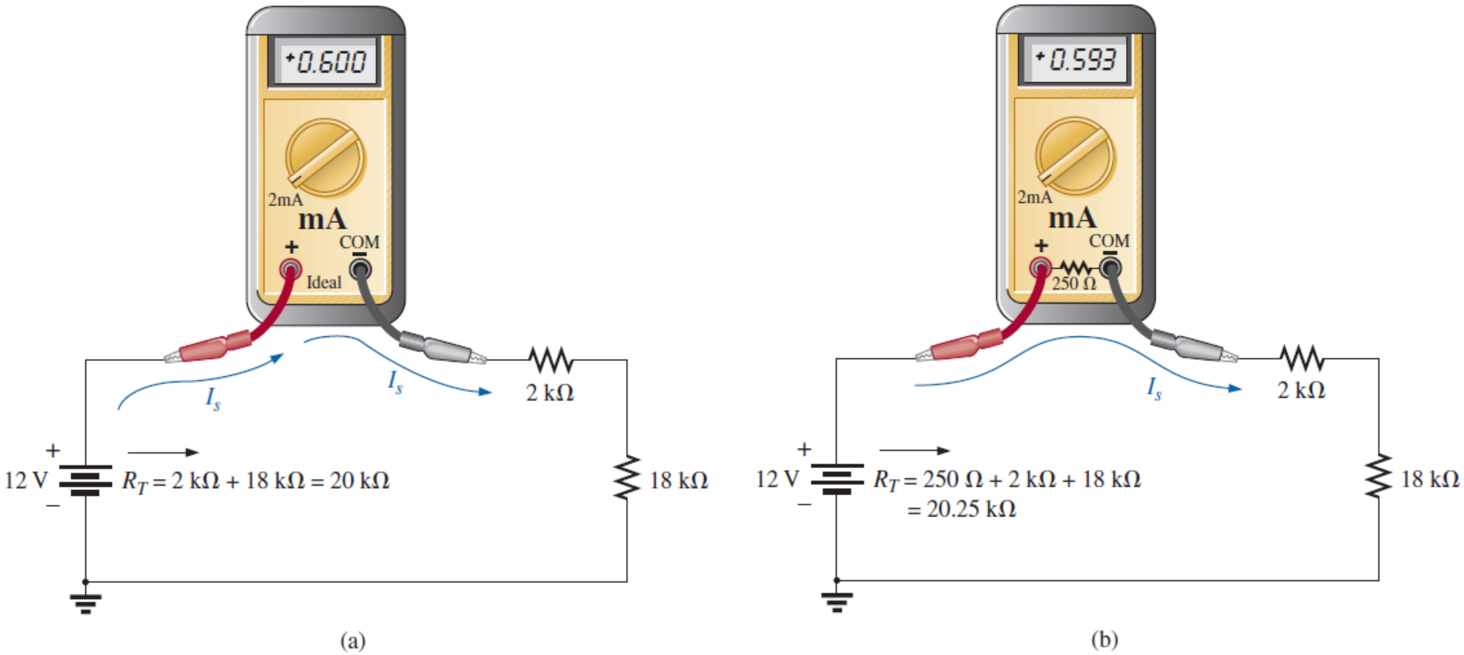


FIG. 74

Applying an ammeter set on the 2 mA scale to a circuit with resistors in the kilohm range: (a) ideal; (b) practical.

Problems

Boylestad:

Chapter: 4

Example: 4.1-4.14

Problems: 1 - 48 (odd)

Sadiku:

Chapter: 2

Practice problems: 2.1, 2.2, 2.5