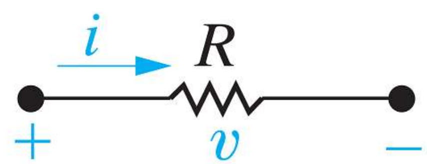
Chapter 2 – Circuit Elements

Review:

- •Independent voltage and current sources
- •Dependent voltage and current sources
- •Resistors



$$\boxed{v = \pm Ri}$$

Ohm's Law

How do you determine which sign to use? Use the passive sign convention!

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More on resistors:

The inverse of resistance is **conductance**.

$$G = \frac{1}{R}; \qquad i = \pm Gv$$

Conductance has the units Siemens, abbreviated "S".

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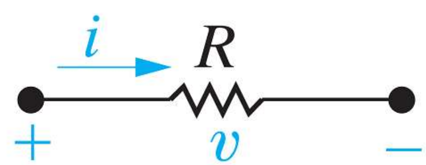
More on resistors

Calculate the power in a resistor:



$$p = +vi = (Ri)i$$
$$= Ri^2 > 0!$$

The power associated with a resistor is always positive. Therefore, resistors always absorb power!

Find the power for this resistor.

$$\boxed{p = -vi = -(-Ri)i = Ri^2 > 0!}$$

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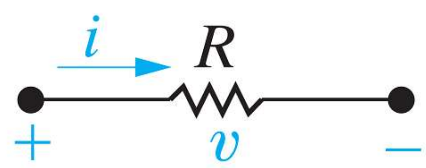
More on resistors

Calculate the power in a resistor using voltage:



$$p = +vi = v\frac{v}{R}$$

$$= \frac{v^2}{R} > 0!$$

The power associated with a resistor is still positive.

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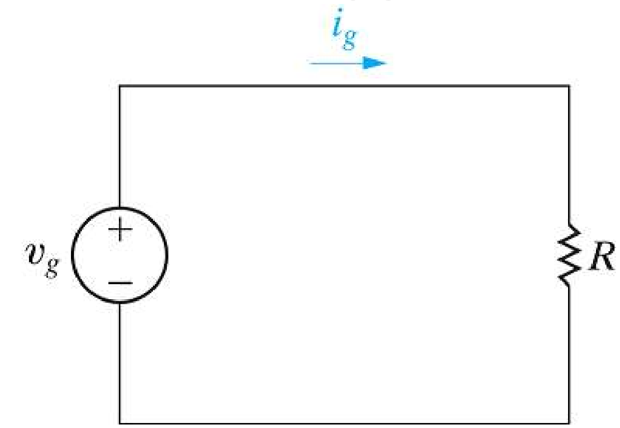

Example (AP 2.3)

Consider the circuit shown here.

(a) If v_g = 1 kV and i_g = 5 mA, find R and the power absorbed by the resistor.

$$R = +\frac{v_g}{i_g} = \frac{1000\text{ V}}{5\text{ mA}} = \frac{1000}{0.005} = 200{,}000\,\Omega = 200\text{ k}\Omega$$

$$p_R = Ri_g^2 = (200{,}000)(0.005)^2 = 5\text{ W}$$

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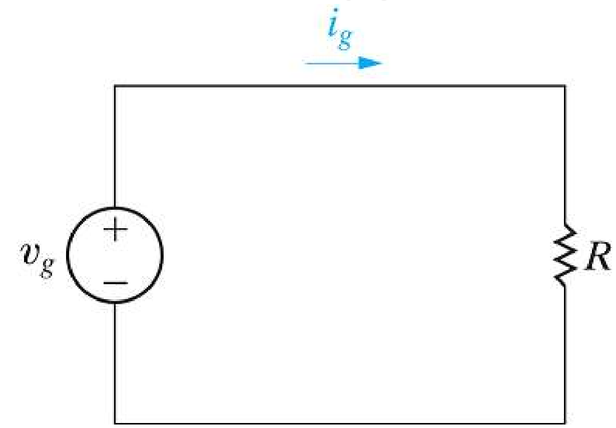
Example (AP 2.3), continued

Consider the circuit shown here.



(b) If i_g = 75 mA and p_g = –3 W, find v_g, R and the power absorbed by the resistor.

$$p_g = -v_g i_g \qquad \Rightarrow \qquad v_g = -\frac{p_g}{i_g} = -\frac{(-3)}{0.075} = 40\text{ V}$$

$$\mathrm{R} = \frac{\mathrm{v_g}}{\mathrm{i_g}} = \frac{40}{0.075} = 533.33\Omega$$

$$p_R = Ri_g^2 = (533.33)(0.075)^2 = 3\text{ W}$$

OR... $\qquad p_R = -p_g = -(-3) = 3\text{ W!}$

We just calculated the power of the resistor to be 3 W. Is the resistor supplying or absorbing power?

A. Supplying
B. Absorbing

Suppose we are told that the voltage drop across a 50 Ω resistor is 10 V. What is the power associated with the resistor?

A. 5000 W
B. 500 W
C. 2 W
D. I need to know the voltage polarity first

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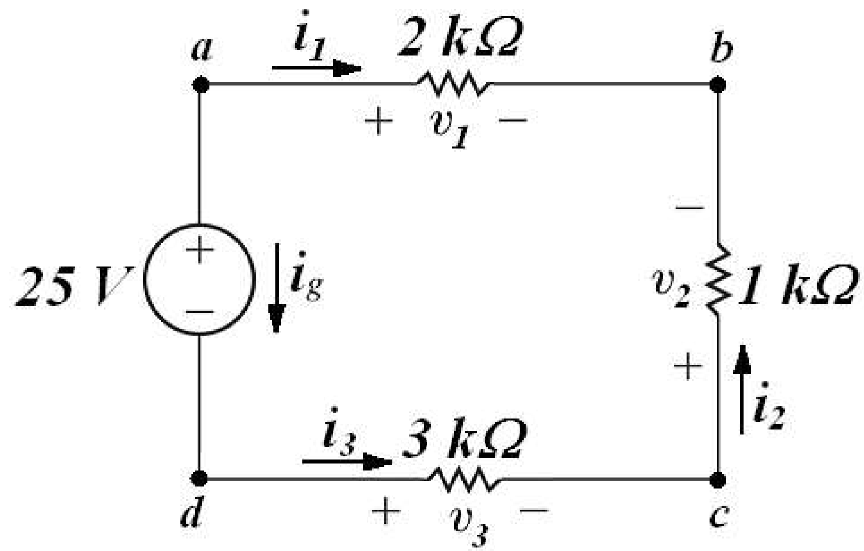
Kirchhoff's Laws

Consider the circuit shown below. We wish to "solve" this circuit. To solve a circuit, we must find all of the unknown voltages and currents.



How many unknowns are in this circuit? Seven – three unknown voltages and four unknown currents.

To solve for 3 unknown voltages and 4 unknown currents, how many independent equations do we need?

A. 4
B. 7
C. 8
D. We need more information

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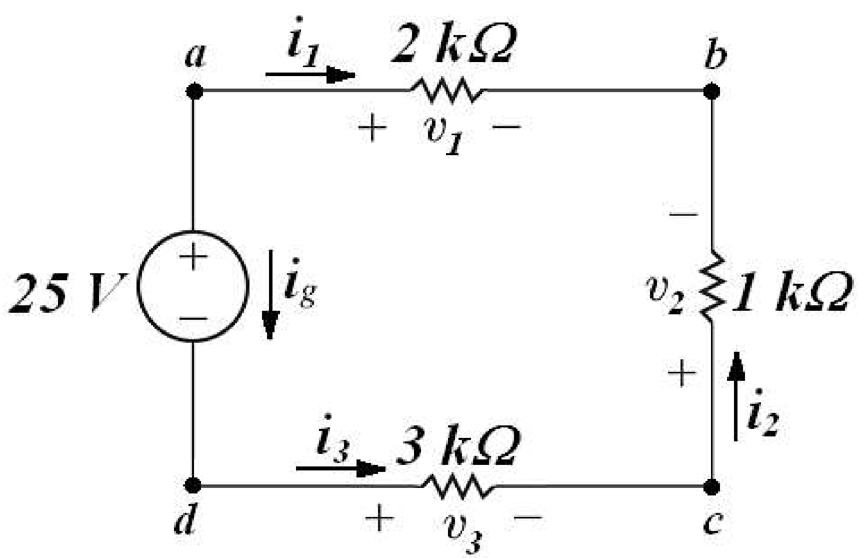
Kirchhoff’s Laws (continued)

The only equations we know how to write at this point come from Ohm’s law. Let’s write them.



$$\boxed{\begin{aligned} v_1 &= 2000 i_1 \\ v_2 &= 1000 i_2 \\ v_3 &= 3000 i_3 \end{aligned}}$$

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Kirchhoff's Laws (continued)

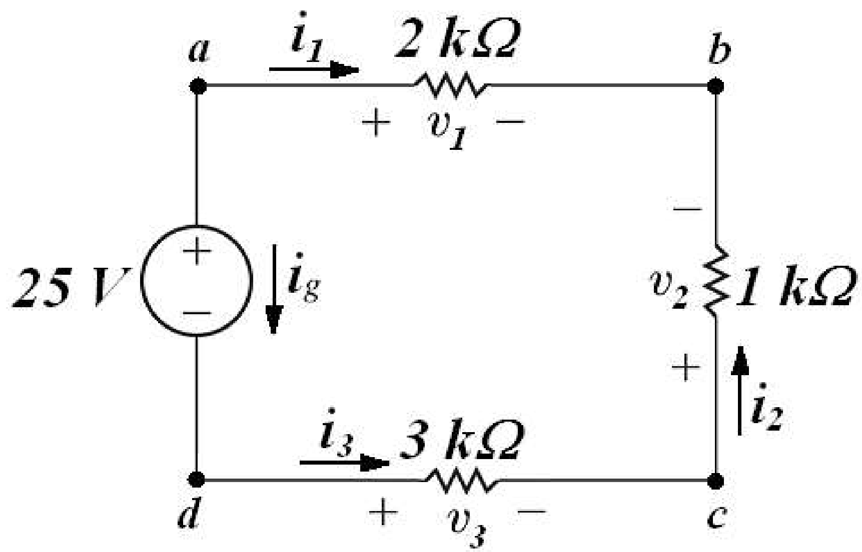
We need more equations – they will come from Kirchhoff's laws.

Kirchhoff's Current Law (KCL)

The algebraic sum of all the currents at any node in a circuit equals zero.

Note – a **node** is a point where two or more circuit elements are connected.

How many nodes are in this circuit?



A. 4
B. 3
C. 2
D. None of the above

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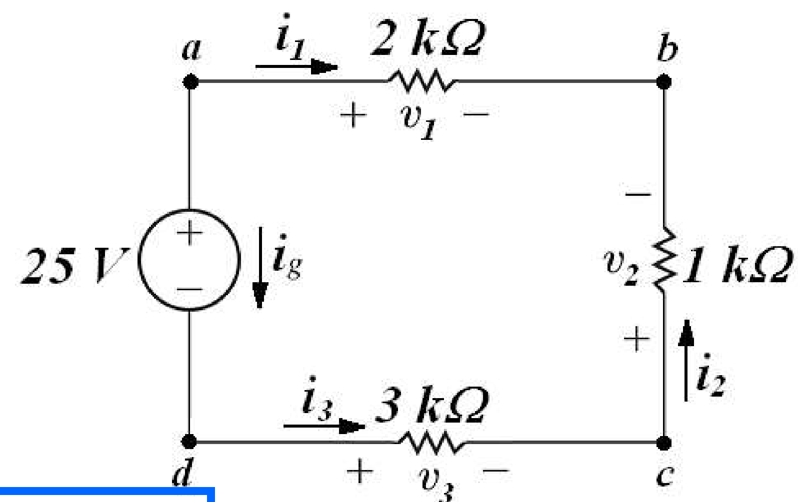
Kirchhoff's Current Law (KCL)

Let's write the KCL equations at each node. Are they all independent?



$$\begin{aligned}
&\text{a (leaving)}: && i_g + i_1 = 0 \\
&\text{b (entering)}: && i_1 + i_2 = 0 \\
&\text{c (enter = leave)}: && i_2 = i_3 \\
&\text{d (leaving)}: && -i_g + i_3 = 0
\end{aligned}$$

Note that only 3 of the 4 are independent – the 4th equation can be derived from the other 3.

If a circuit has 6 nodes, how many independent KCL equations can you write?

A. 7
B. 6
C. 5
D. None of the above

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Kirchhoff's Laws (continued)

We have 3 equations from Ohm's law and 3 (independent) KCL equations – we need one more equation, because we have 7 unknowns. That equation will come from Kirchhoff's Voltage Law

> Kirchhoff's Voltage Law (KVL)
>
> The algebraic sum of all the voltages around any closed path in a circuit equals zero.

Note – a closed path starts at any node, travels through selected circuit elements, and returns back to the starting node without including any intermediate nodes more than once.

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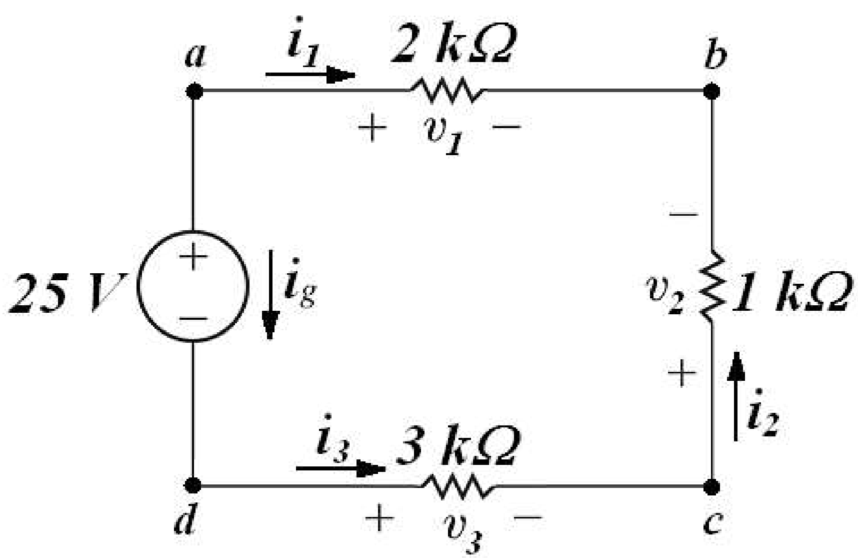
Kirchhoff's Voltage Law (KVL)

Let's write the KVL equation around the closed path formed by this circuit.



Start at node a and go clockwise:

$$\boxed{+v_1 - v_2 - v_3 - 25 = 0}$$

Start at node d and go counter-clockwise:

$$\boxed{+v_3 + v_2 - v_1 + 25 = 0}$$

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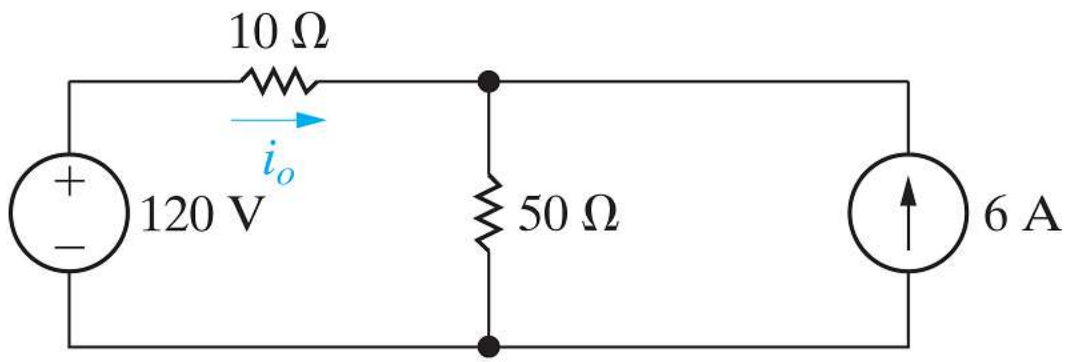
Kirchhoff's Laws (continued)

Now we have 7 equations and 7 unknowns, so we can plug the 7 equations into a calculator and solve them to solve the circuit.

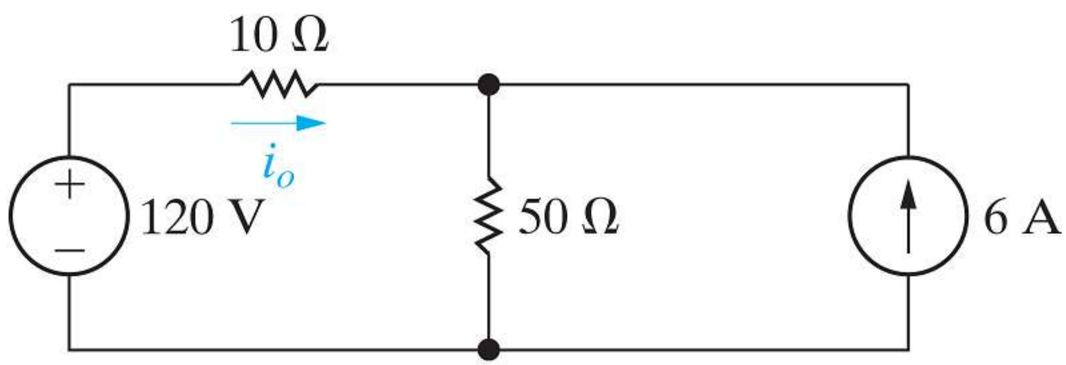
Analysis of circuits with resistors and constant sources is based on the use of Ohm's Law, KCL and KVL. However, we will develop some useful analysis techniques that will NOT require us to solve 7 equations for the simple example circuit we've been studying. Actually, we can solve this circuit with just 1 equation!

How many unknown voltages and currents are in this circuit?



- A. 4 voltages; 4 currents
- B. 4 voltages; 3 currents
- C. 3 voltages; 4 currents
- D. 3 voltages; 3 currents

How many Ohm's Law, KCL, and KVL equations will we need to solve this circuit?



A. 2 OL, 2 KCL, 2 KVL

B. 2 OL, 1 KCL, 3 KVL

C. 2 OL, 3 KCL, 1 KVL