ENG2200
Electric Circuits

Chapter 2

Circuit Elements

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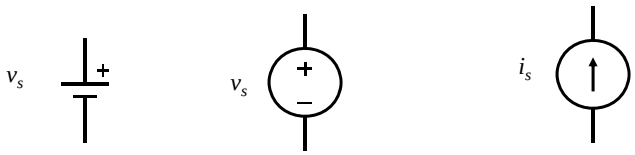
- Voltage and current sources
- Resistance (Ohm's law)
- Kirchhoff's laws
- Dependent sources

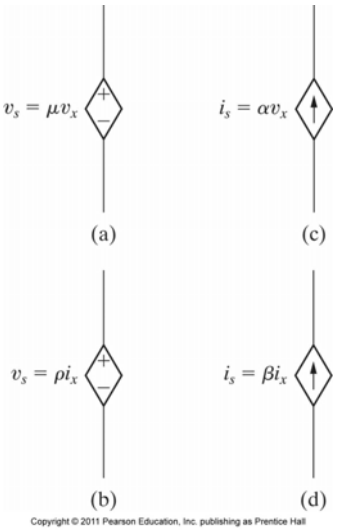
Voltage and Current Sources (Independent)

- Ideal voltage source: Constant voltage across its terminals regardless of the current flowing in theses terminals
- Ideal current source: Constant current through its terminals regardless of the voltage across theses terminals

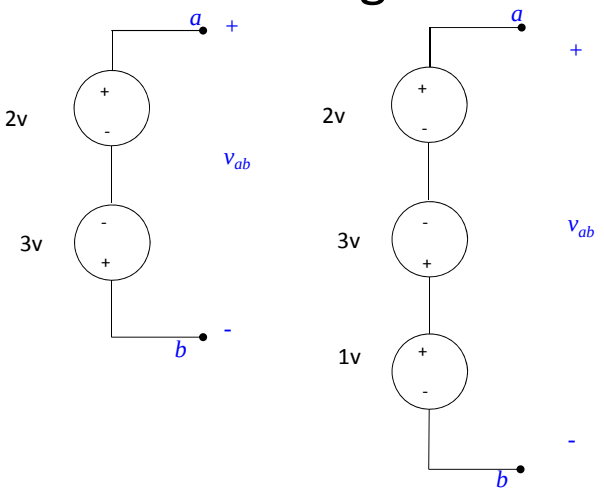


Dependent Sources

- Some times referred to as *controlled sources*
- The value depends on the current or voltage in another part of the circuit.

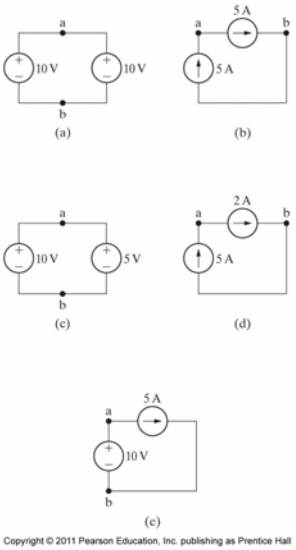


Voltage Sources



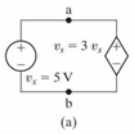
Example

- Which of the circuits to the right is valid?

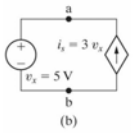


Example

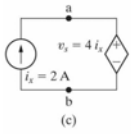
- Which of these circuits are valid?



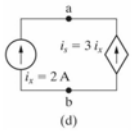
(a)



(b)

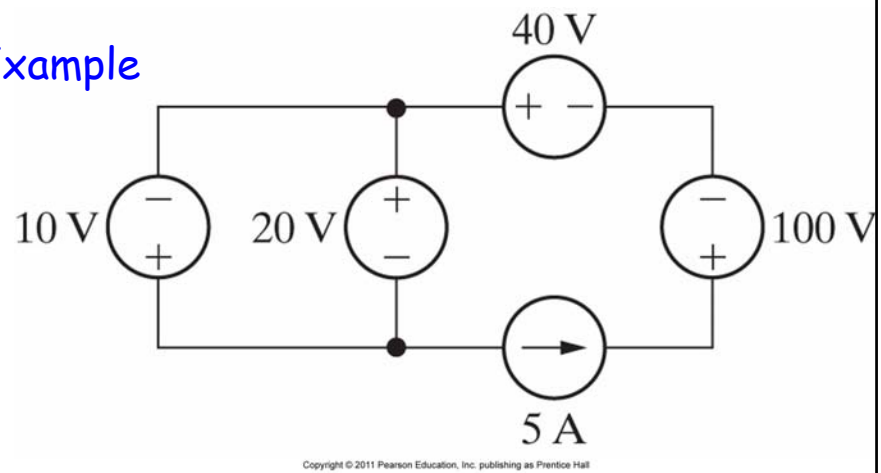


(c)



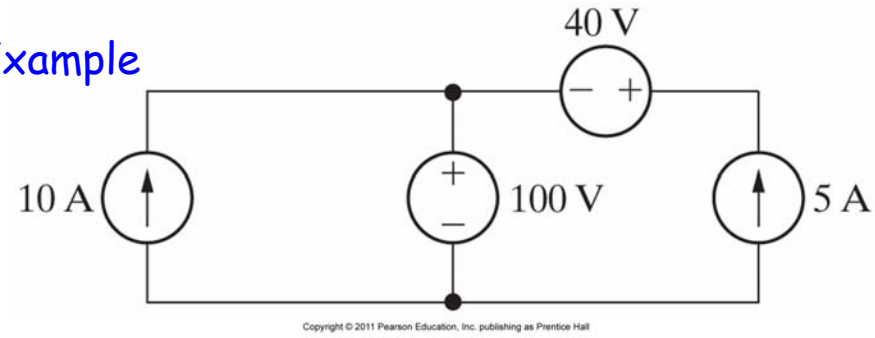
(d)

Example



- If the interconnection is valid, find the total power developed by the voltage sources. If not explain why.

Example



- If the interconnection is valid, find the total developed by the voltage sources. If not explain why.

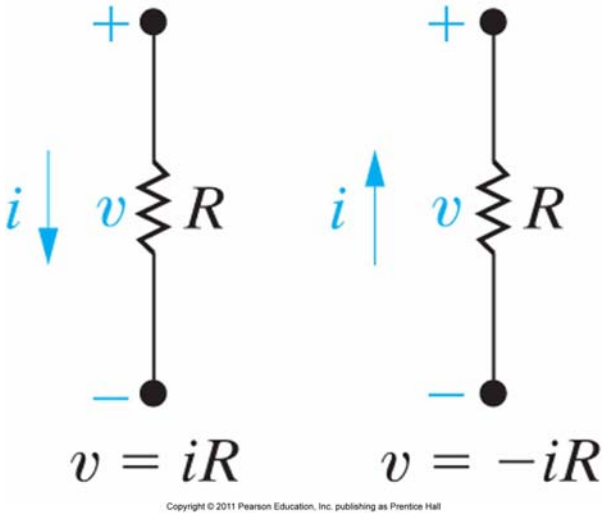
Resistance

- Resistance is the capacity of the material to impede the flow of current (charges) R and is measured in ohm Ω.
- The inverse of the capacitance is **conductance**, G measured in siemens (S)
- The resistance of a wire is $$R = \rho \frac{l}{A}$$
- R is the resistance, l is the length in meters, A is the cross-sectional area in square meters, ρ is the resistivity of the material in ohm meter

Resistance

- Typical values for resistivity in Ω.m
- Silver 1.59×10^{-8} Ω.m at 20 C
- Copper 1.68×10^{-8} Ω.m
- Germanium 4.6×10^{-1} Ω.m
- Sea water 2×10^{-1} Ω.m
- Hard rubber $1 \times 10^{+13}$ Ω.m

Ohm's Law

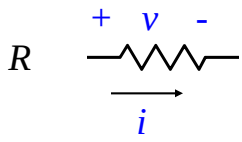


Power in a resistor

$$p = vi$$

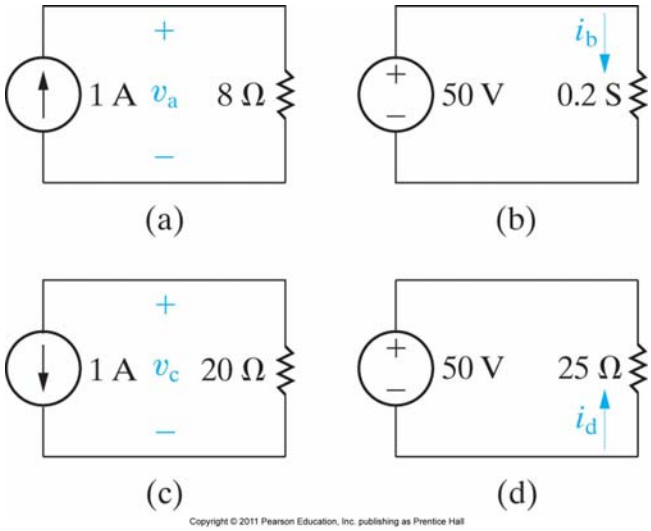
$$p = i^2 R$$

$$p = \frac{v^2}{R}$$



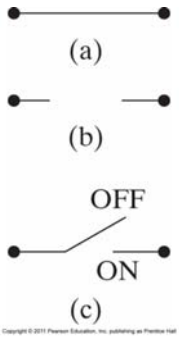
Example

find *v* or *i* in every circuit



Short Circuit and Open Circuit

- Short Circuit
  - Wire
  - R = 0
  - No resistance
  - No voltage
- Open Circuit
  - Air (or insulator)
  - R=∞
  - No current flowing

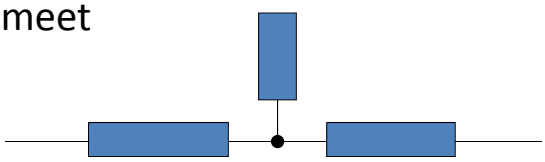


I-V Characteristics of a Device

- I-V characteristic of a resistor
- Ideal voltage source
- ideal current source

Kirchoff's Laws

- A node is a point where two or more circuit elements meet

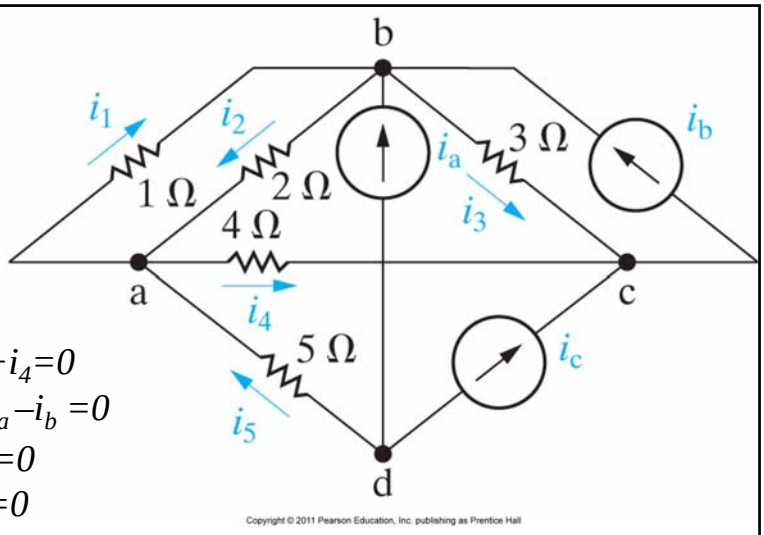


- **KCL: The algebraic sum of all currents at any node in a circuit equals zero**

Kirchoff's Laws

- **Closed Path** or a **loop**: Starting from any node, trace a closed path going through some of the basic circuit elements and returning to the staring node without passing through an element twice;
- **KVL: The algebraic sum of al voltages around any closed path in a circuit equals zero.**

leaving = positive



a: $-i_2-i_5+i_1+i_4=0$

b: $i_2+i_3-i_1-i_a-i_b=0$

c: $i_b-i_3-i_c-i_4=0$

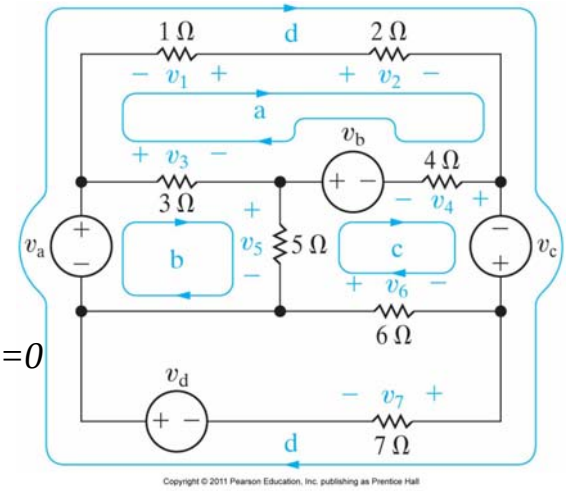
d: $i_5+i_a+i_c=0$

a: $-v_1+v_2+v_4-v_b-v_3=0$

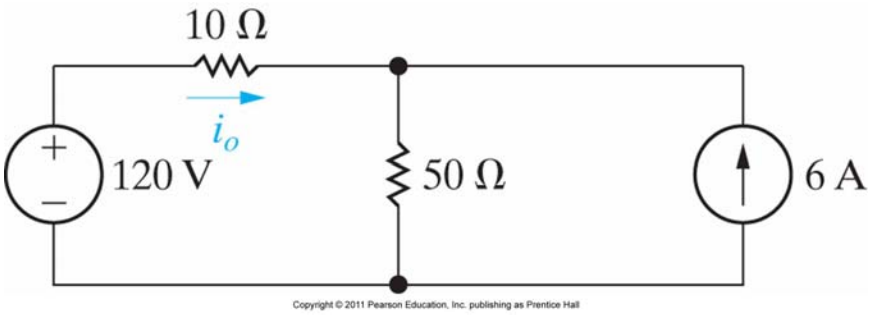
b: $v_3+v_5-v_a=0$

c: $v_b-v_4-v_c-v_6-v_5=0$

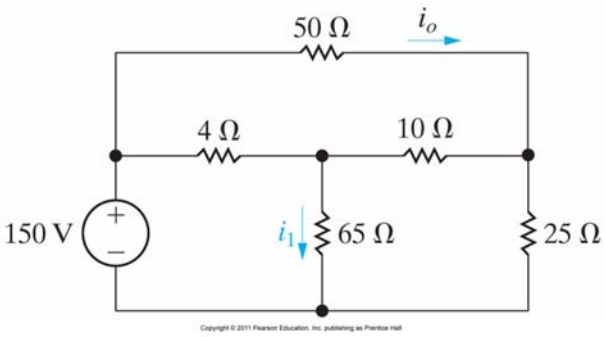
d: $-v_a-v_1+v_2-v_c+v_7-v_d=0$



Example -- Find i_0

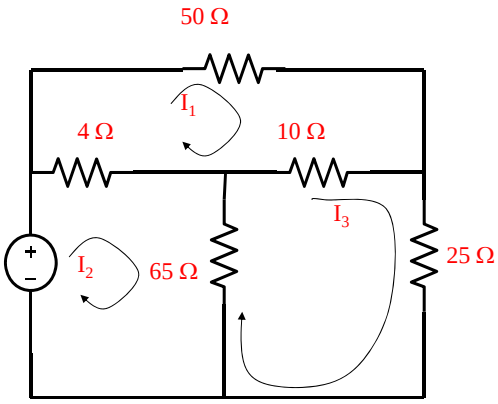


Example

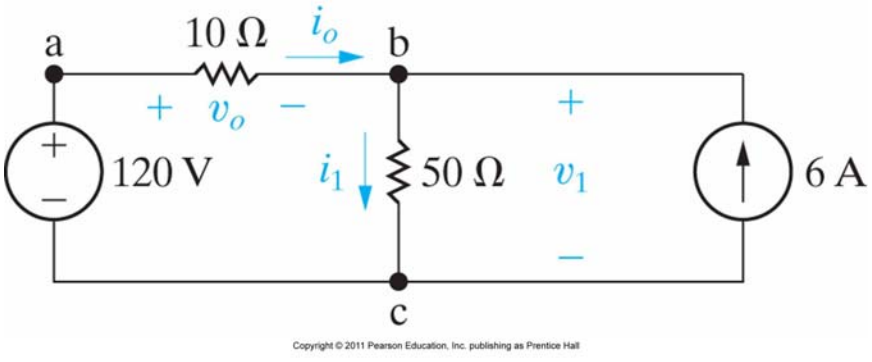


- If i_0=1A, find i_1
- Find the power dissipated in every register

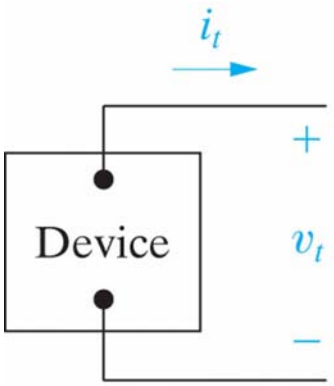
More difficult



Find i_o



Construct a circuit model for the device



(a)

v_t (V)	i_t (A)
30	0
15	3
0	6

(b)

Find the power delivered to a 10 Ω R

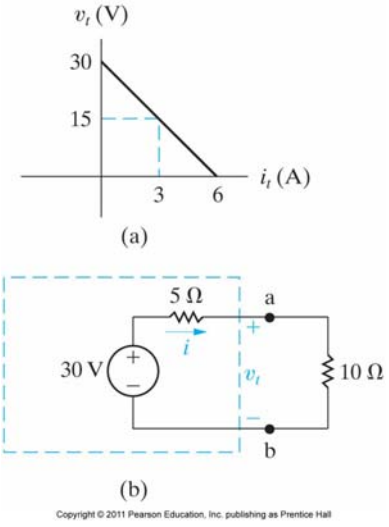
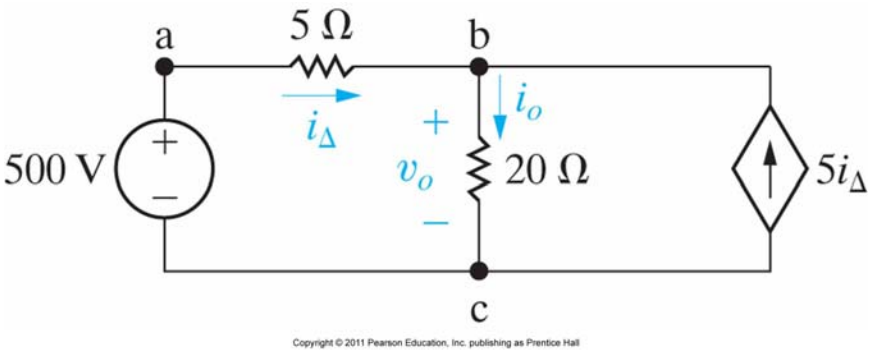
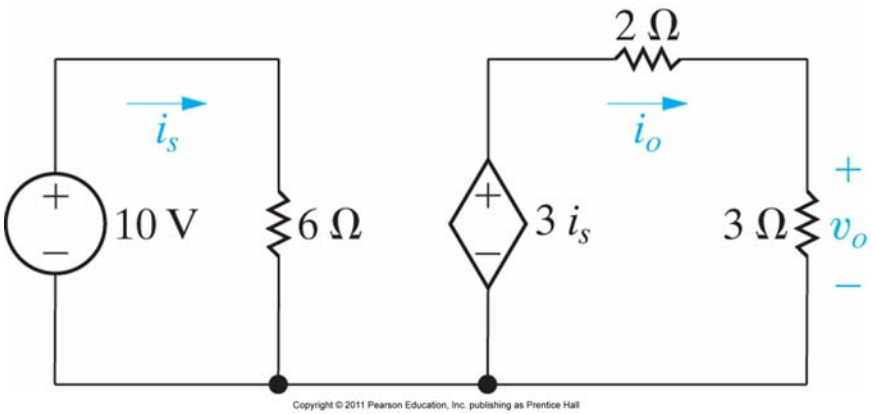


Figure 2.22 A circuit with a dependent source.



Example



Example

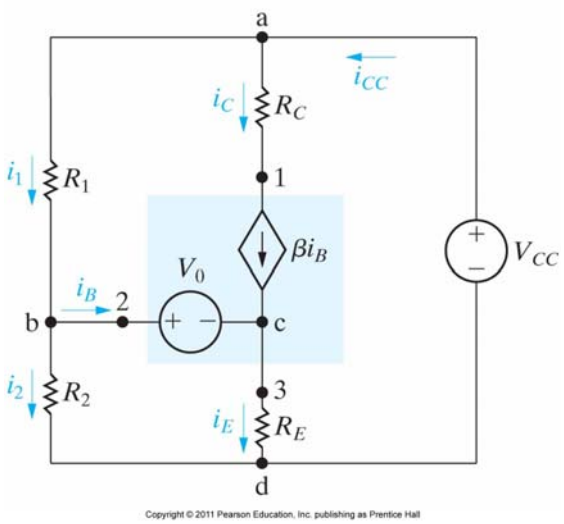


TABLE 2.1 Physiological Reactions to Current Levels in Humans

Physiological Reaction	Current
Barely perceptible	3–5 mA
Extreme pain	35–50 mA
Muscle paralysis	50–70 mA
Heart stoppage	500 mA

Note: Data taken from W. F. Cooper, *Electrical Safety Engineering*, 2d ed. (London: Butterworth, 1986); and C. D. Winburn, *Practical Electrical Safety* (Monticello, N.Y.: Marcel Dekker, 1988).

Example 2.9

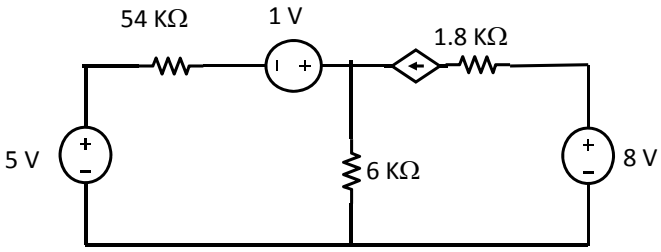


Figure P2.9