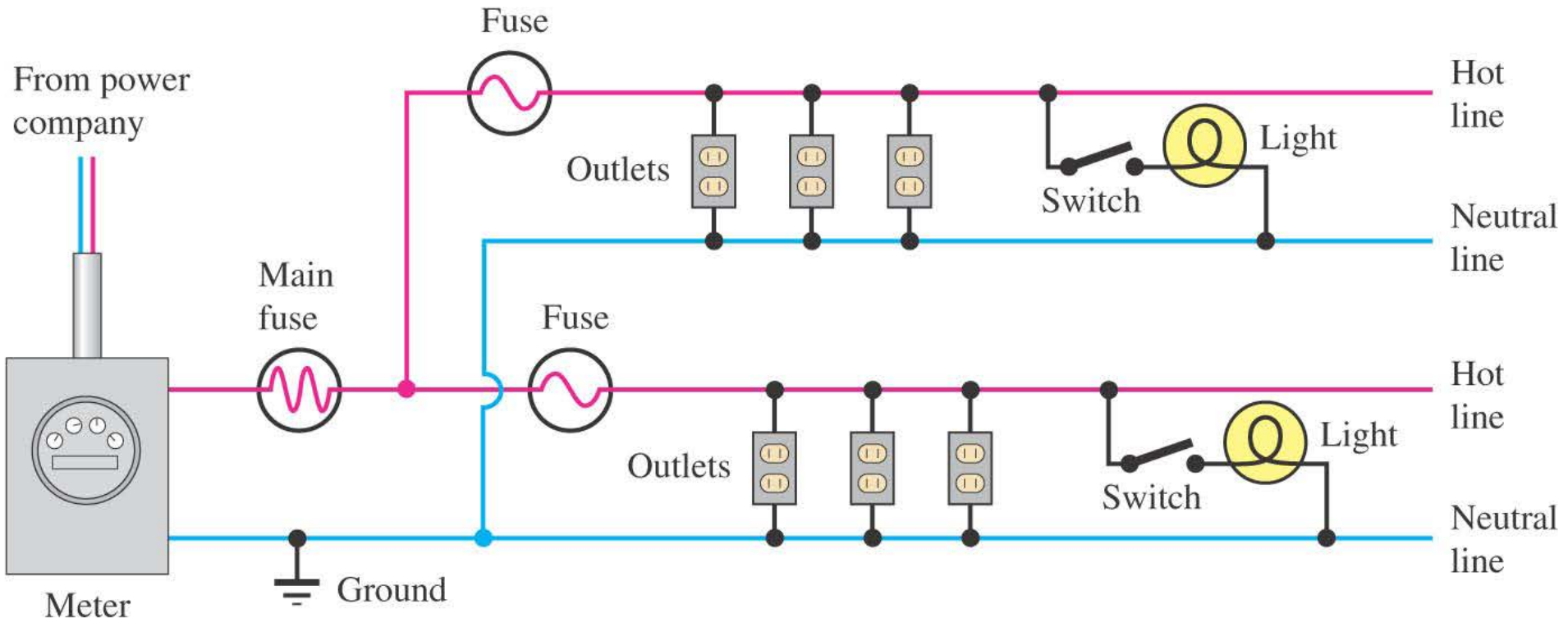
PHYS 122-Lecture 8:
Kirchhoff's Rules
(aka, nodal and mesh analysis)

- Basics of DC Circuits of Chapter 26
- Examples

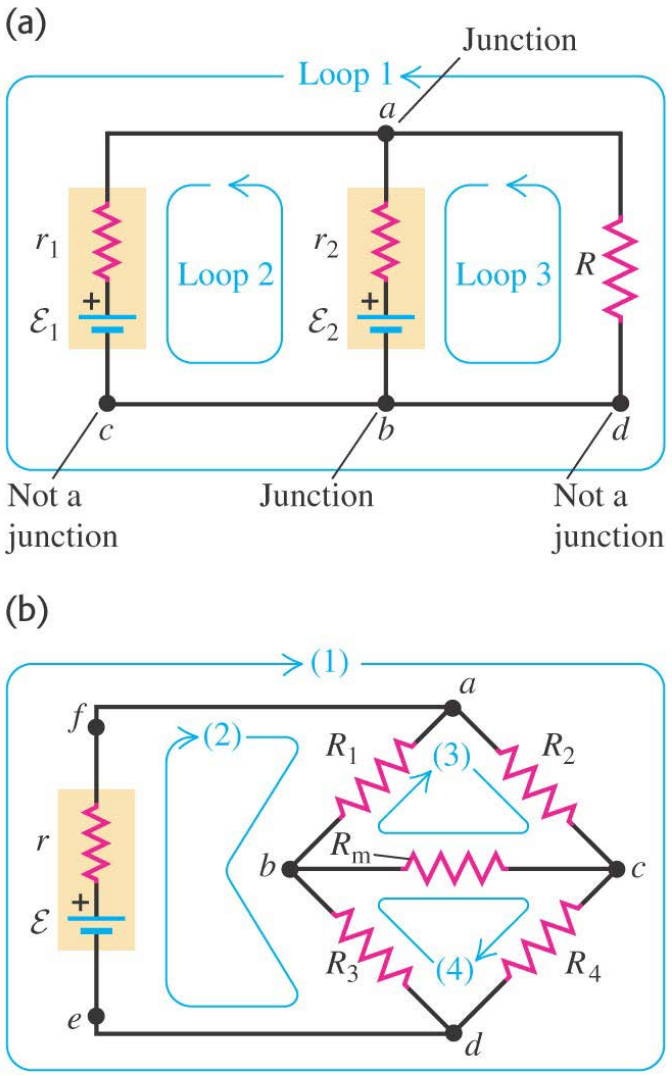
Power distribution systems

- Follow the text discussion using Figure 26.24 below.



Kirchhoff's Rules I

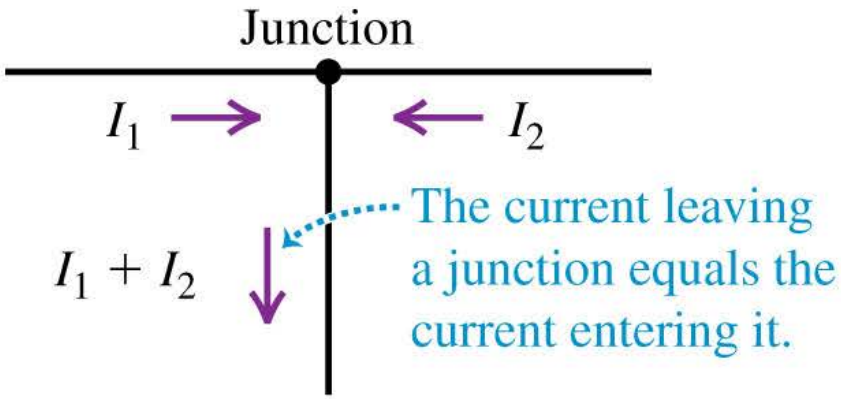
- A *junction* is a point where three or more conductors meet.
- A *loop* is any closed conducting path.
- See Figure 26.6 at the right.



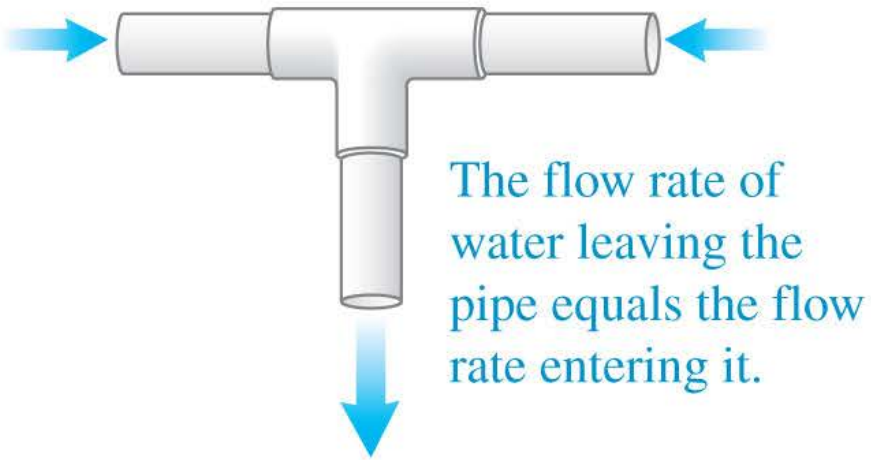
Kirchoff's Rules II

- 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: $\Sigma V = 0$.

(a) Kirchhoff's junction rule

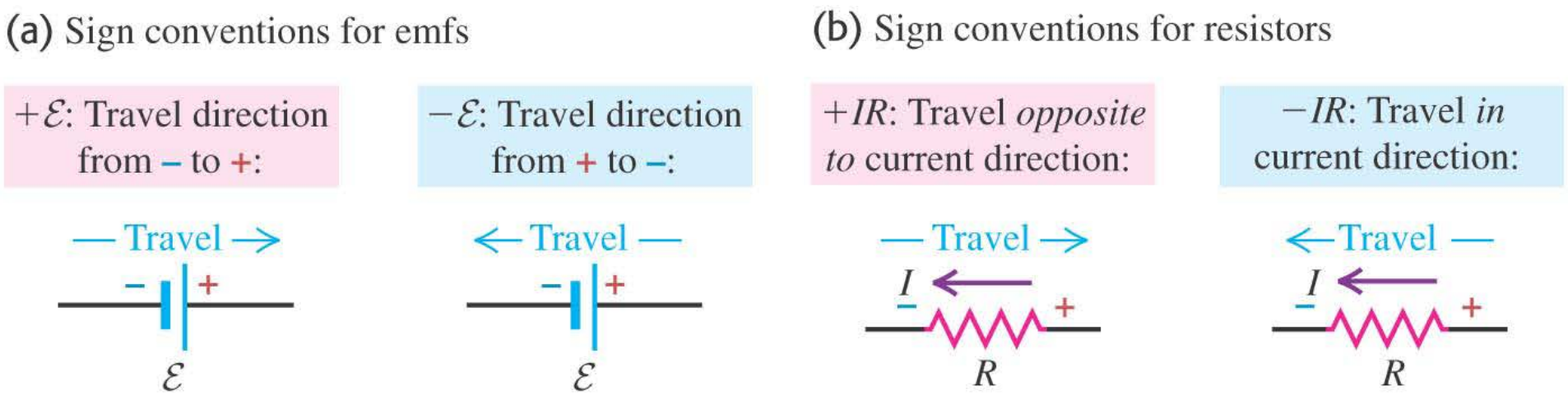


(b) Water-pipe analogy



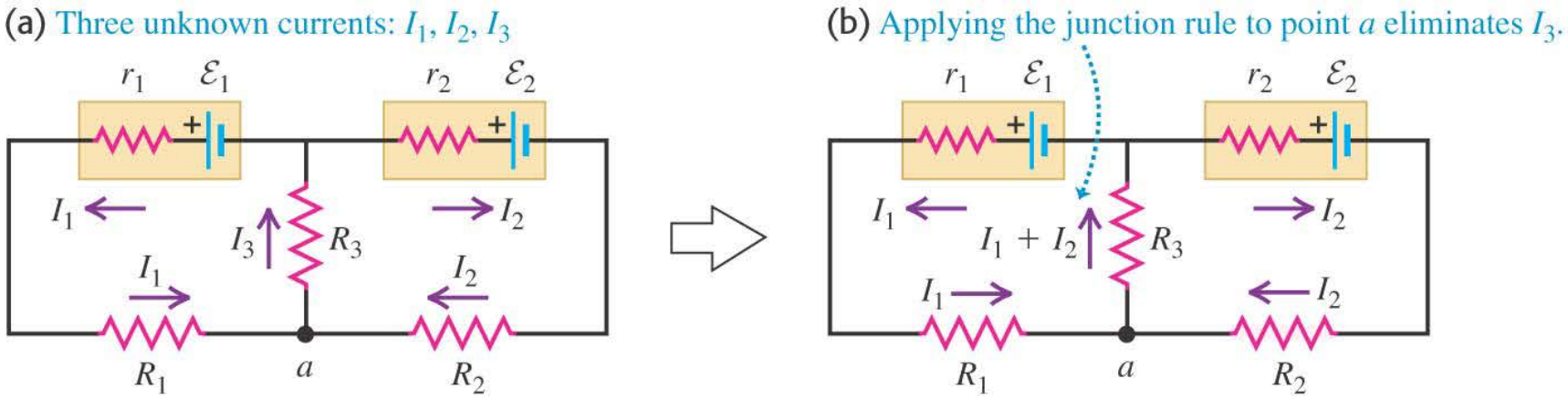
Sign convention for the loop rule

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



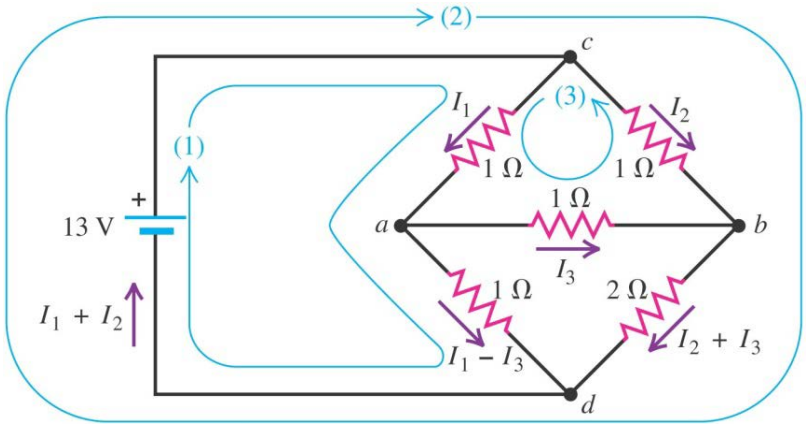
Reducing the number of unknown currents

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

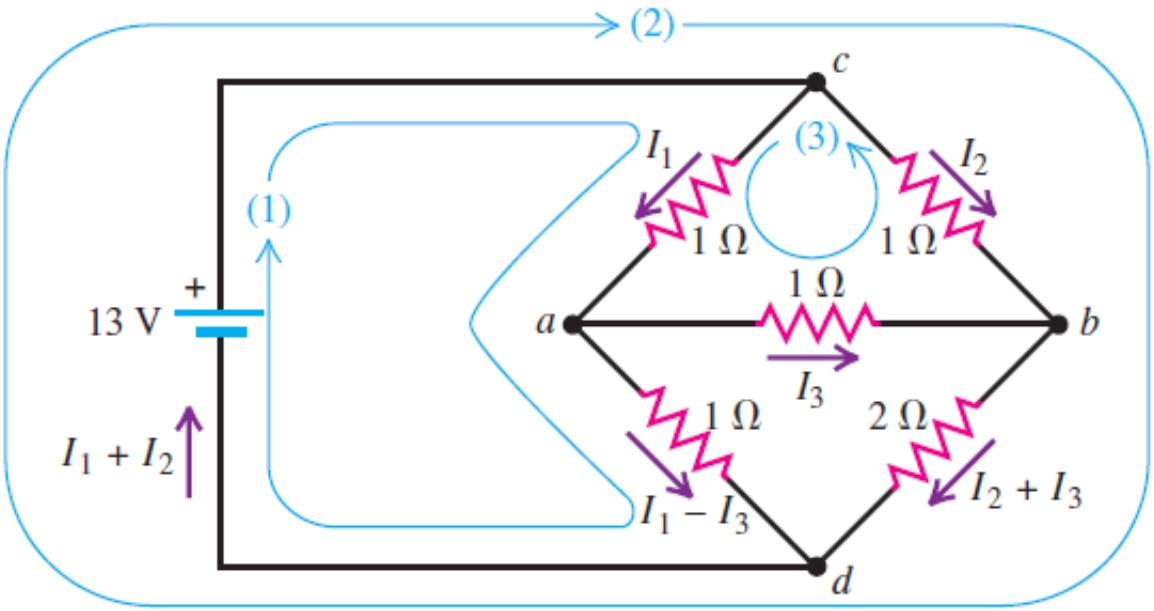


A complex network

- 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.



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

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

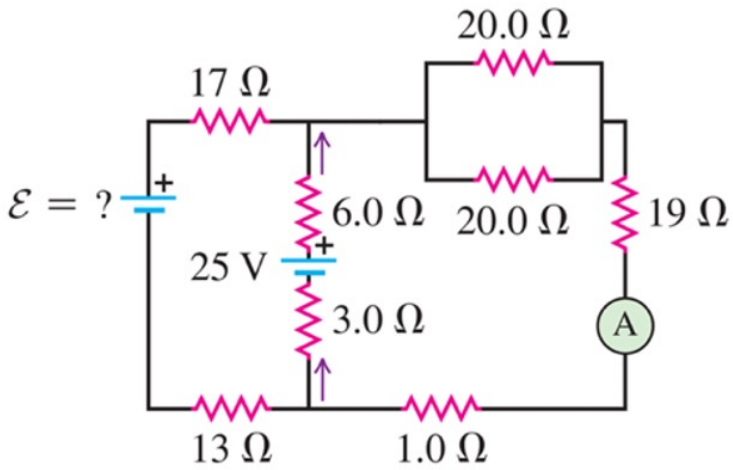
$$78\ \text{V} = I_1(13\ \Omega) \qquad I_1 = 6\ \text{A}$$

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

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

•• In the circuit shown in Fig. E26.32, the 6.0 Ω resistor is consuming energy at a rate of 24 J/s when the current through it flows as shown. (a) Find the current through the ammeter A. (b) What are the polarity and emf $\mathcal{E}$ of the unknown battery, assuming it has negligible internal resistance?

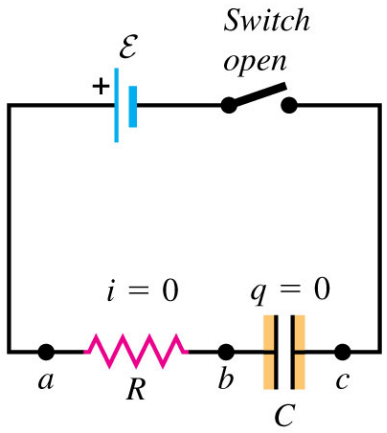
Figure E26.32



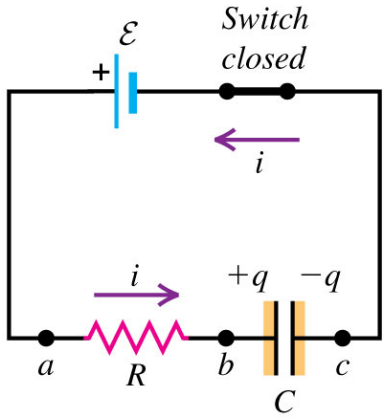
Charging a capacitor

- 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

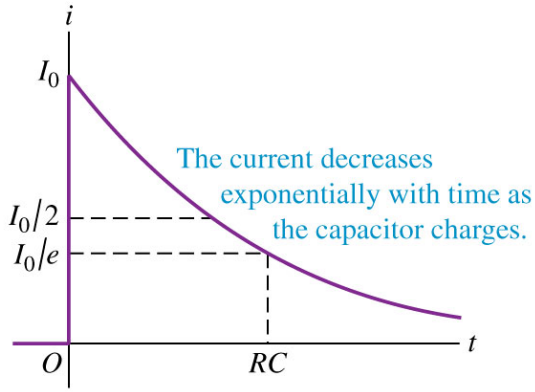


(b) Charging the capacitor

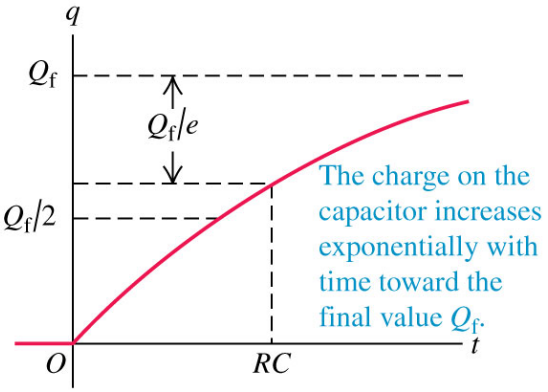


When the switch is closed, the charge on the capacitor increases over time while the current decreases.

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



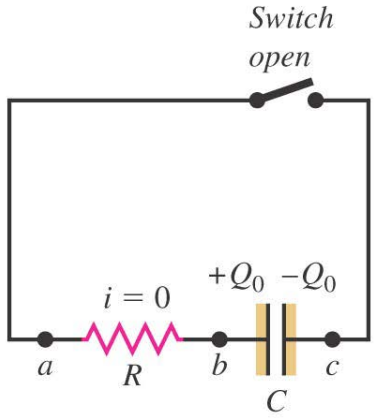
(b) Graph of capacitor charge versus time for a charging capacitor



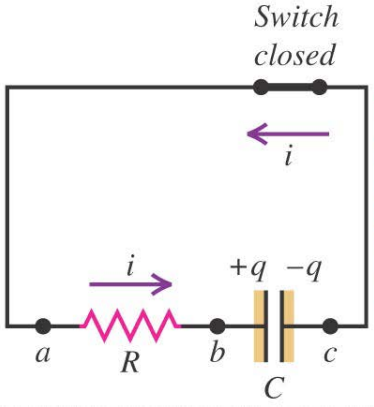
Discharging a capacitor

- 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.

(a) Capacitor initially charged

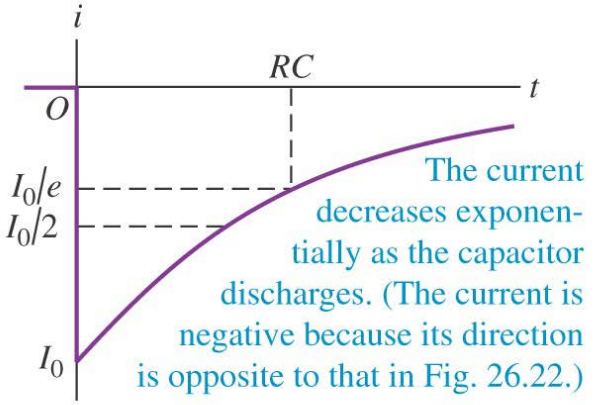


(b) Discharging the capacitor



When the switch is closed, the charge on the capacitor and the current both decrease over time.

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



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