Chapter 26

Direct-Current Circuits

PowerPoint® Lectures for
University Physics, Thirteenth Edition
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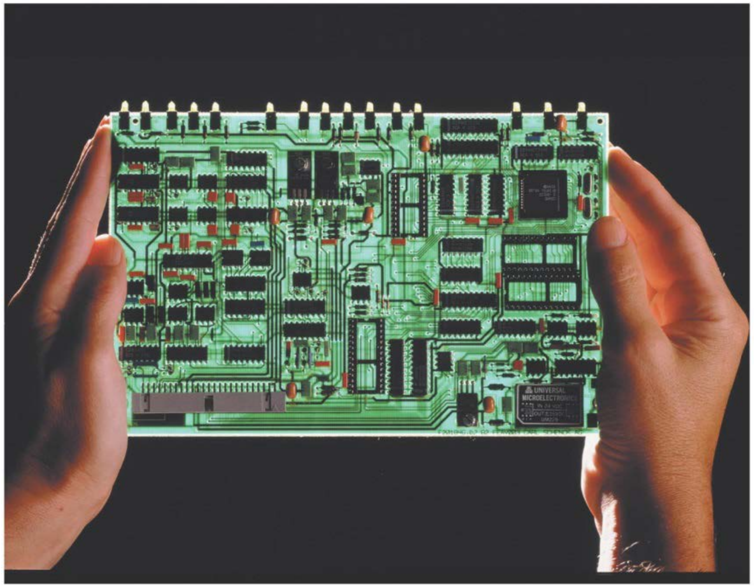
Lectures by Wayne Anderson

Goals for Chapter 26

- To analyze circuits having resistors in series and parallel
- To apply Kirchhoff's rules to multiloop circuits
- To learn how to use various types of meters in a circuit
- To analyze circuits containing capacitors and resistors
- To study power distribution in the home

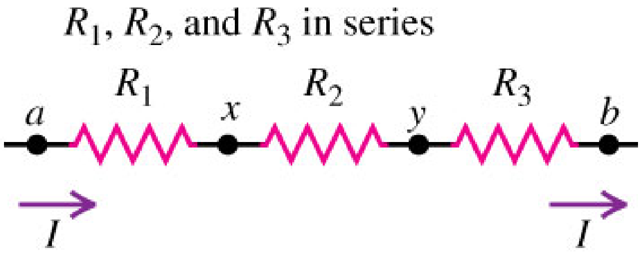
Introduction

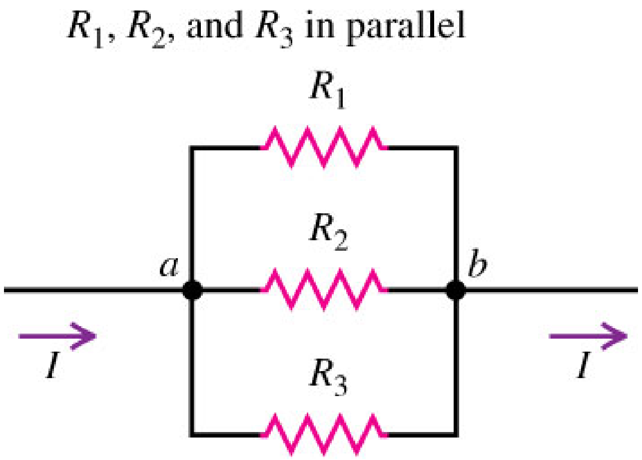
- How can we apply series/parallel combinations of resistors to a complex circuit board?
- In this chapter, we will learn general methods for analyzing more complex networks.
- We shall look at various instruments for measuring electrical quantities in circuits.



Resistors in series and parallel

- Resistors are in *series* if they are connected one after the other so the current is the same in all of them (see left figure below).
- The *equivalent resistance* of a series combination is the *sum* of the individual resistances: $R_{eq} = R_1 + R_2 + R_3 + \ldots$
- Resistors are in *parallel* if they are connected so that the potential difference must be the same across all of them (see right figure below).
- The *equivalent resistance* of a parallel combination is given by $1/R_{eq} = 1/R_1 + 1/R_2 + 1/R_3 + \ldots$

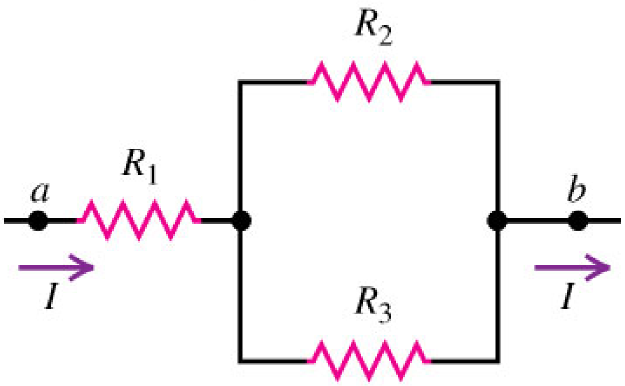




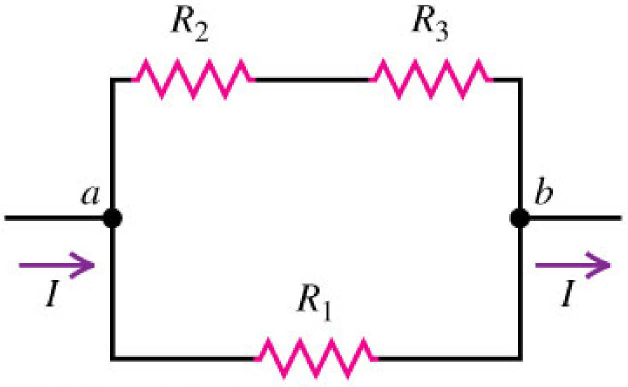
Series and parallel combinations

- Resistors can also be connected in combinations of series and parallel, as shown in Figure 26.1(c) and (d) at the right.

(c) R_1 in series with parallel combination of R_2 and R_3

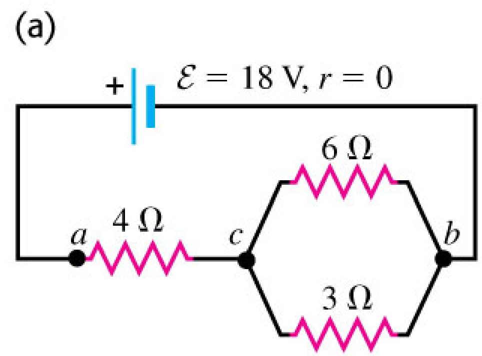


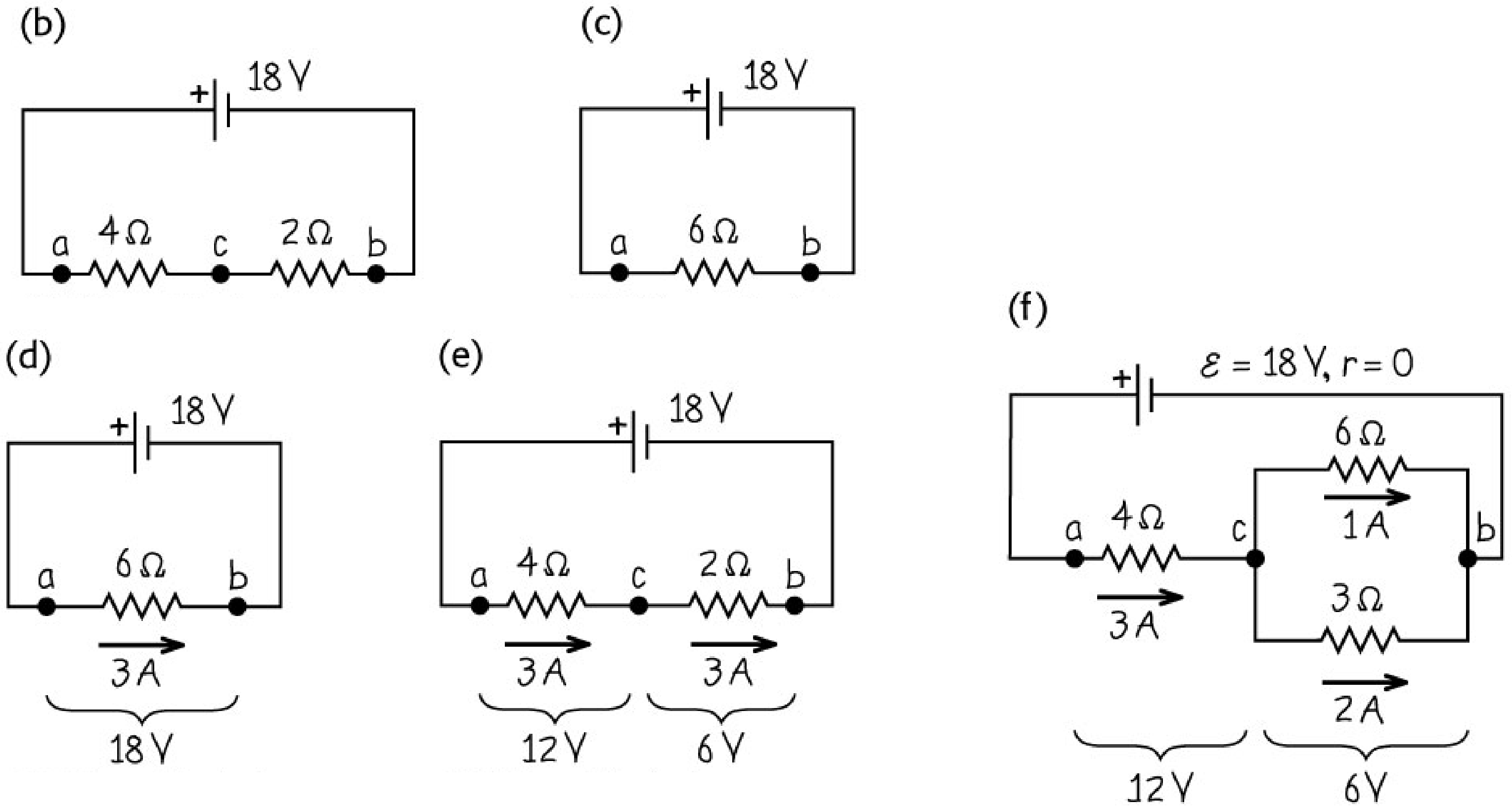
(d) R_1 in parallel with series combination of R_2 and R_3



Equivalent resistance

- Read Problem-Solving Strategy 26.1.
- Follow Example 26.1 using Figure 26.3 below and right.

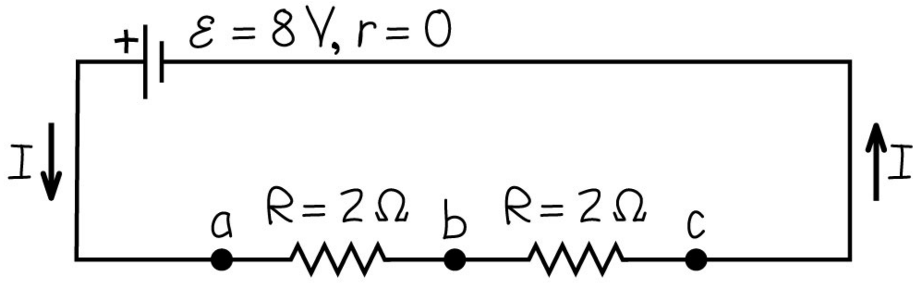




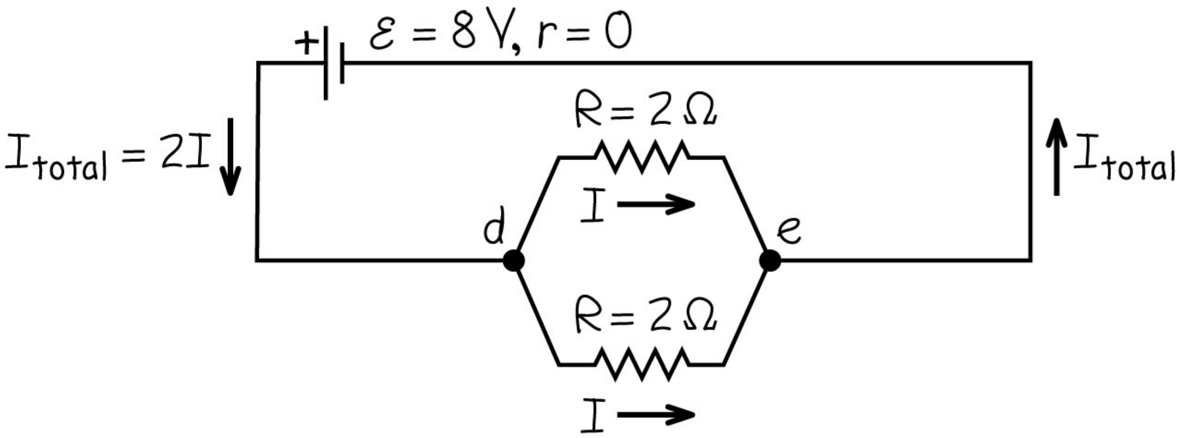
Series versus parallel combinations

- Follow Example 26.2 using Figure 26.4 below.

(a) Light bulbs in series

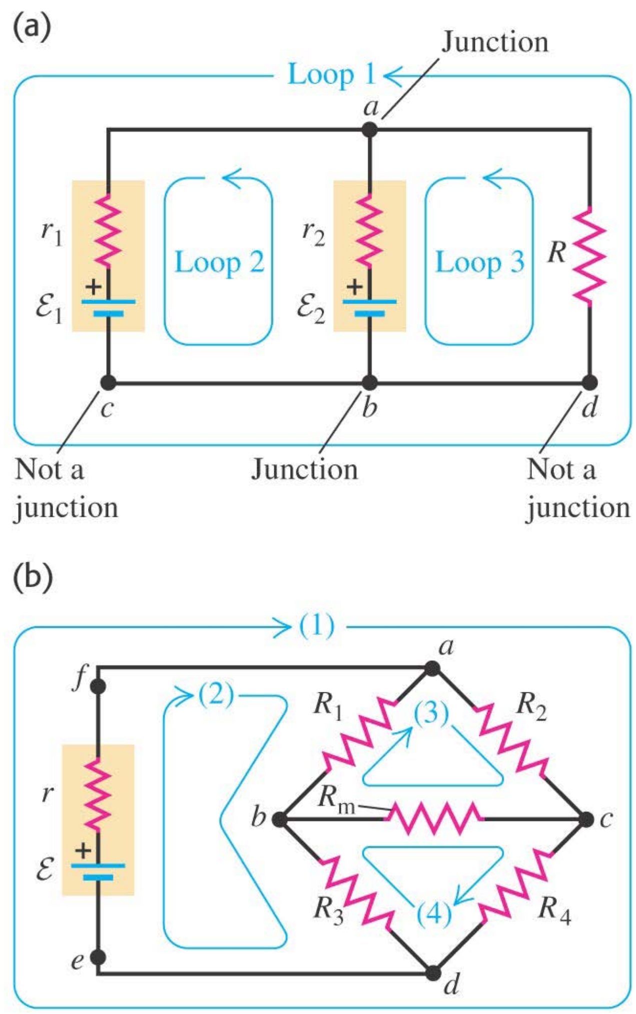


(b) Light bulbs in parallel



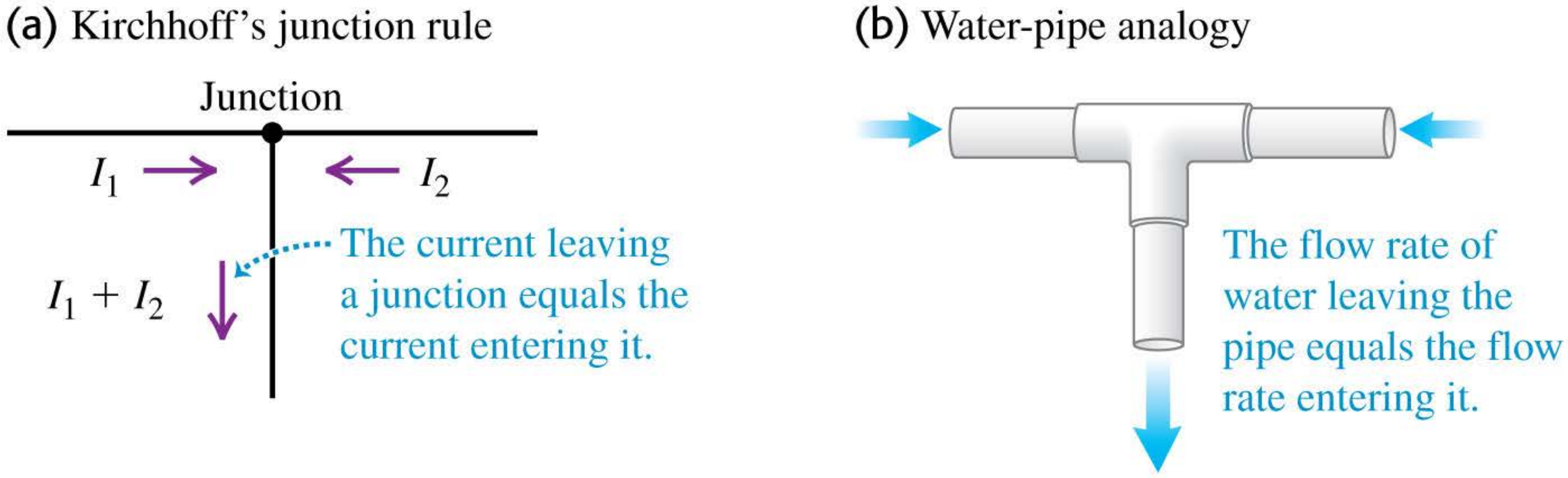
Kirchhoff's Rules I

- A *junction* is a point where three or more conductors meet.
- A *loop* is any closed conducting path.
- See Figure 26.6 at the right.



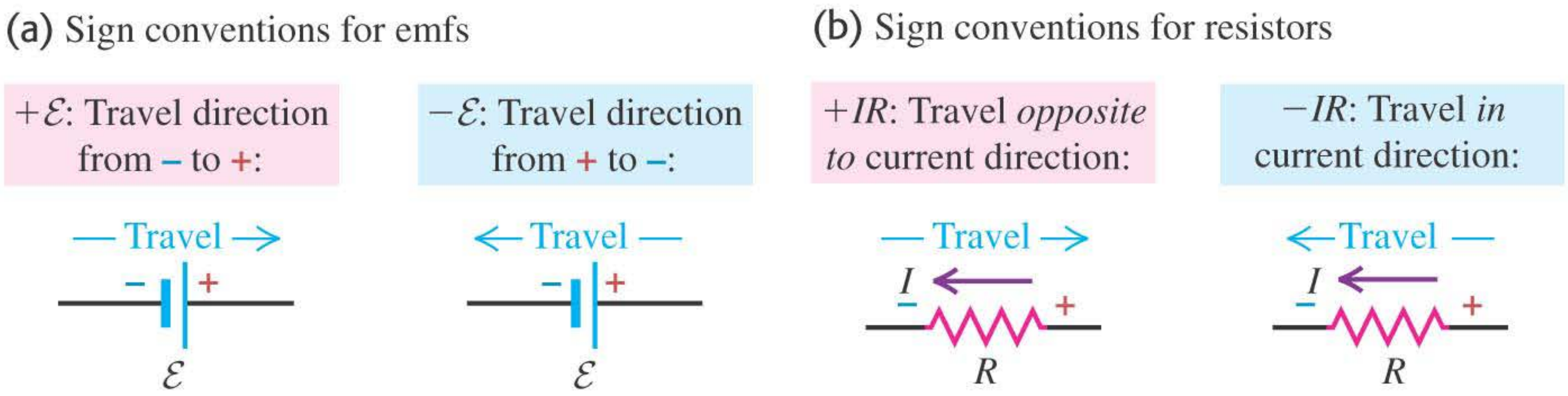
Kirchoff’s Rules II

- Kirchhoff’s *junction rule*: The algebraic sum of the currents into any junction is zero: $\Sigma I = 0$. (See Figure 26.7 below.)
- Kirchhoff’s *loop rule*: The algebraic sum of the potential differences in any loop must equal zero: $\Sigma V = 0$.



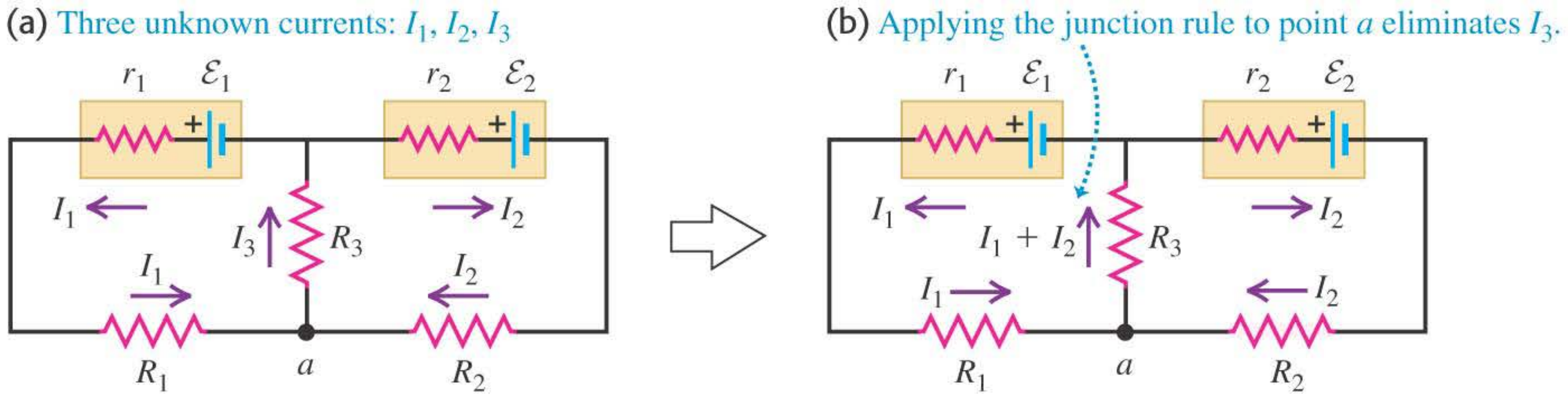
Sign convention for the loop rule

- Figure 26.8 below shows the sign convention for emfs and resistors.



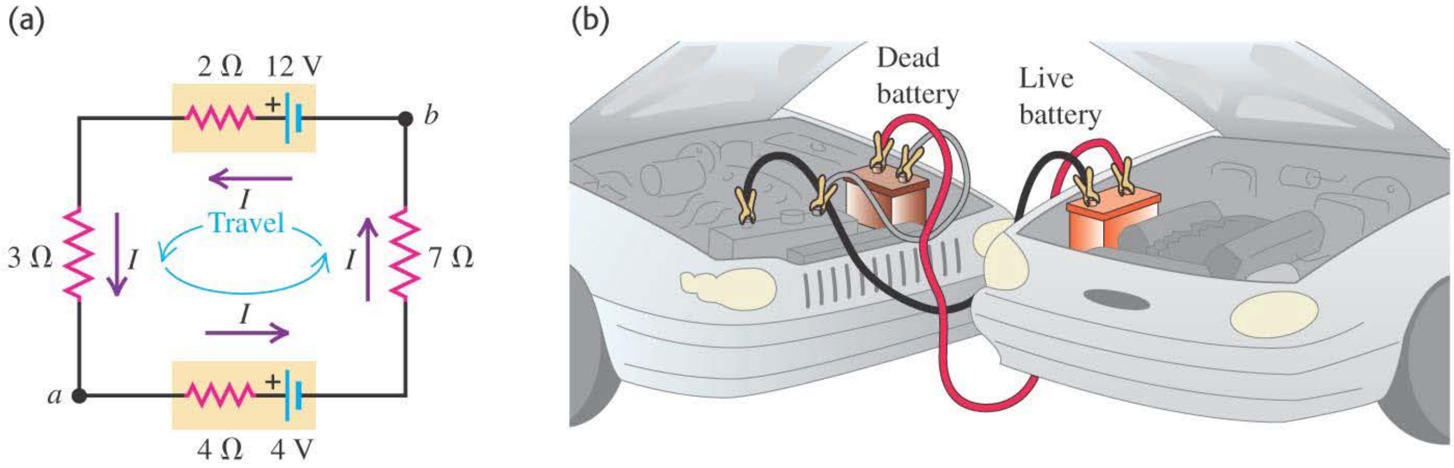
Reducing the number of unknown currents

- Read Problem-Solving Strategy 26.2.
- Figure 26.9 below shows how to use the junction rule to reduce the number of unknown currents.



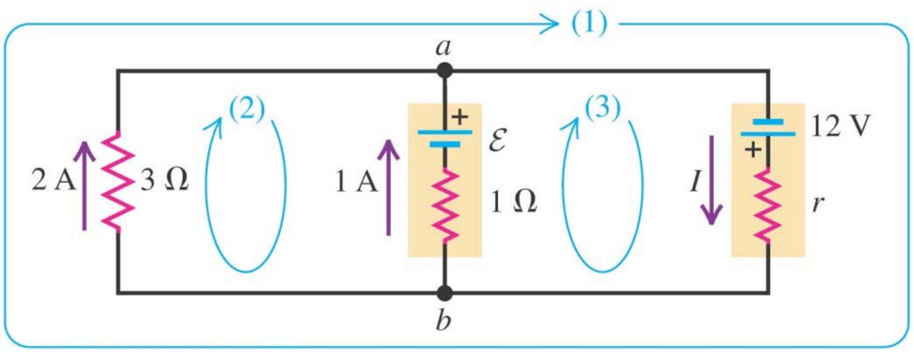
A single-loop circuit

- Follow Example 26.3, using Figure 26.10 below.



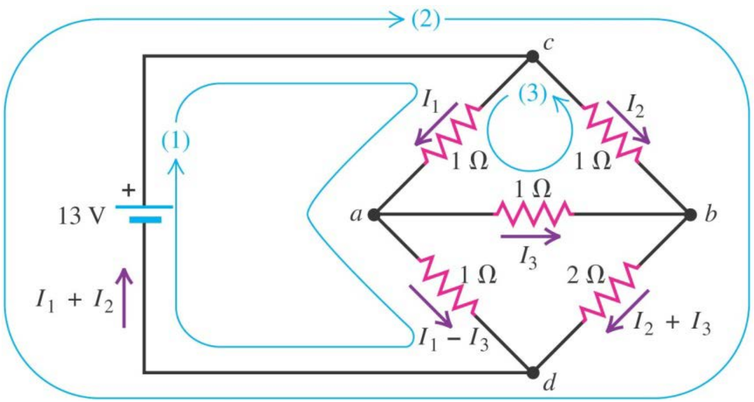
Charging a battery

- Follow Example 26.4, which shows how to charge a battery. Use Figure 26.11 below.
- Follow Example 26.5, which looks at the power delivered in the same circuit as in the previous example.

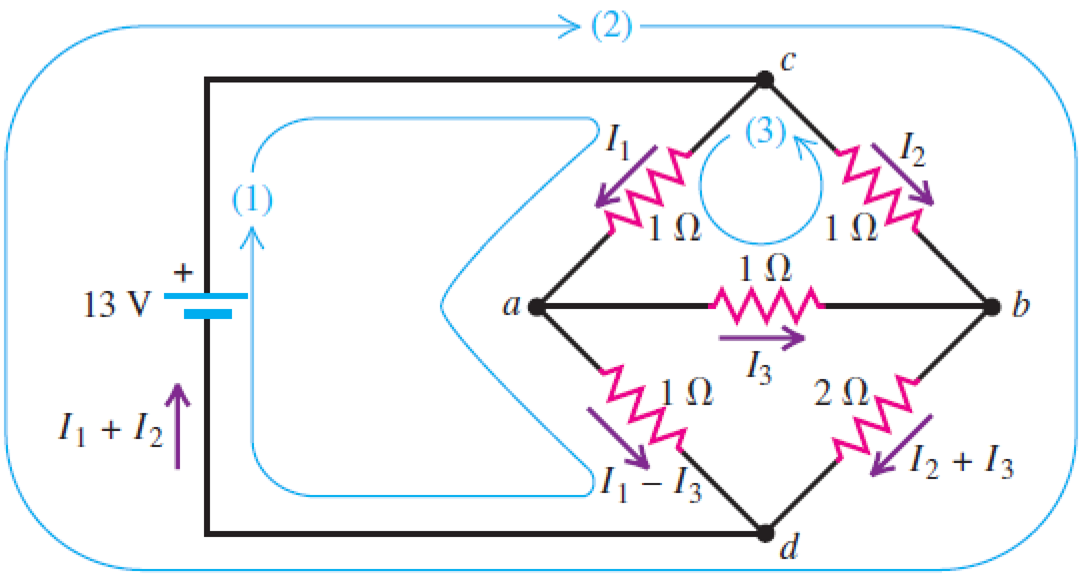


A complex network

- Follow Example 26.6, using Figure 26.12 below.
- Follow Example 26.7 which looks at the same circuit as above.



26.12 A network circuit with several resistors.



$$13\ \text{V} - I_1(1\ \Omega) - (I_1 - I_3)(1\ \Omega) = 0$$
$$-I_2(1\ \Omega) - (I_2 + I_3)(2\ \Omega) + 13\ \text{V} = 0$$
$$-I_1(1\ \Omega) - I_3(1\ \Omega) + I_2(1\ \Omega) = 0$$

$$13\ \text{V} = I_1(2\ \Omega) - I_3(1\ \Omega)$$
$$13\ \text{V} = I_1(3\ \Omega) + I_3(5\ \Omega)$$

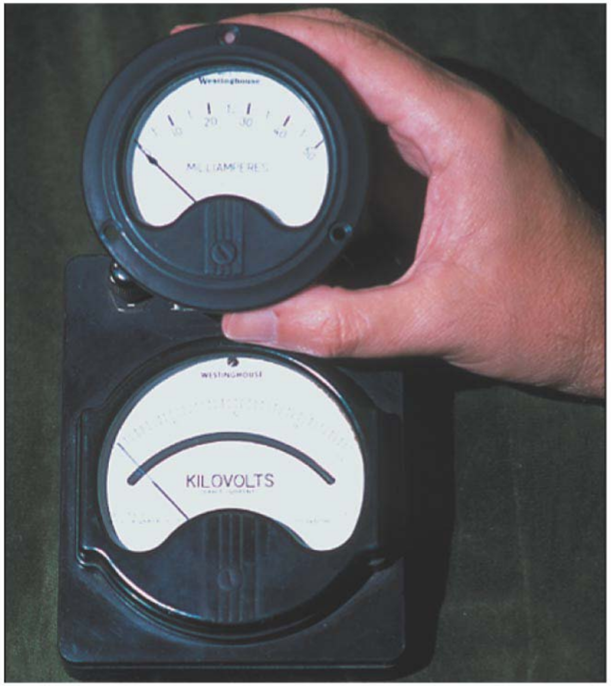
$$78\ \text{V} = I_1(13\ \Omega) \qquad I_1 = 6\ \text{A}$$

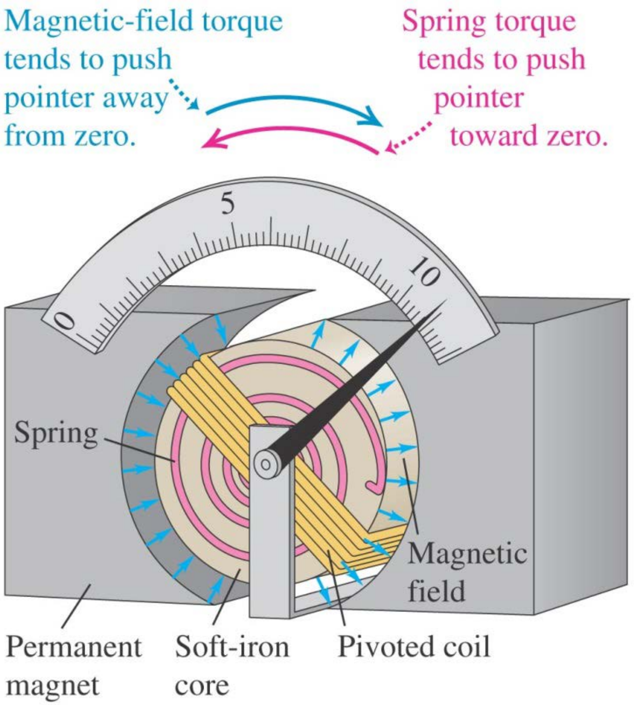
$$I_3 = -1\ \text{A},$$
$$I_2 = 5\ \text{A}.$$

$$R_{eq} = \frac{13\ \text{V}}{11\ \text{A}} = 1.2\ \Omega$$

D’Arsonval galvanometer

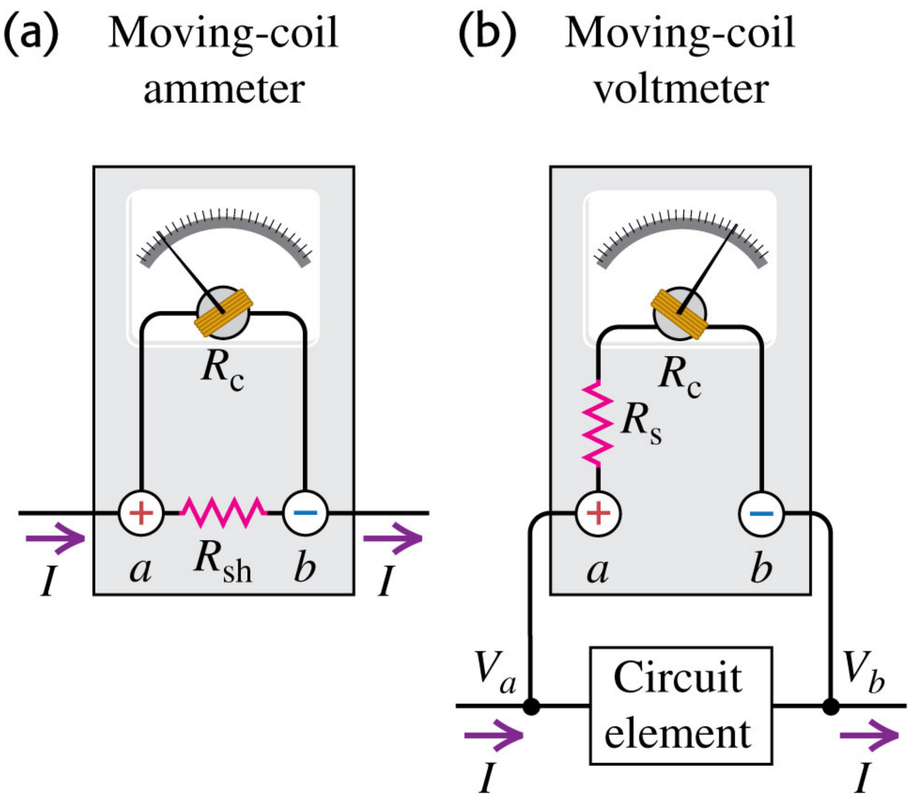
- A *d’Arsonval galvanometer* measures the current through it (see Figures 26.13 and 26.14 below).
- Many electrical instruments, such as ammeters and voltmeters, use a galvanometer in their design.





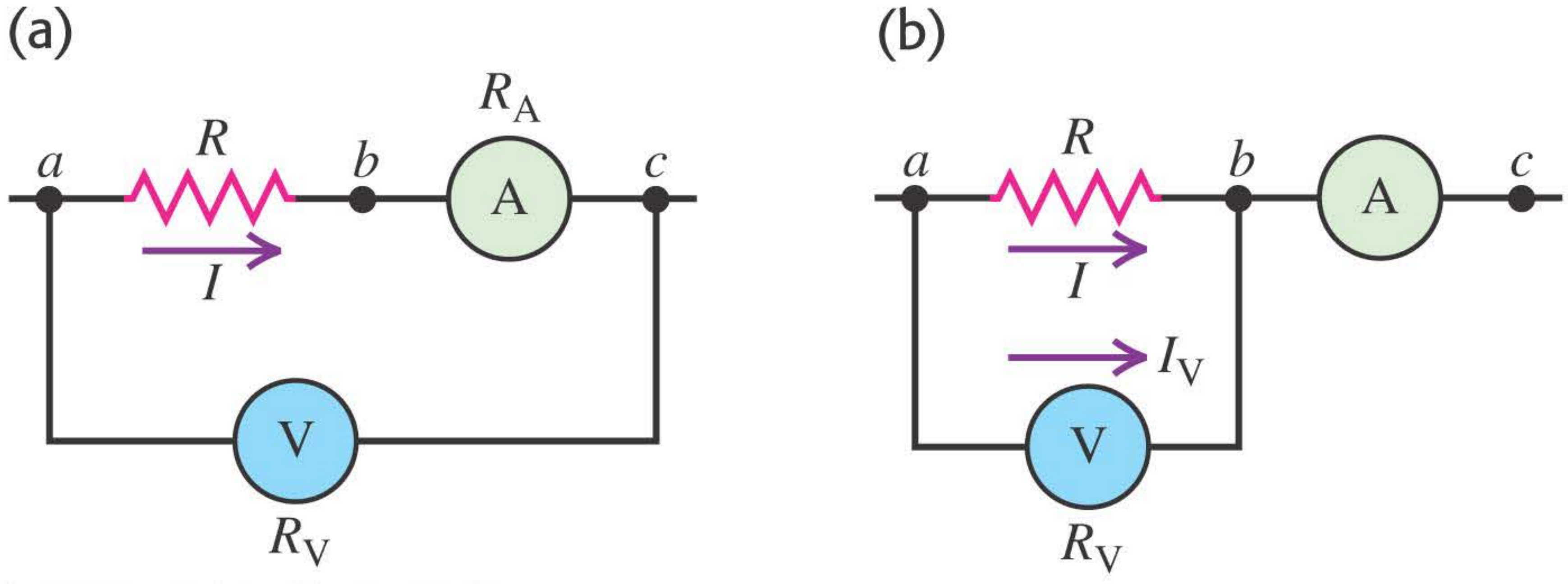
Ammeters and voltmeters

- An *ammeter* measures the current passing through it.
- A *voltmeter* measures the potential difference between two points.
- Figure 26.15 at the right shows how to use a galvanometer to make an ammeter and a voltmeter.
- Follow Examples 26.8 (ammeter) and 26.9 (ammeter).



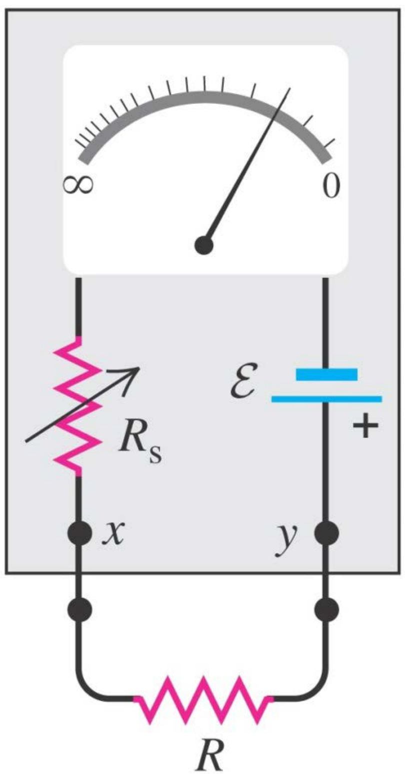
Ammeters and voltmeters in combination

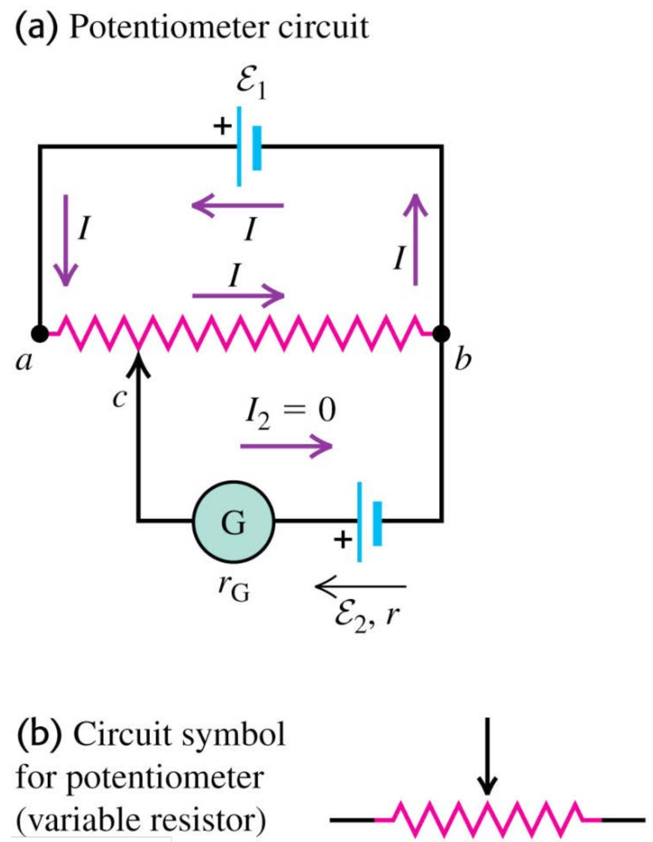
- An ammeter and a voltmeter may be used together to measure resistance and power. Figure 26.16 below illustrates how this can be done.
- Follow Example 26.10 using Figure 26.16(a).
- Follow Example 26.11 using Figure 26.16(b).



Ohmmeters and potentiometers

- An *ohmmeter* is designed to measure resistance. (See Figure 26.17 below left.)
- A *potentiometer* measures the emf of a source without drawing any current from the source. (See Figure 26.19 below right.)

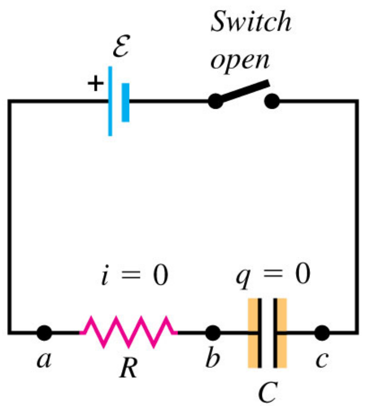




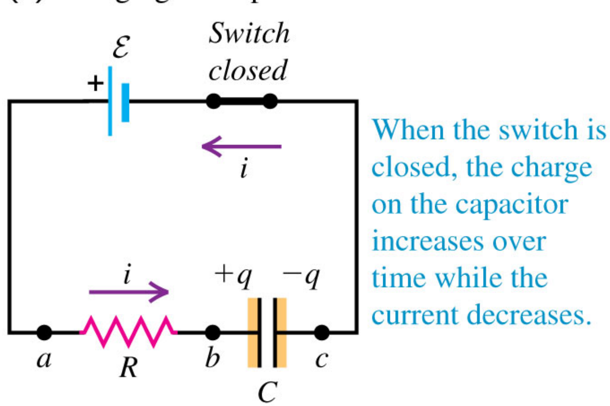
Charging a capacitor

- Read the discussion of charging a capacitor in the text, using Figures 26.20 and 26.21 below.
- The *time constant* is $\tau = RC$.

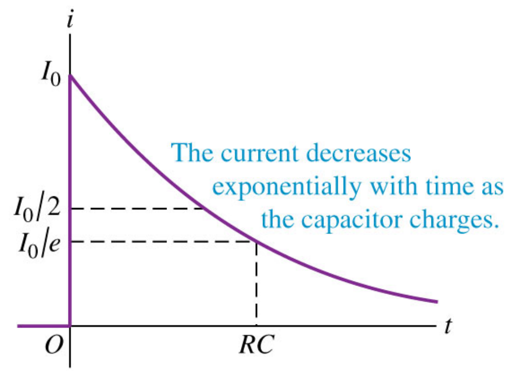
(a) Capacitor initially uncharged



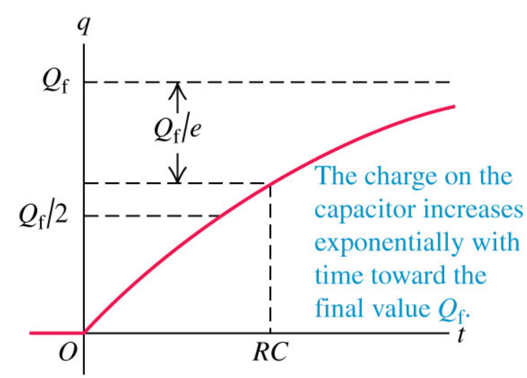
(b) Charging the capacitor



(a) Graph of current versus time for a charging capacitor

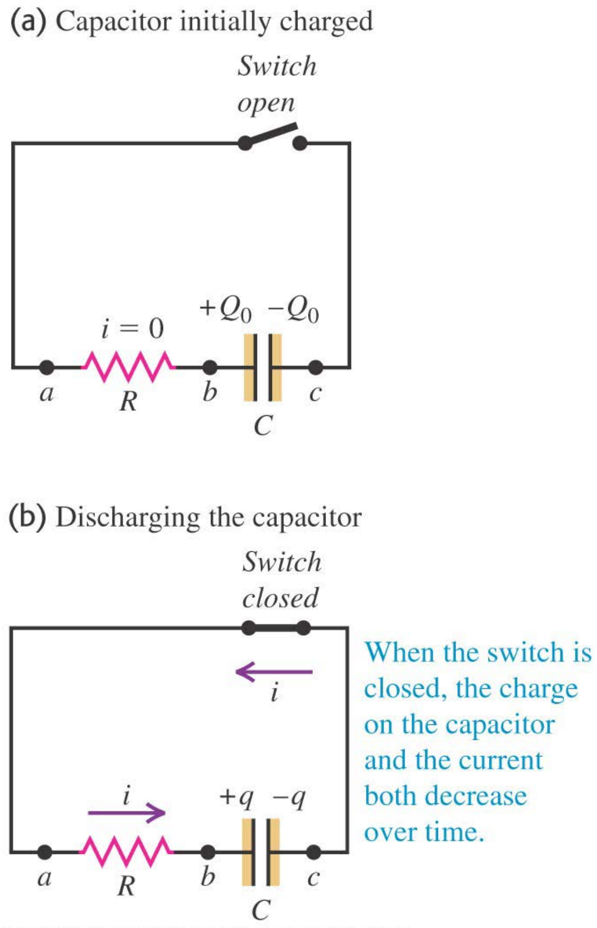


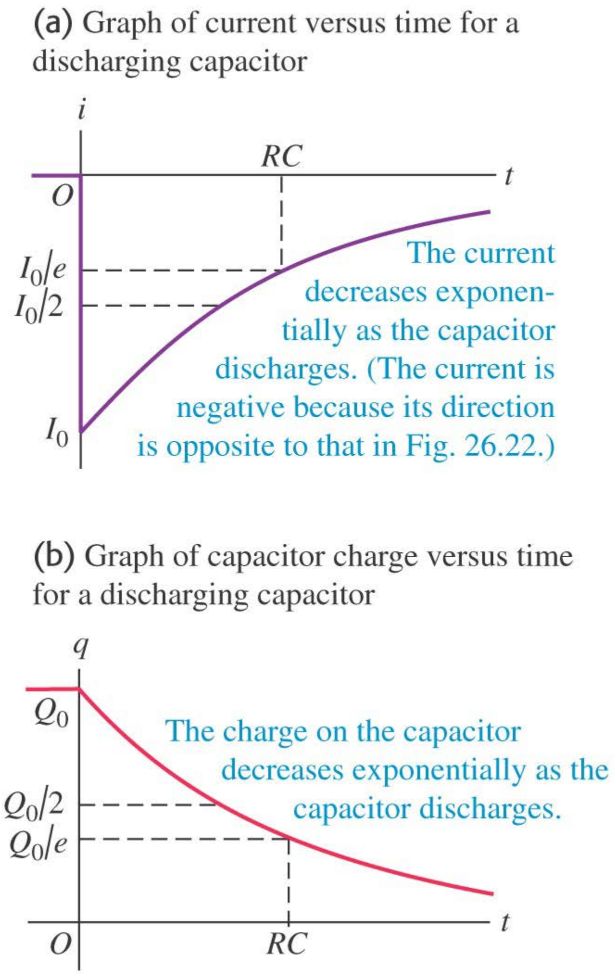
(b) Graph of capacitor charge versus time for a charging capacitor



Discharging a capacitor

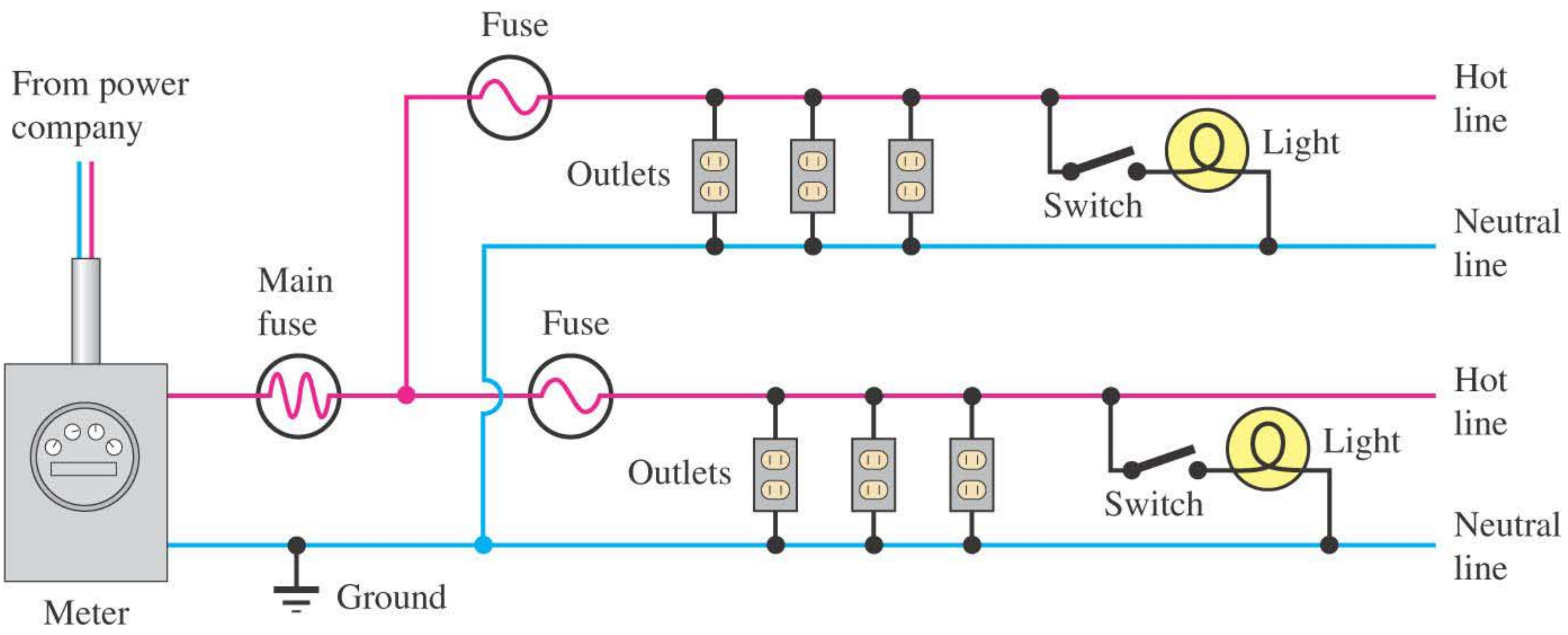
- Read the discussion of discharging a capacitor in the text, using Figures 26.22 and 26.23 below.
- Follow Examples 26.12 and 26.13.





Power distribution systems

- Follow the text discussion using Figure 26.24 below.



Household wiring

- Figure 26.26 at the right shows why it is safer to use a three-prong plug for electrical appliances.
- Follow Example 26.14.