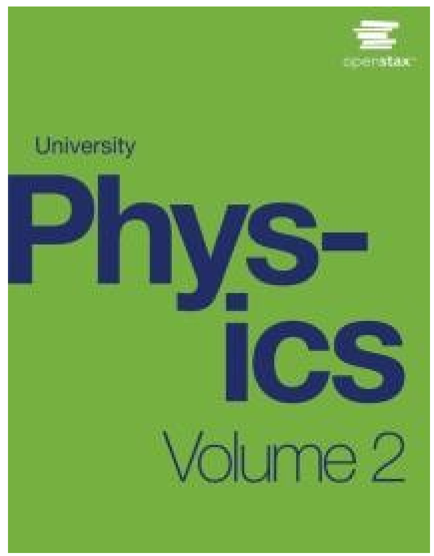
UNIVERSITY PHYSICS

Chapter 14 INDUCTANCE

PowerPoint Image Slideshow



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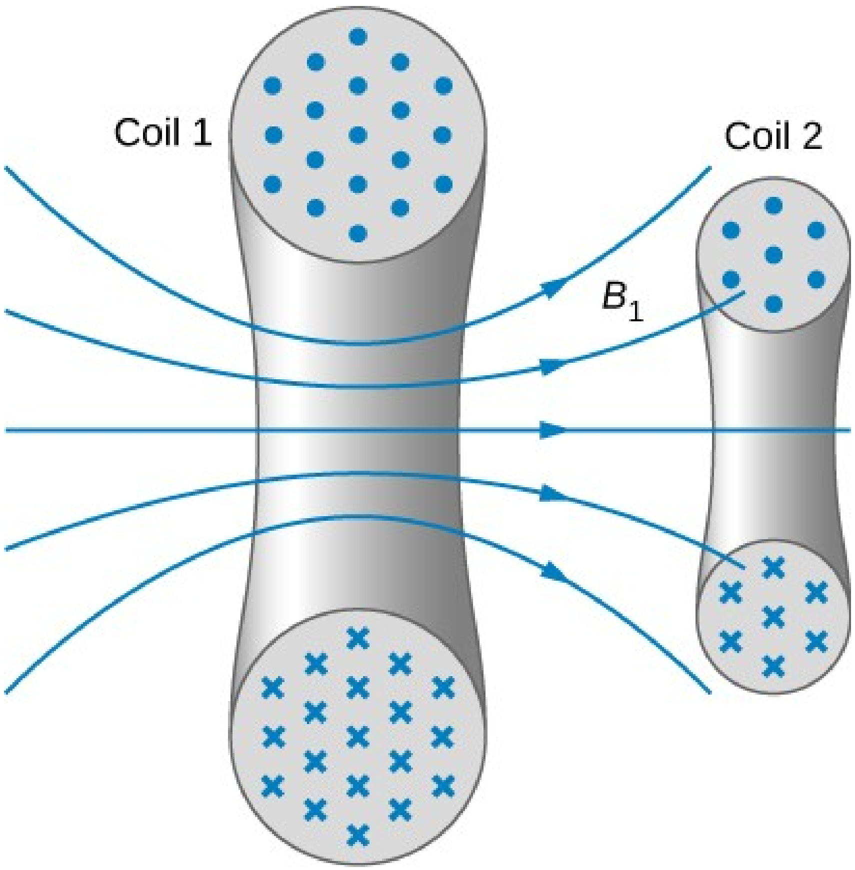
Mutual inductance

FIGURE 14.2



Mutual inductance

Some of the magnetic field lines produced by the current in coil 1 pass through coil 2.

$$M = \frac{N_2 \Phi_{21}}{I_1} = \frac{N_1 \Phi_{12}}{I_2}$$

$$\epsilon_1 = -M \frac{dI_2}{dt}$$

$$\epsilon_2 = -M \frac{dI_1}{dt}$$

FIGURE 14.3

The heating coils of an electric clothes dryer can be counter-wound so that their magnetic fields cancel one another, greatly reducing the mutual inductance with the case of the dryer.

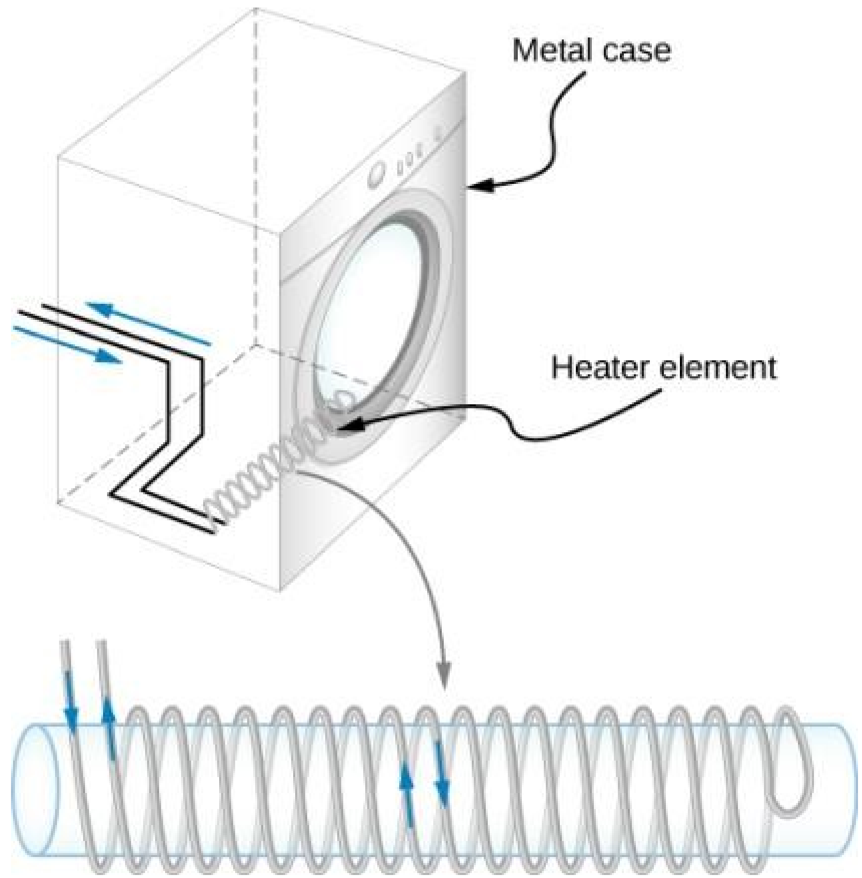
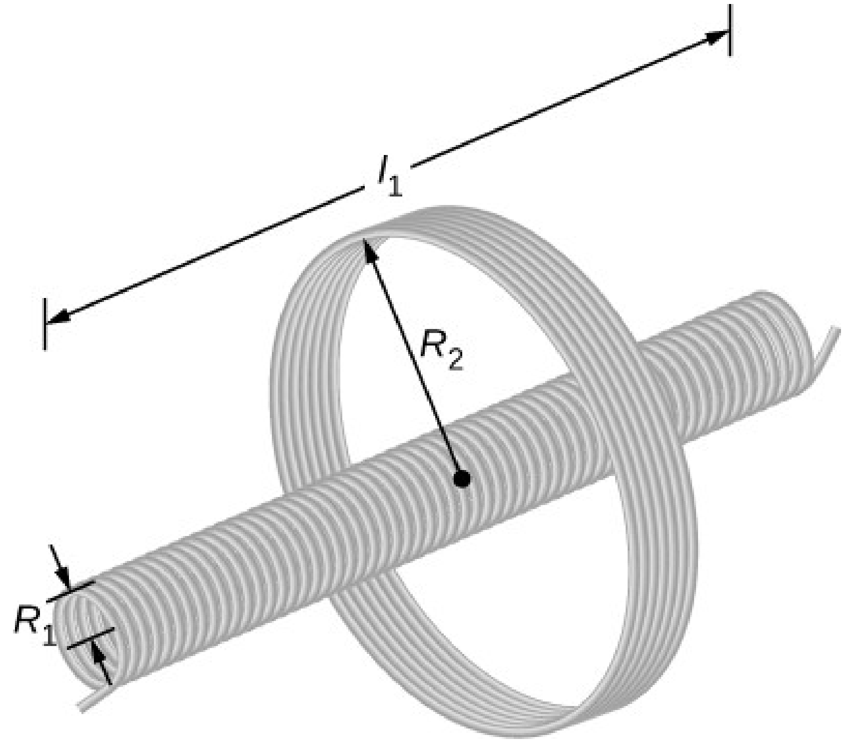


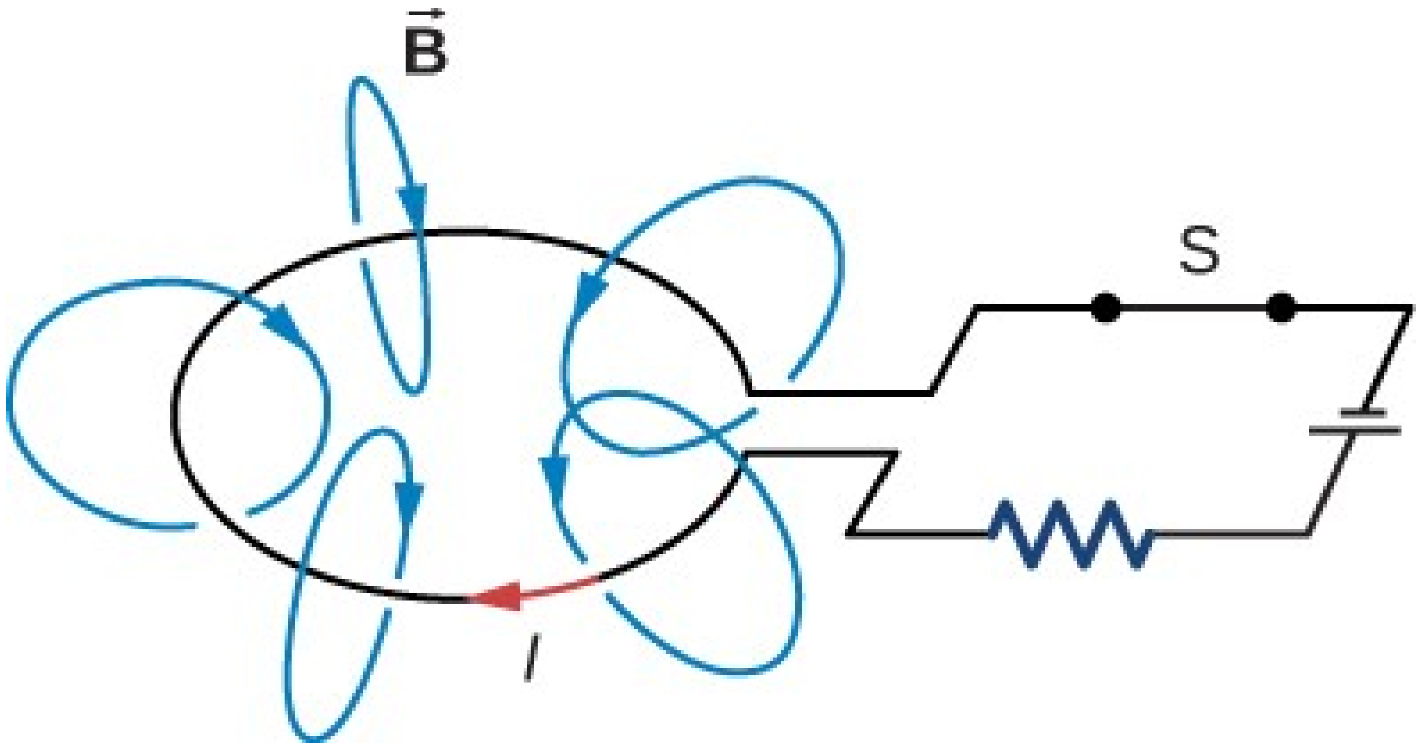
FIGURE 14.4



A solenoid surrounded by a coil.

Self Inductance

FIGURE 14.5

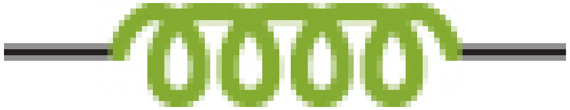


A magnetic field is produced by the current *I* in the loop. If *I* were to vary with time, the magnetic flux through the loop would also vary and an emf would be induced in the loop.

$$N\Phi_m = LI$$

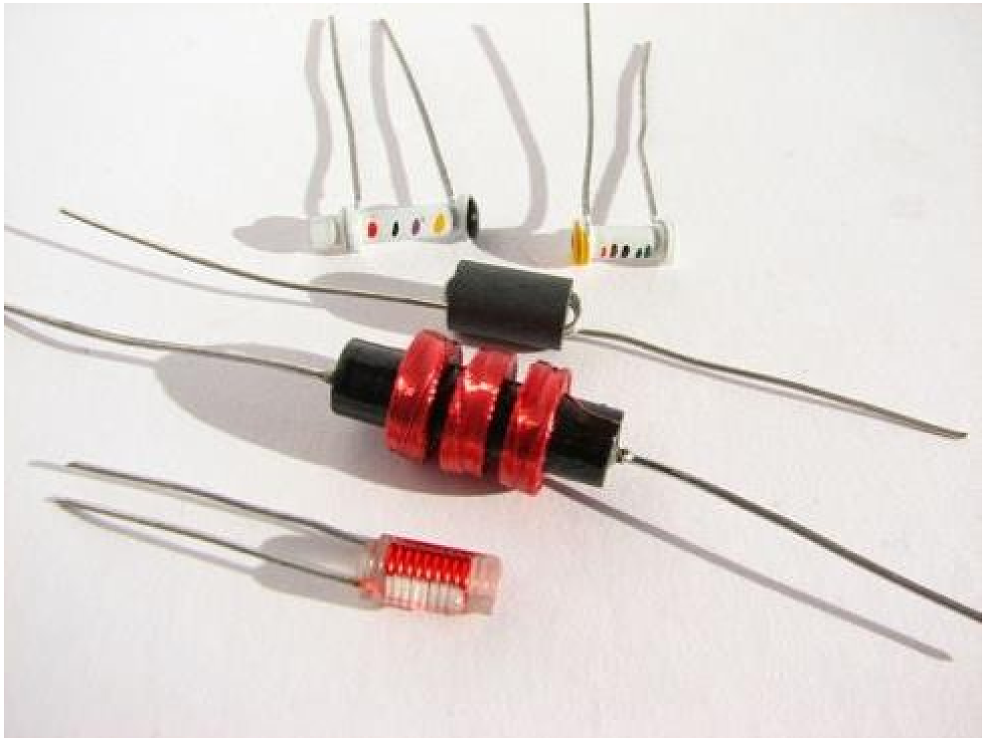
$$\epsilon = -L\frac{dI}{dt}$$

FIGURE 14.6



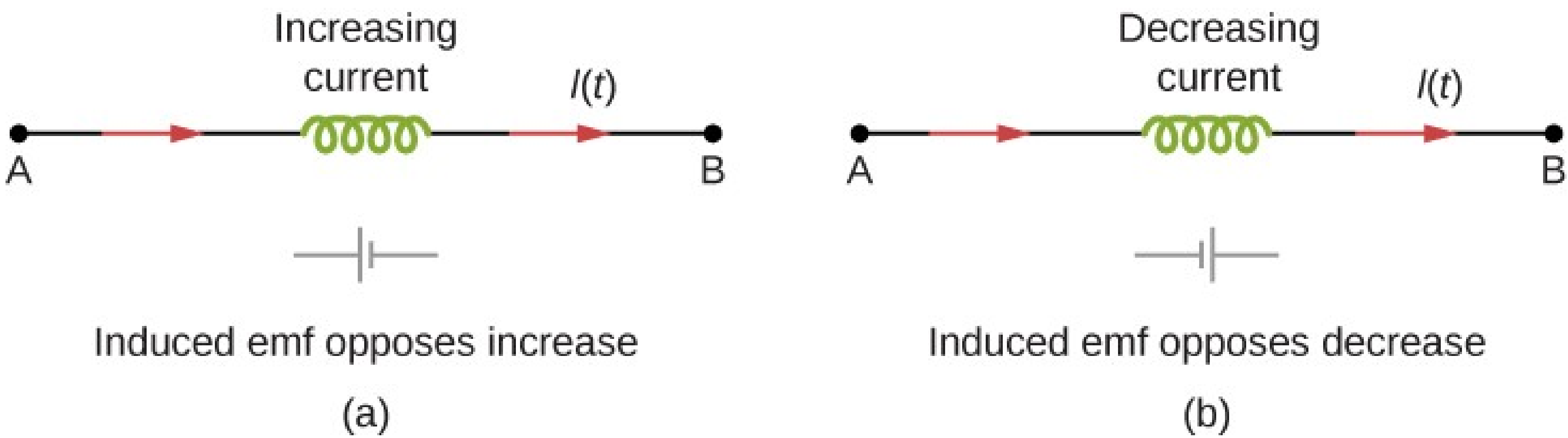
Symbol used to represent an inductor in a circuit.

FIGURE 14.7



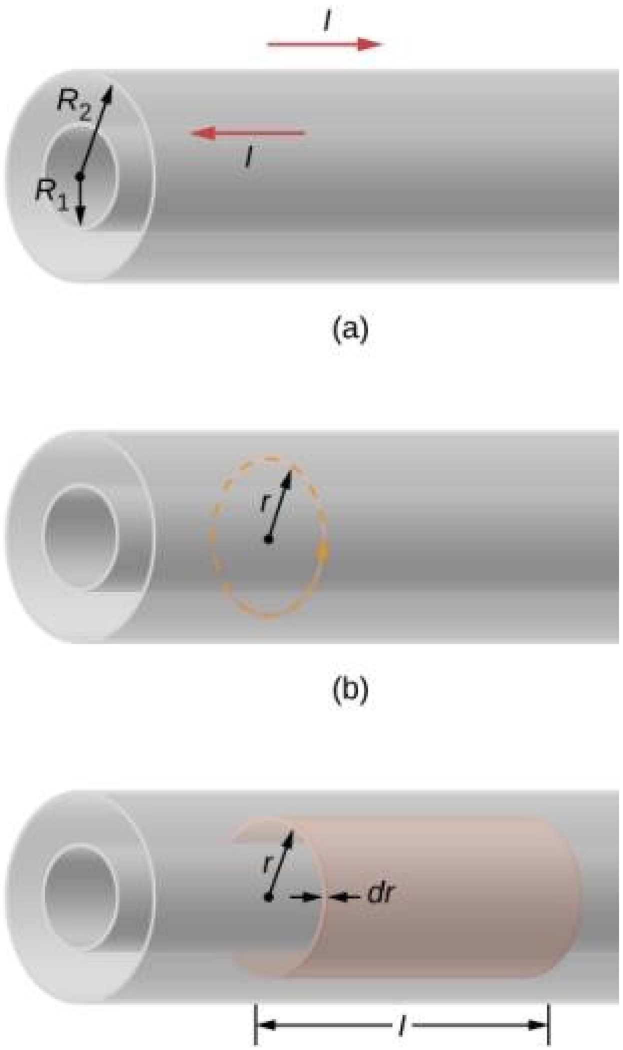
A variety of inductors. Whether they are encapsulated like the top three shown or wound around in a coil like the bottom-most one, each is simply a relatively long coil of wire. (credit: Windell Oskay)

FIGURE 14.8



The induced emf across an inductor always acts to oppose the change in the current. This can be visualized as an imaginary battery causing current to flow to oppose the change in (a) and reinforce the change in (b).

FIGURE 14.11



(a) (b) (c)

Example 14.3

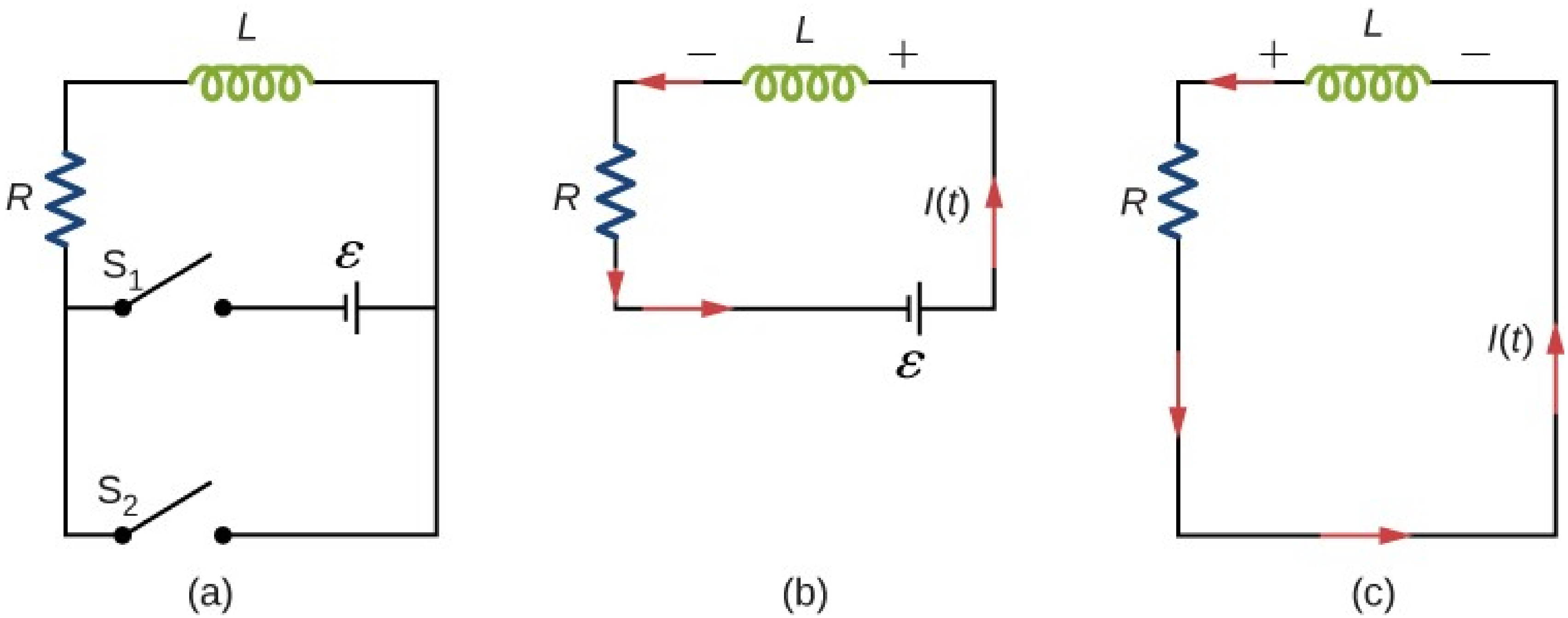
a) A coaxial cable is represented here by two hollow, concentric cylindrical conductors along which electric current flows in opposite directions.

b) The magnetic field between the conductors can be found by applying Ampère's law to the dashed path.

c) The cylindrical shell is used to find the magnetic energy stored in a length *l* of the cable.

RL Circuits

FIGURE 14.12



a) An *RL* circuit with switches S_1 and S_2.

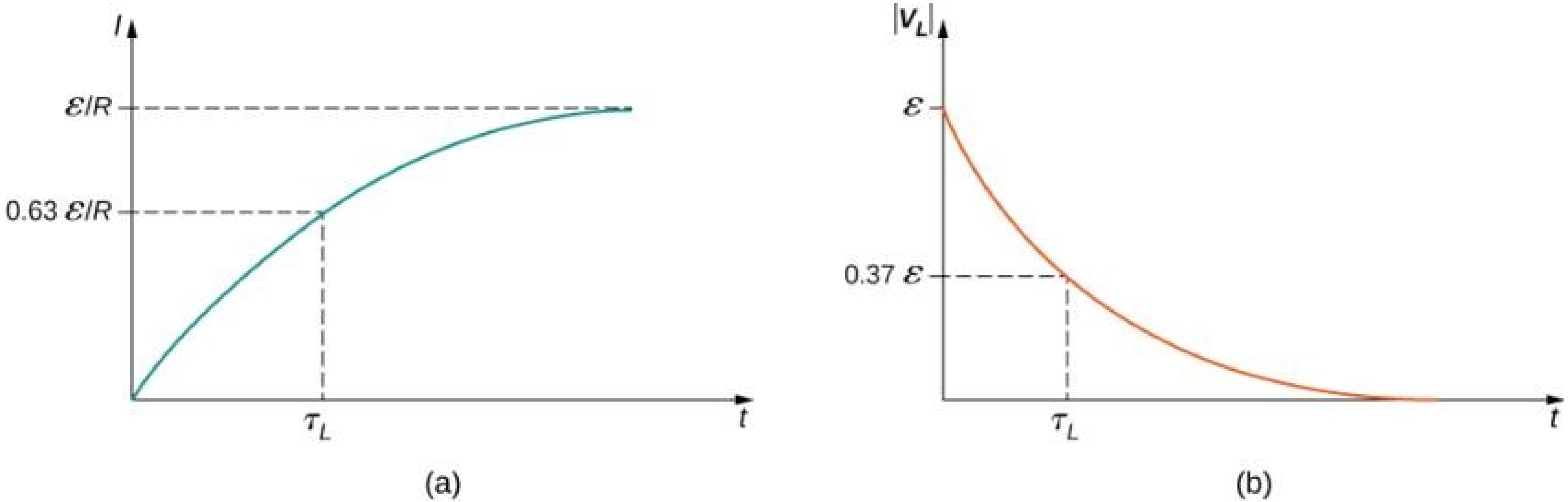
b) The equivalent circuit with S_1 closed and S_2 open.

c) The equivalent circuit after S_1 is opened and S_2 is closed.

Applying Kirchoff's rule

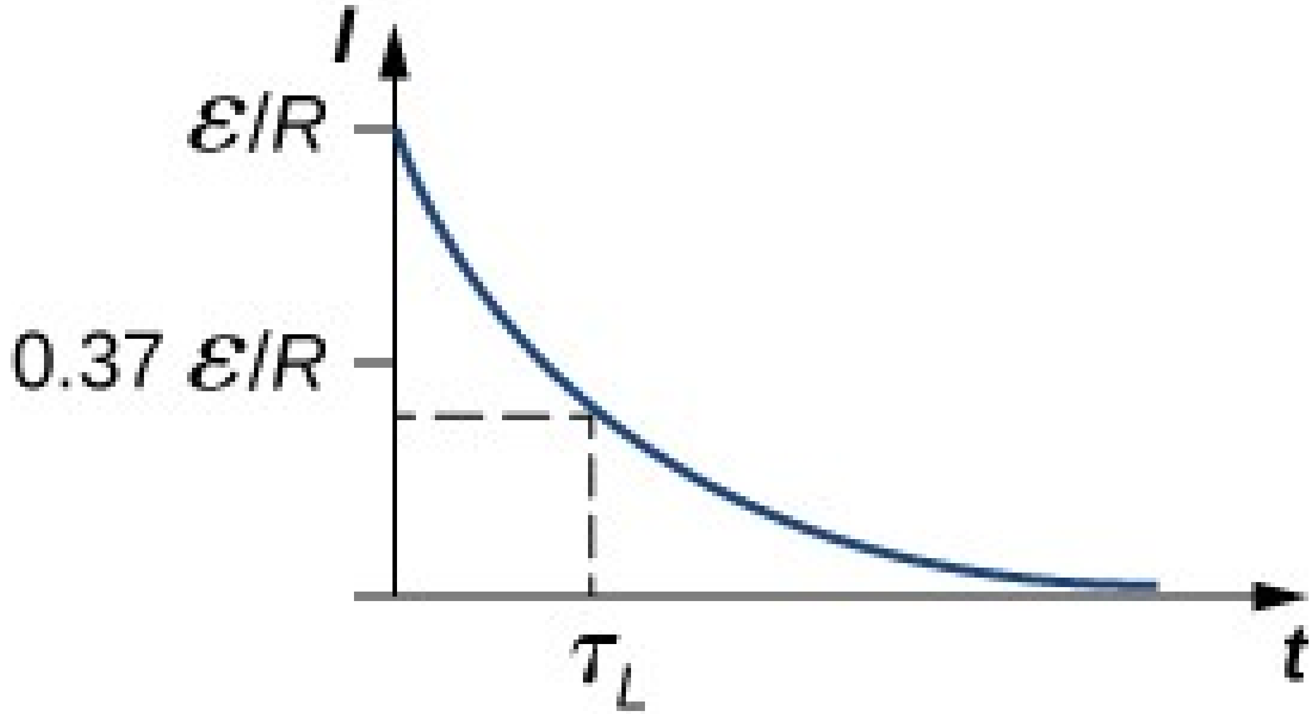
$$V - L\frac{dI}{dt} - IR = 0$$

FIGURE 14.13



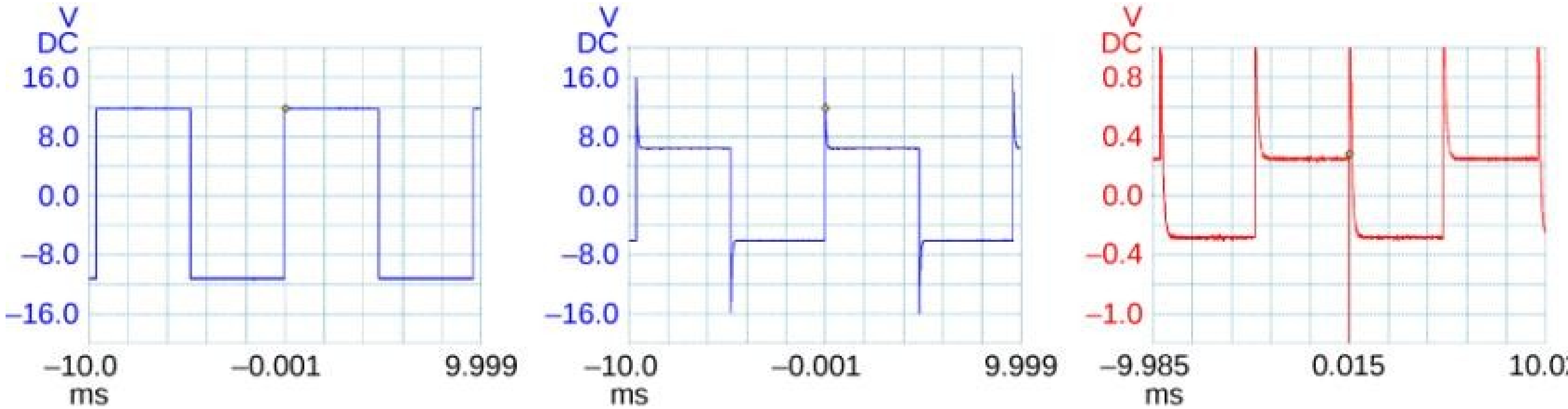
Time variation of (a) the electric current and (b) the magnitude of the induced voltage across the coil in the circuit of **Figure 14.12(b)**.

FIGURE 14.14



Time variation of electric current in the *RL* circuit of **Figure 14.12**(c). The induced voltage across the coil also decays exponentially.

FIGURE 14.15

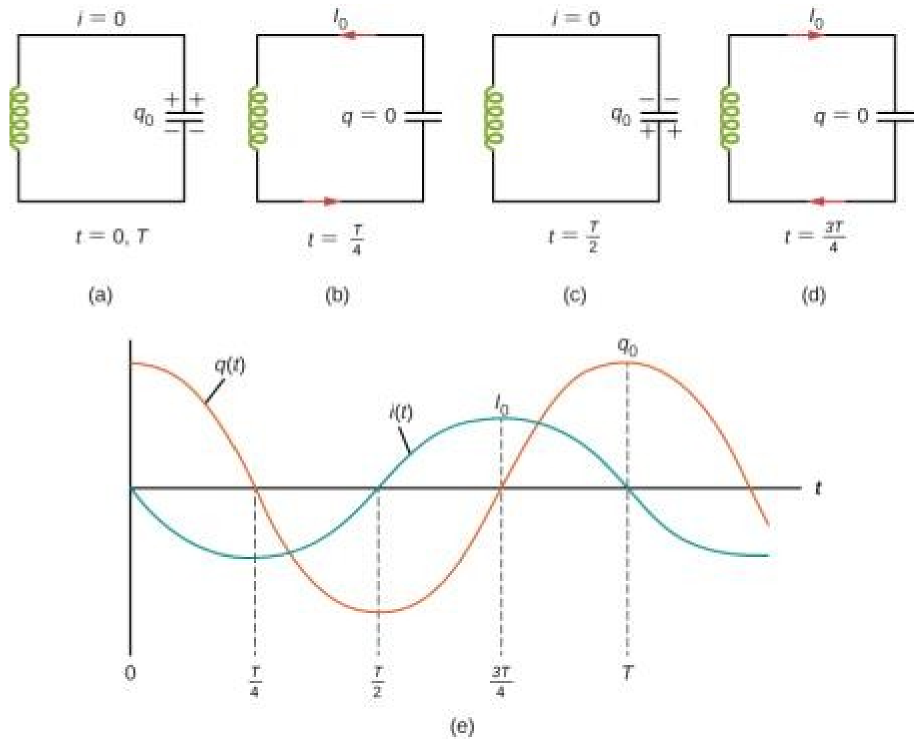


(a) Voltage across the source (b) Voltage across the inductor (c) Voltage across the resistor

A generator in an *RL* circuit produces a square-pulse output in which the voltage oscillates between zero and some set value. These oscilloscope traces show (a) the voltage across the source; (b) the voltage across the inductor; (c) the voltage across the resistor.

LC Circuits

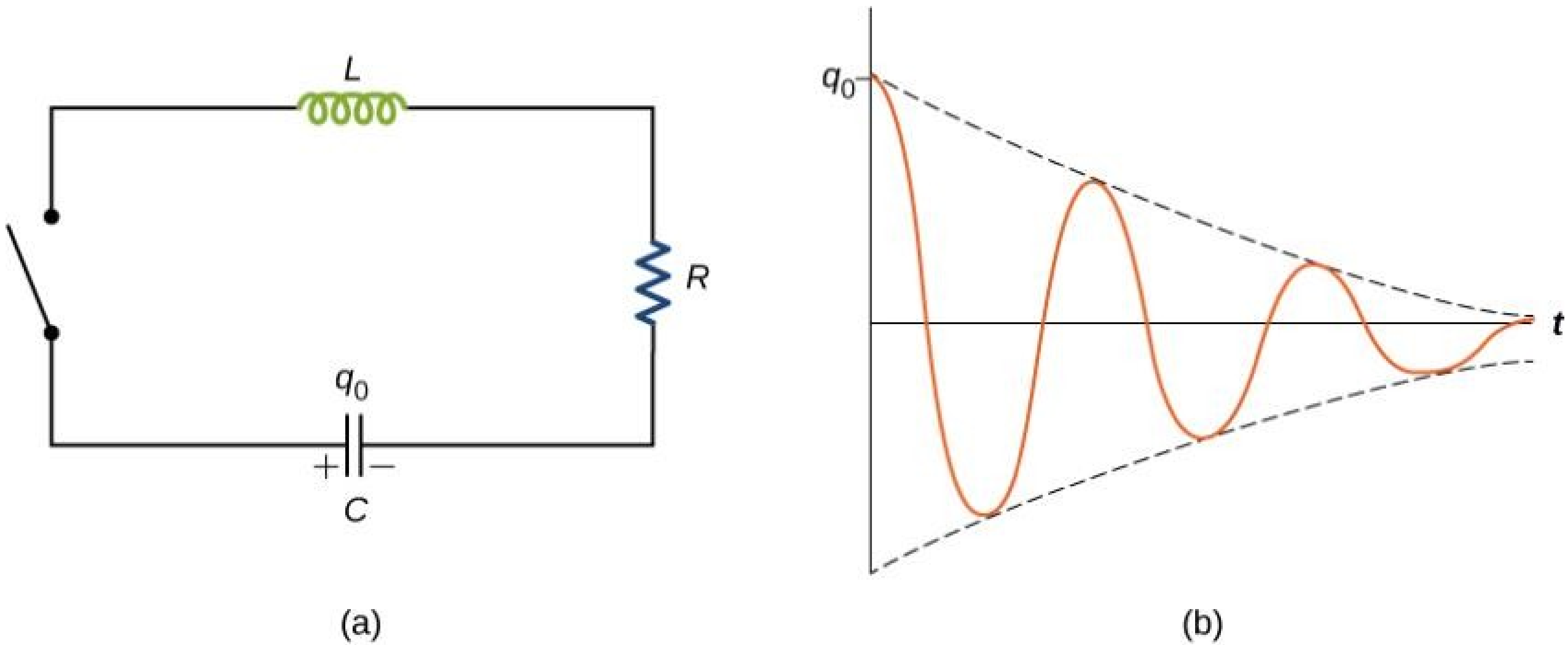
FIGURE 14.16



(a–d) The oscillation of charge storage with changing directions of current in an *LC* circuit. (e) The graphs show the distribution of charge and current between the capacitor and inductor.

RLC Circuits

FIGURE 14.17



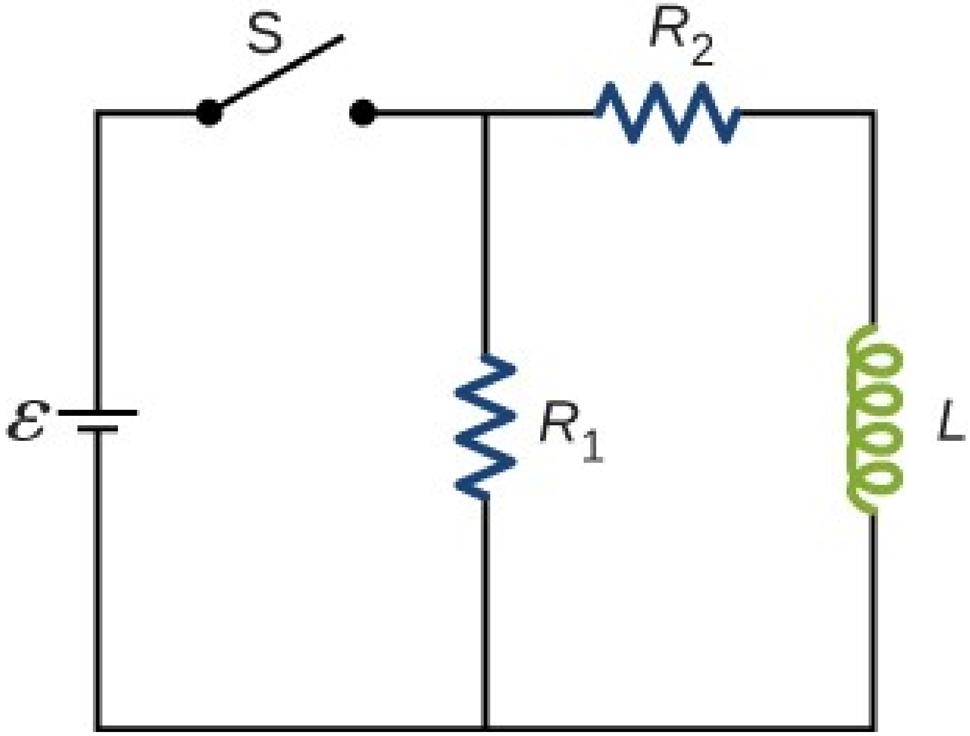
a) An *RLC* circuit. Electromagnetic oscillations begin when the switch is closed. The capacitor is fully charged initially.

b) Damped oscillations of the capacitor charge are shown in this curve of charge versus time, or q versus t. The capacitor contains a charge q_0 before the switch is closed.

$$L\frac{d^2q}{dt^2} + R\frac{dq}{dt} + \frac{q}{C} = 0$$

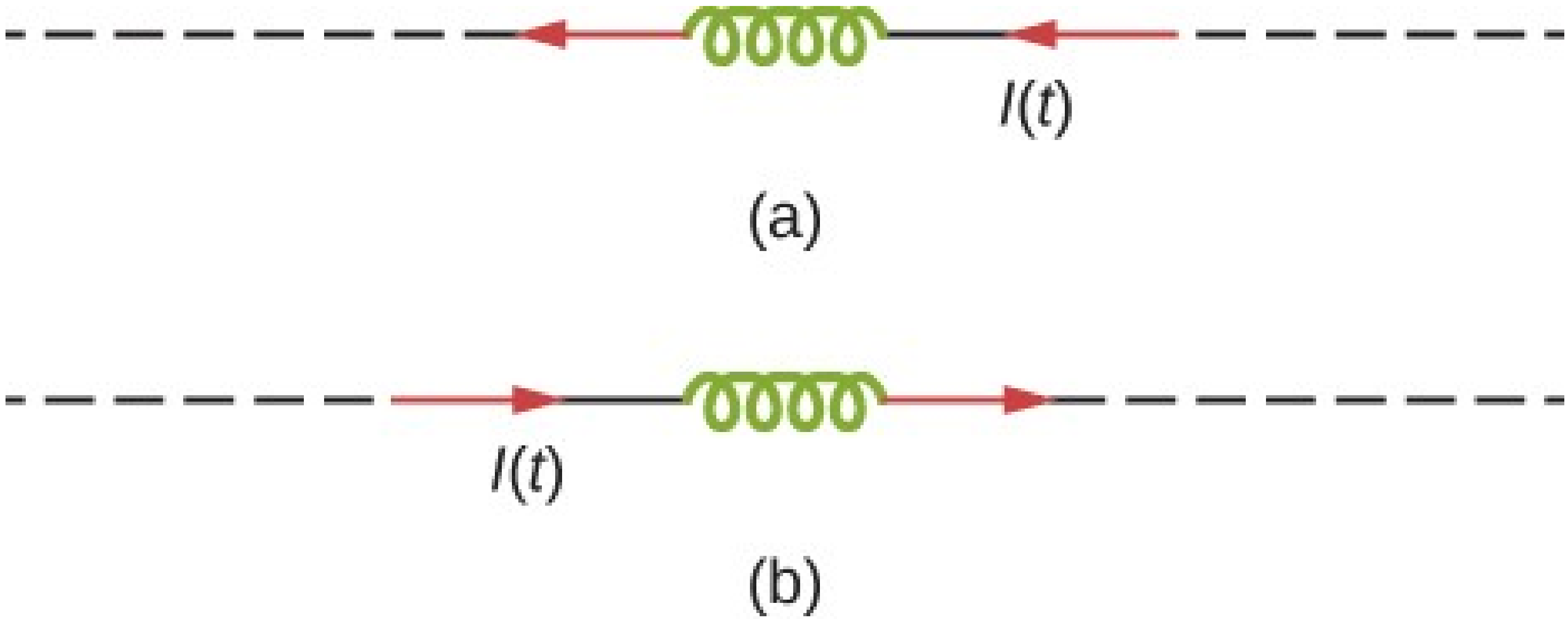
Examples

EXERCISE 19



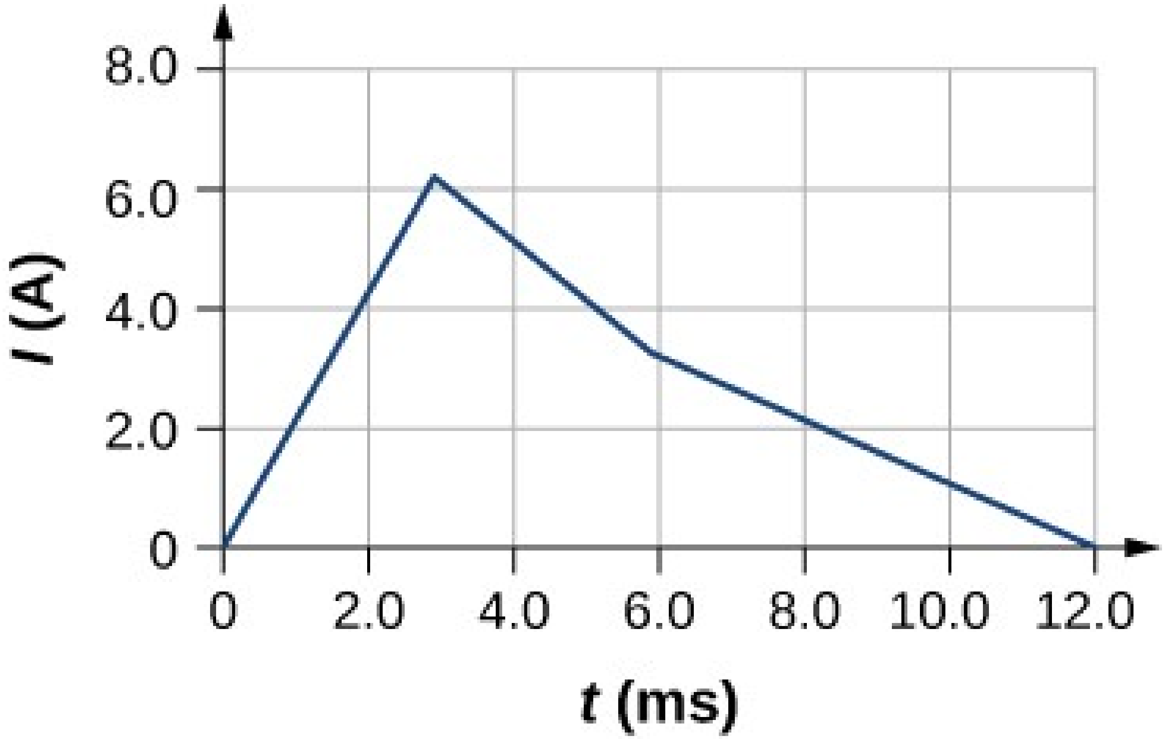
Describe how the currents through R_1 and R_2 shown below vary with time after switch S is closed.

EXERCISE 36



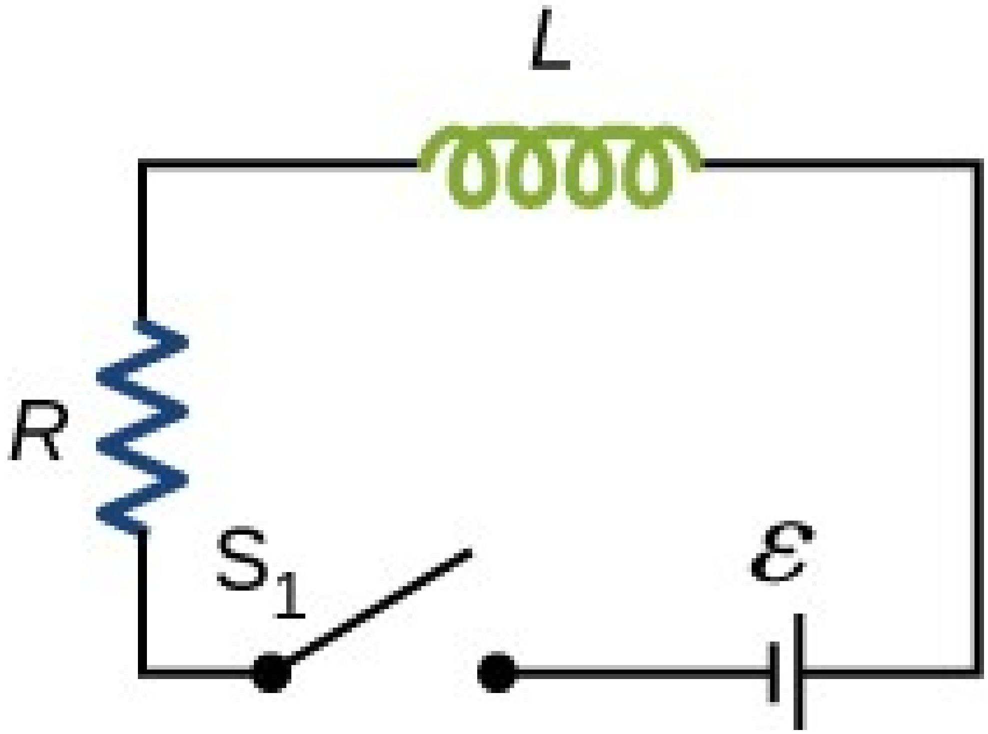
The current shown in part (a) below is increasing, whereas that shown in part (b) is decreasing. In each case, determine which end of the inductor is at the higher potential.

EXERCISE 42



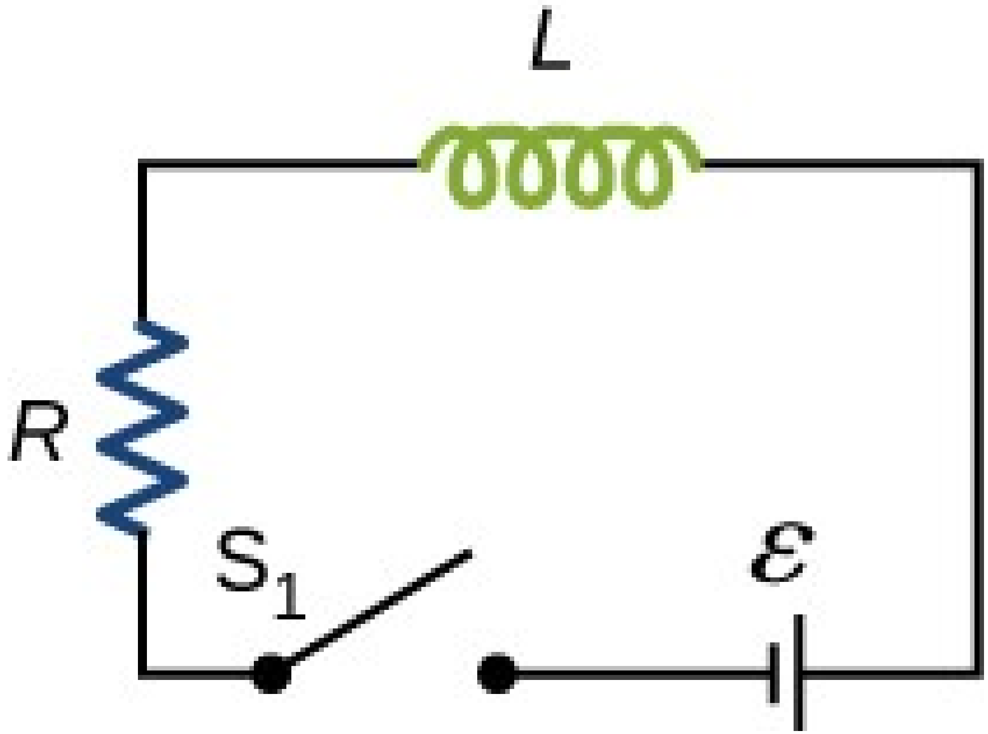
The current *I(t)* through a 5.0-mH inductor varies with time, as shown below. The resistance of the inductor is $5.0\ \Omega$. Calculate the voltage across the inductor at $t = 2.0$ ms, $t = 4.0$ ms, and $t = 8.0$ ms.

EXERCISE 55



How long after switch S_1 is thrown does it take the current in the circuit shown to reach half its maximum value? Express your answer in terms of the time constant of the circuit.

EXERCISE 57



The current in the *RL* circuit shown below reaches half its maximum value in 1.75 ms after the switch S_1 is thrown. Determine (a) the time constant of the circuit and (b) the resistance of the circuit if $L = 250 \text{ mH}$.