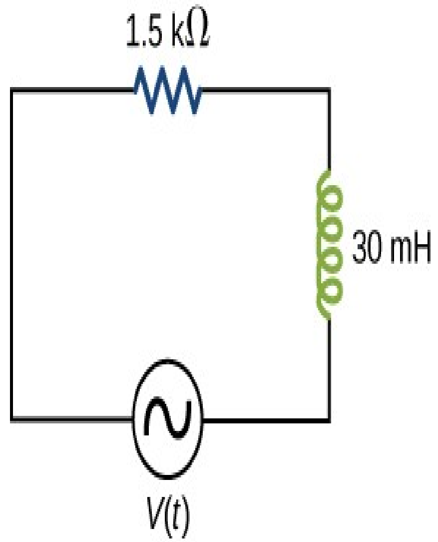
UNIVERSITY PHYSICS

Chapter 15 ALTERNATING-CURRENT CIRCUITS

PowerPoint Image Slideshow



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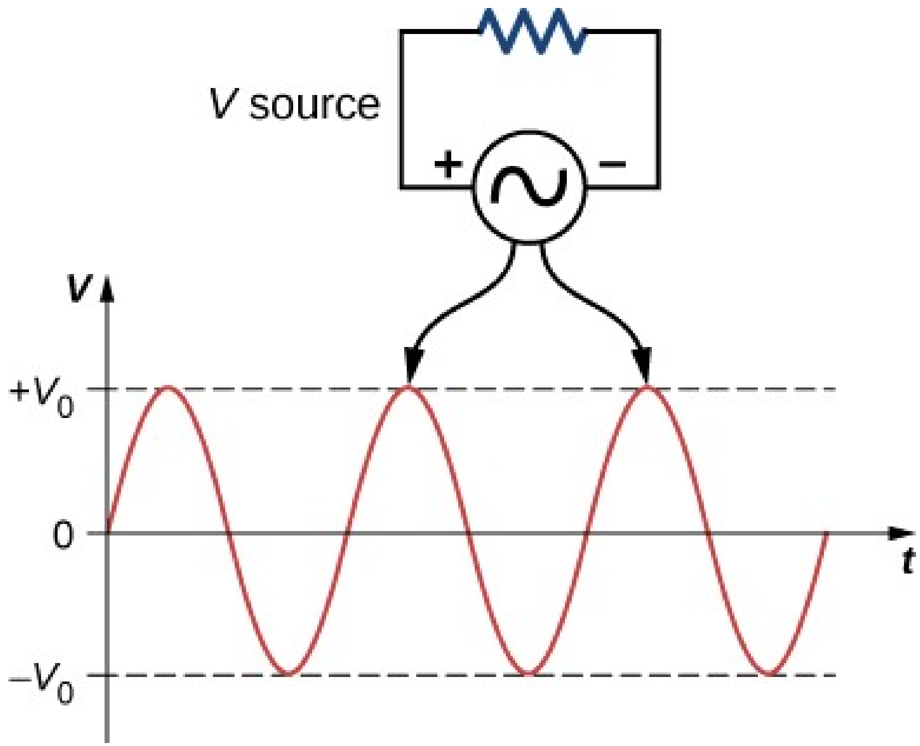
Alternating current

FIGURE 15.2

a) The dc voltage and current are constant in time, once the current is established.

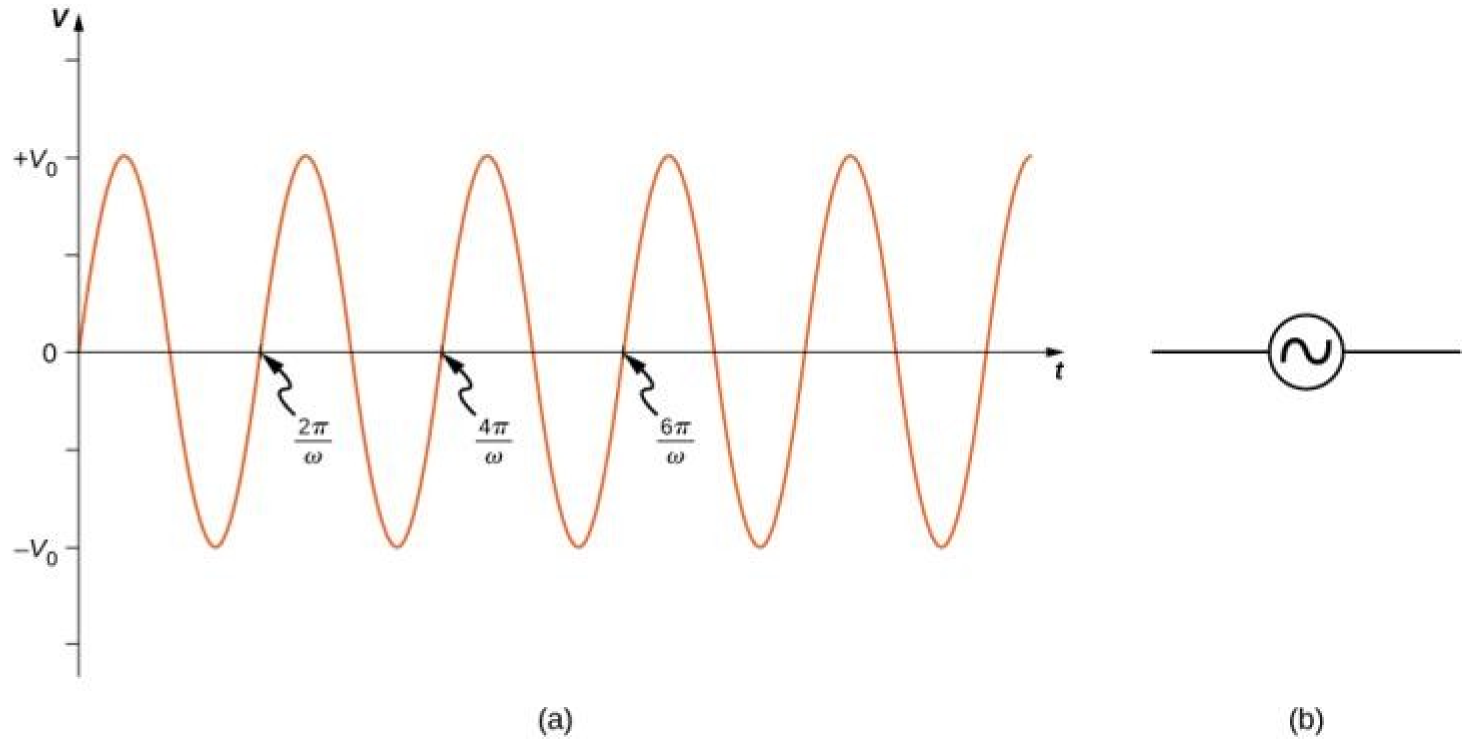
b) The voltage and current versus time are quite different for ac power. In this example, which shows 60-Hz ac power and time *t* in milliseconds, voltage and current are sinusoidal and are in phase for a simple resistance circuit. The frequencies and peak voltages of ac sources differ greatly.

FIGURE 15.3



The potential difference V between the terminals of an ac voltage source fluctuates, so the source and the resistor have ac sine waves on top of each other. The mathematical expression for v is given by $v = V_0 \sin \omega t$.

FIGURE 15.4

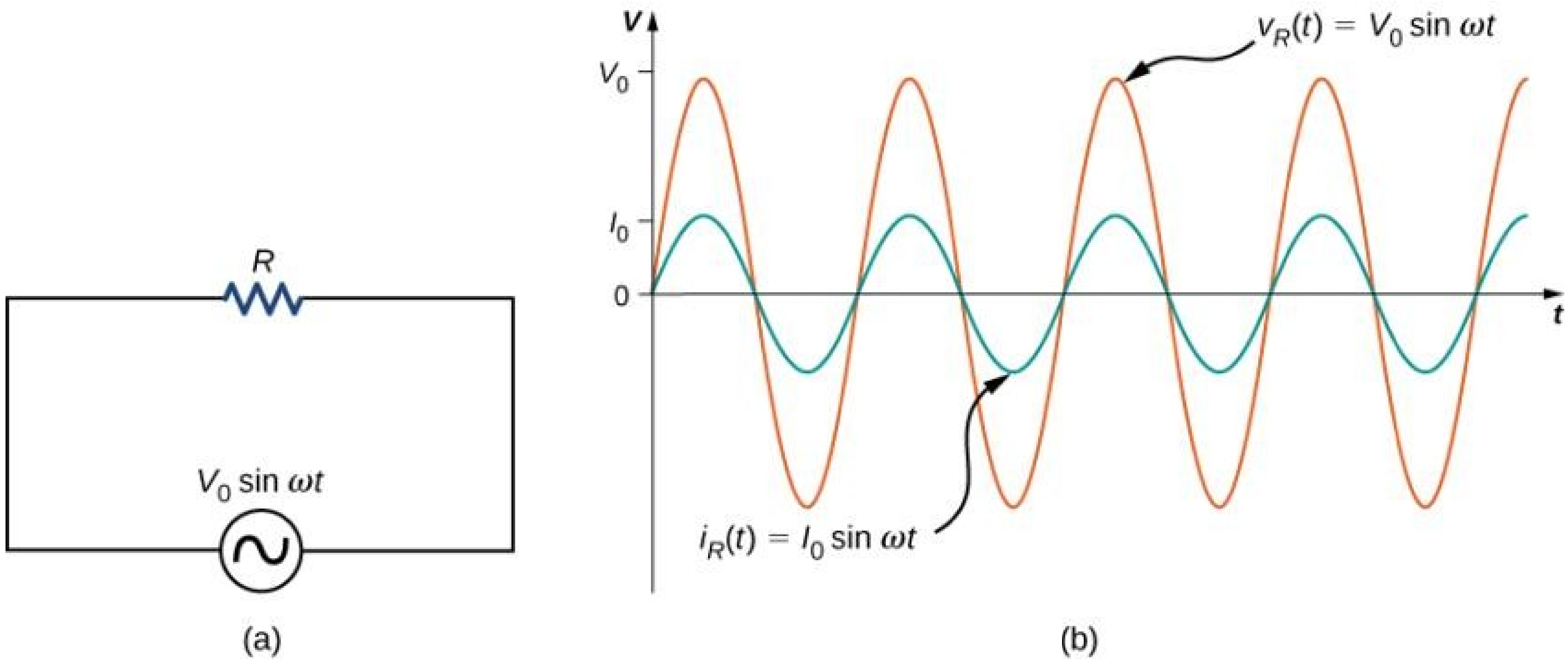


a) The output $v(t) = V_0 \sin \omega t$ of an ac generator.

b) Symbol used to represent an ac voltage source in a circuit diagram.

Adding circuit elements

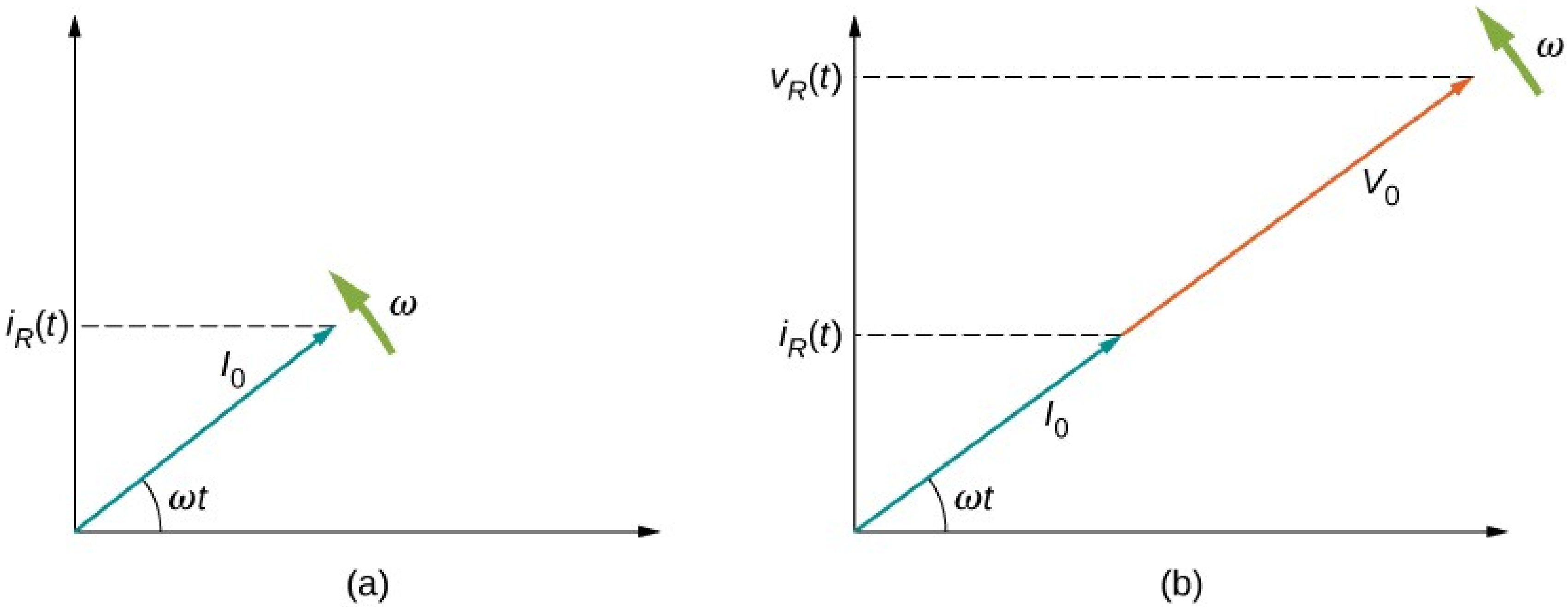
FIGURE 15.5



a) A resistor connected across an ac voltage source.

b) The current $i_R(t)$ through the resistor and the voltage $v_R(t)$ across the resistor. The two quantities are in phase.

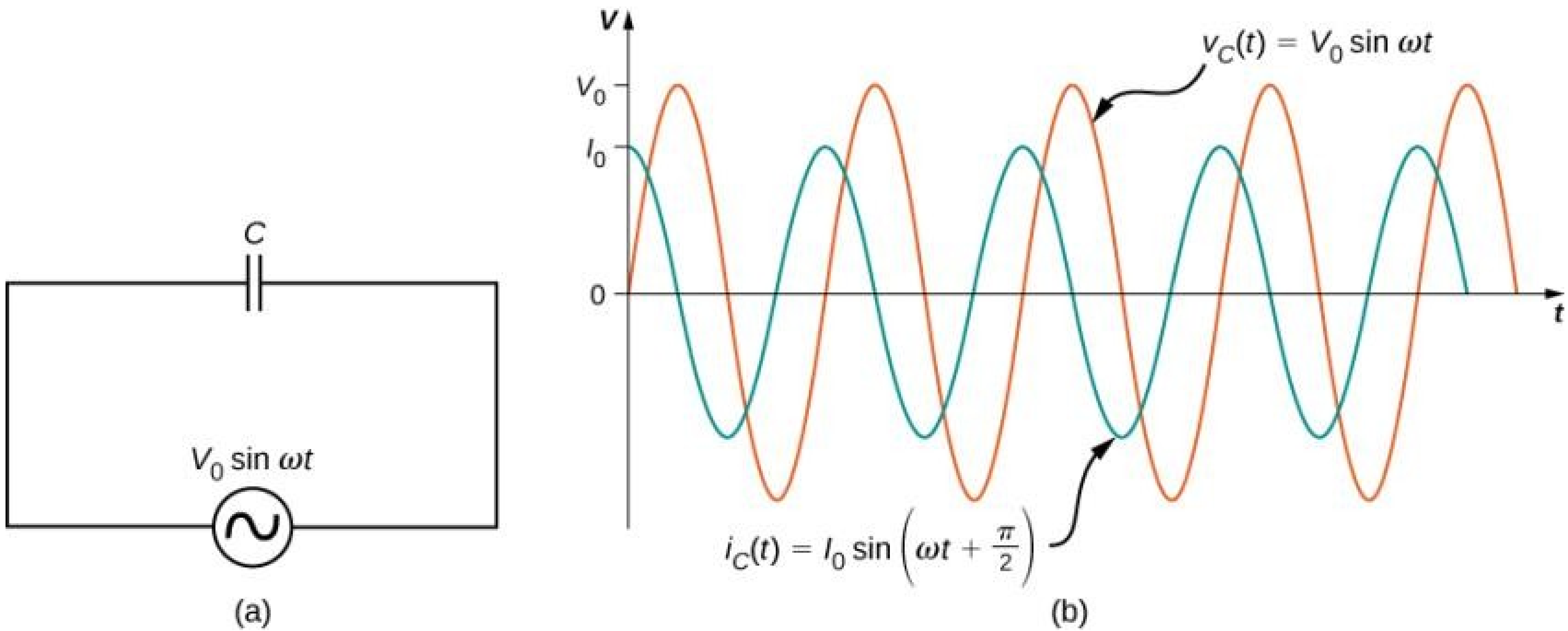
FIGURE 15.6



a) The phasor diagram representing the current through the resistor of **Figure 15.5**.

b) The phasor diagram representing both $i_R(t)$ and $v_R(t)$.

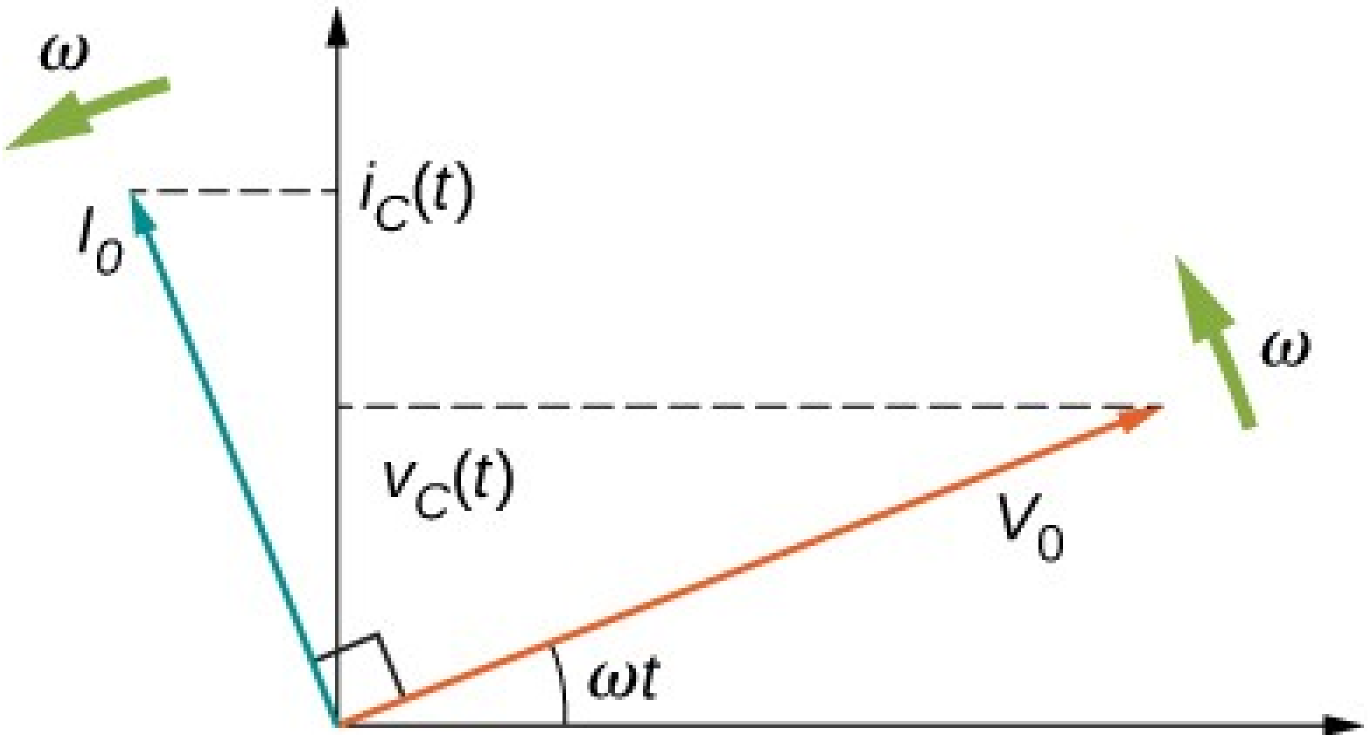
FIGURE 15.7



a) A capacitor connected across an ac generator.

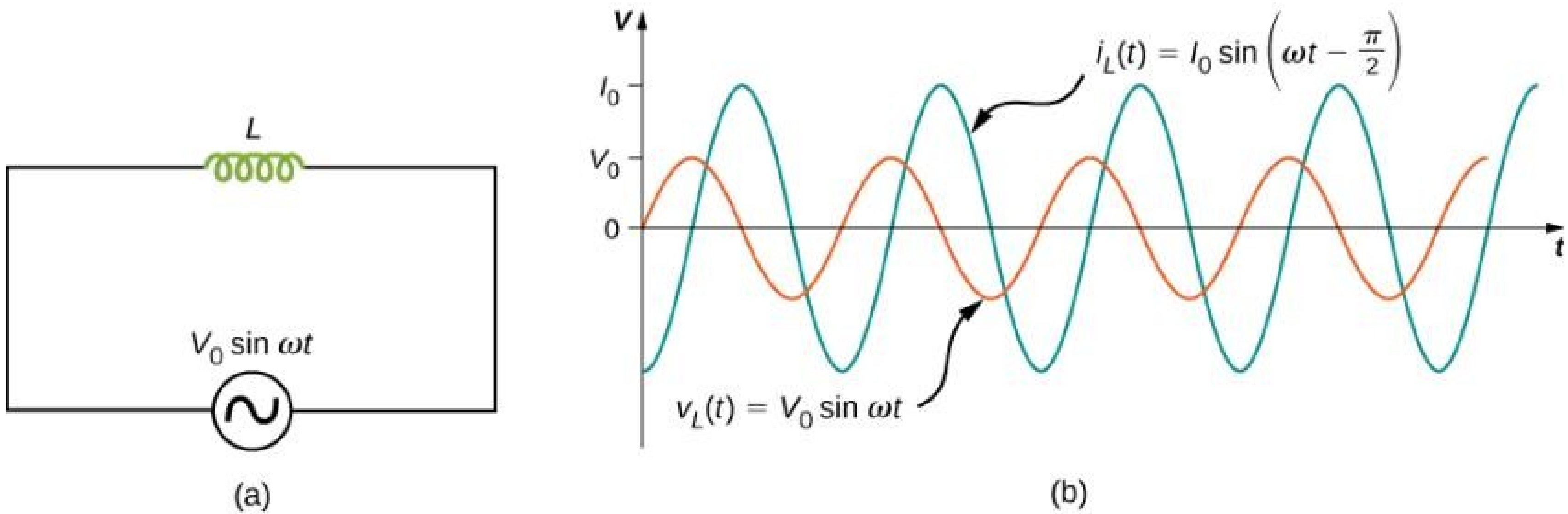
b) The current $i_C(t)$ through the capacitor and the voltage $v_C(t)$ across the capacitor. Notice that $i_C(t)$ leads $v_C(t)$ by $\pi/2$ rad.

FIGURE 15.8



The phasor diagram for the capacitor of Figure 15.7. The current phasor leads the voltage phasor by $\pi/2$ rad as they both rotate with the same angular frequency.

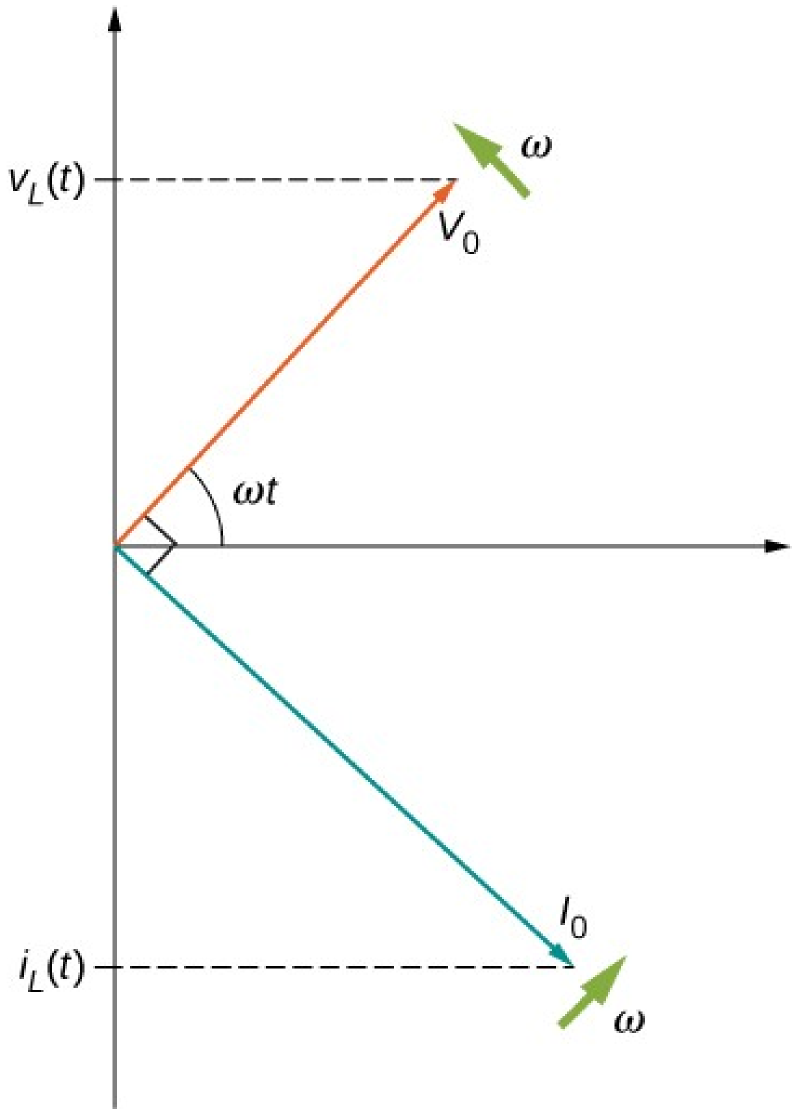
FIGURE 15.9



a) An inductor connected across an ac generator.

b) The current $i_L(t)$ through the inductor and the voltage $v_L(t)$ across the inductor. Here $i_L(t)$ lags $v_L(t)$ by $\pi/2$ rad.

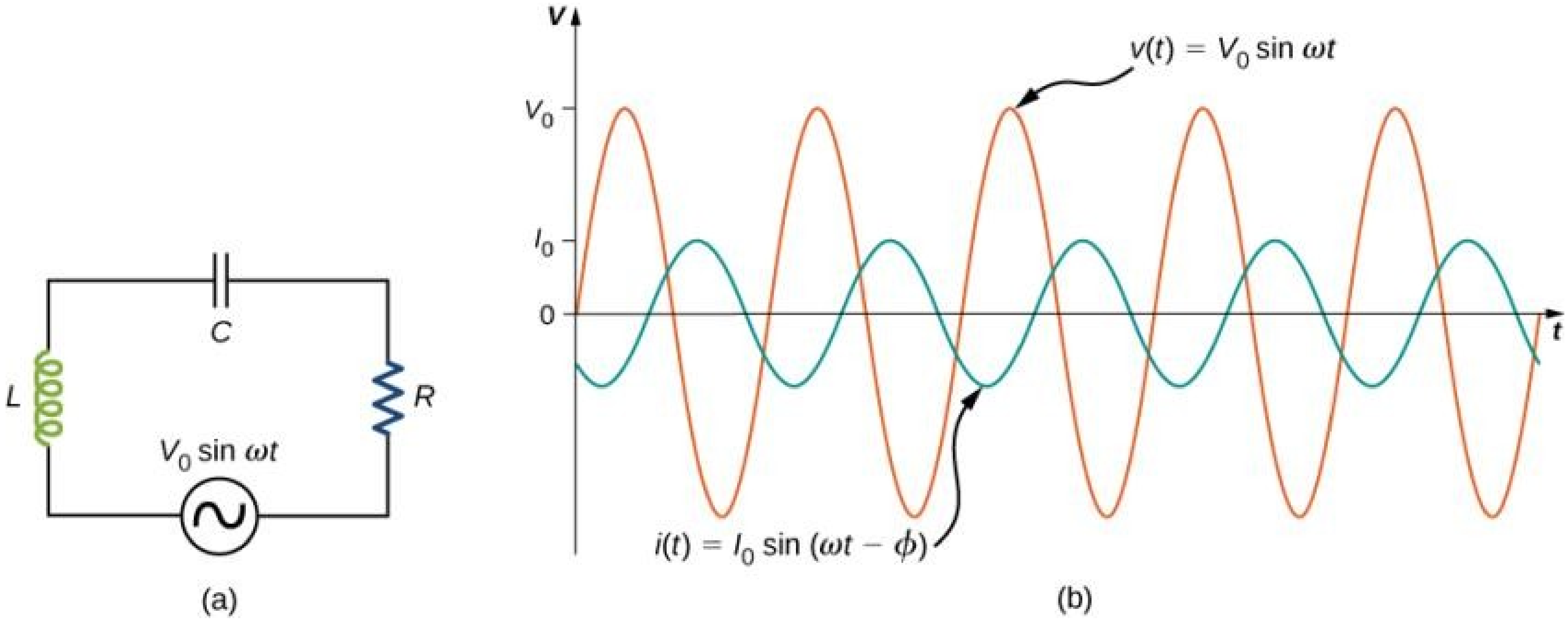
FIGURE 15.10



The phasor diagram for the inductor of **Figure 15.9**. The current phasor lags the voltage phasor by $\pi/2$ rad as they both rotate with the same angular frequency.

RLC Circuits

FIGURE 15.11



a) An *RLC* series circuit.

b) A comparison of the generator output voltage and the current. The value of the phase difference ϕ depends on the values of *R*, *C*, and *L*.

FIGURE 15.12

The phasor diagram for the *RLC* series circuit of **Figure 15.11**.

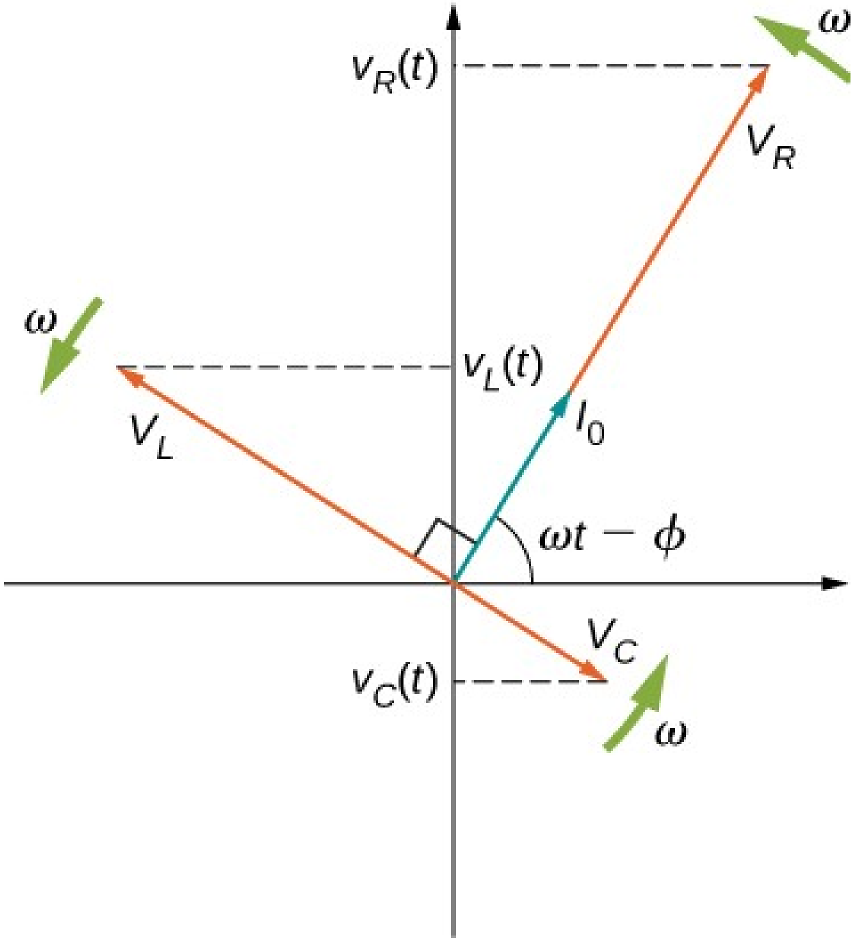
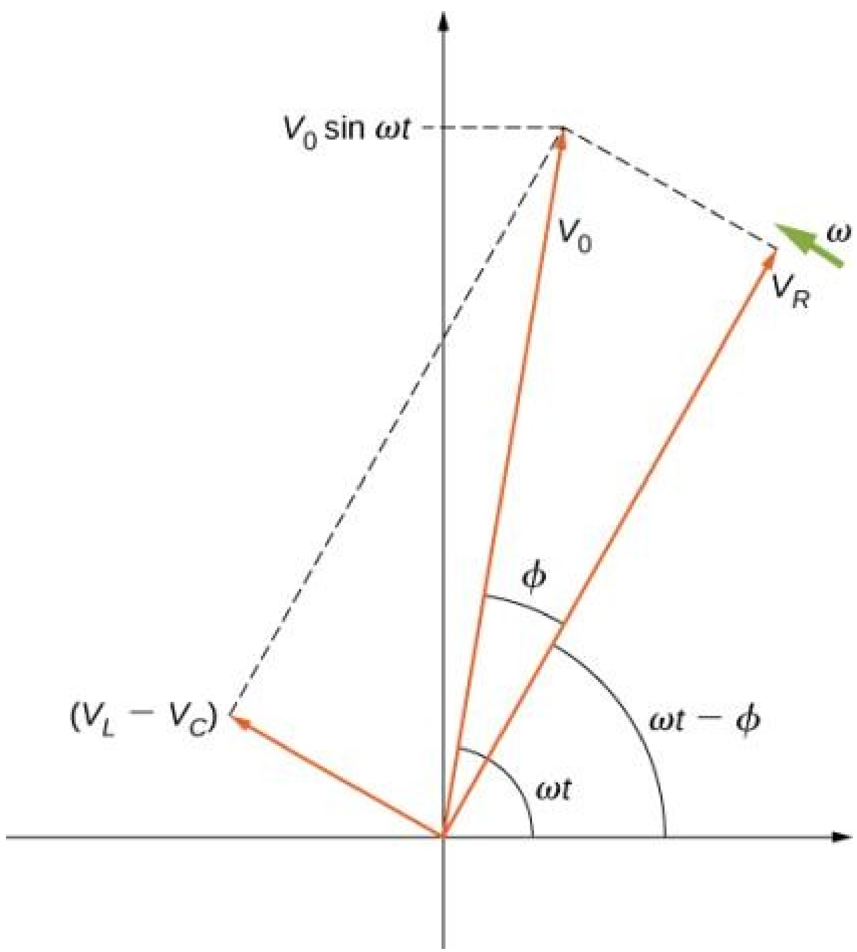
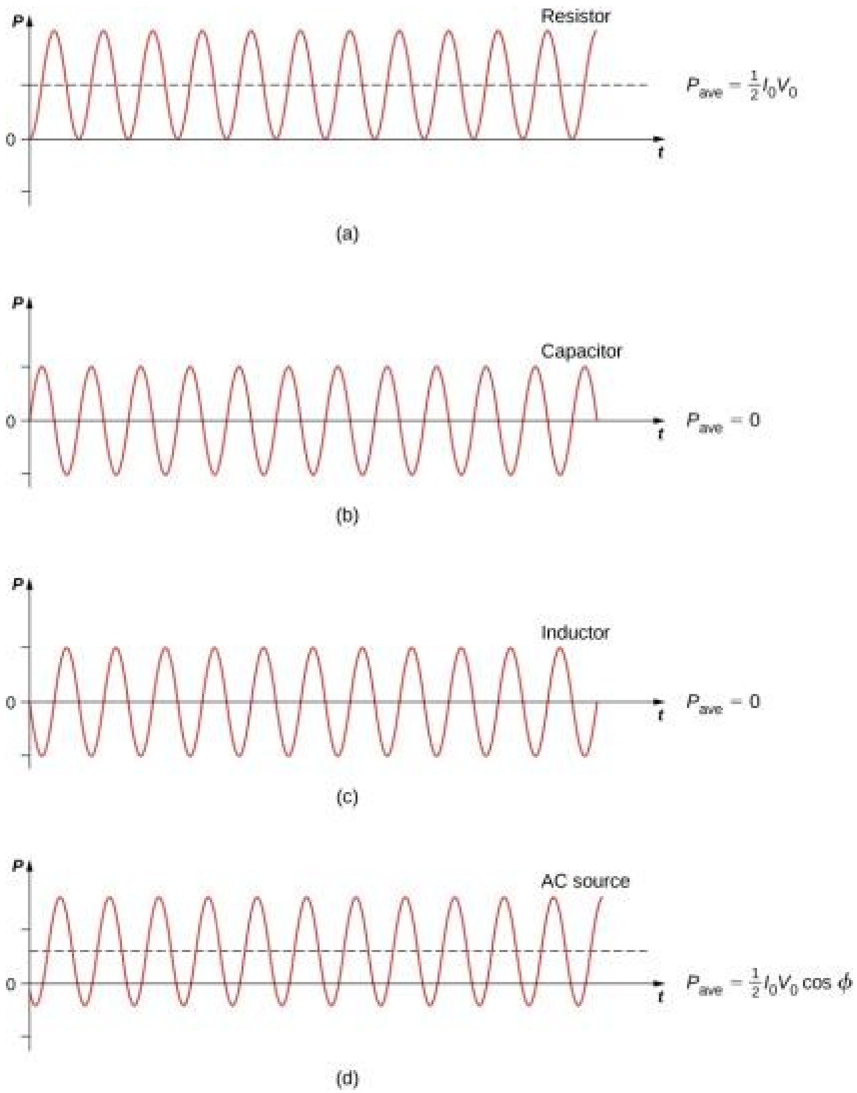


FIGURE 15.13



The resultant of the phasors for $v_L(t)$, $v_C(t)$, and $v_R(t)$ is equal to the phasor for $v(t) = V_0 \sin \omega t$. The $i(t)$ phasor (not shown) is aligned with the $v_R(t)$ phasor.

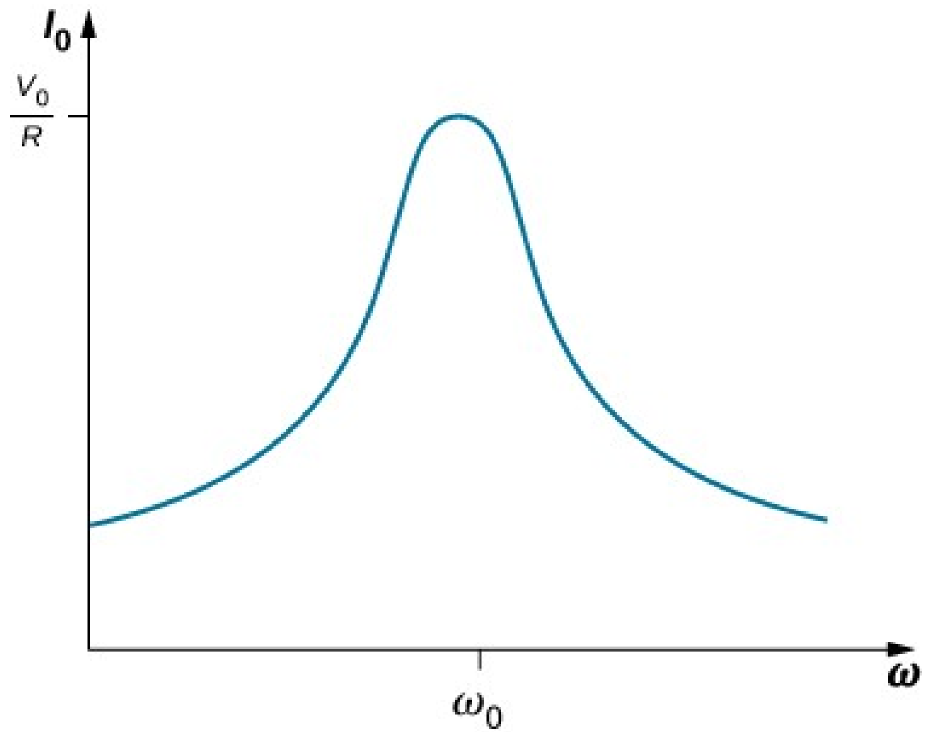
FIGURE 15.16



Graph of instantaneous power for various circuit elements. (a) For the resistor, $P_{ave} = I_0 V_0/2$, whereas for (b) the capacitor and (c) the inductor, $P_{ave} = 0$. (d) For the source, $P_{ave} = I_0 V_0 (\cos \phi)/2$, which may be positive, negative, or zero, depending on ϕ.

Resonance

FIGURE 15.17

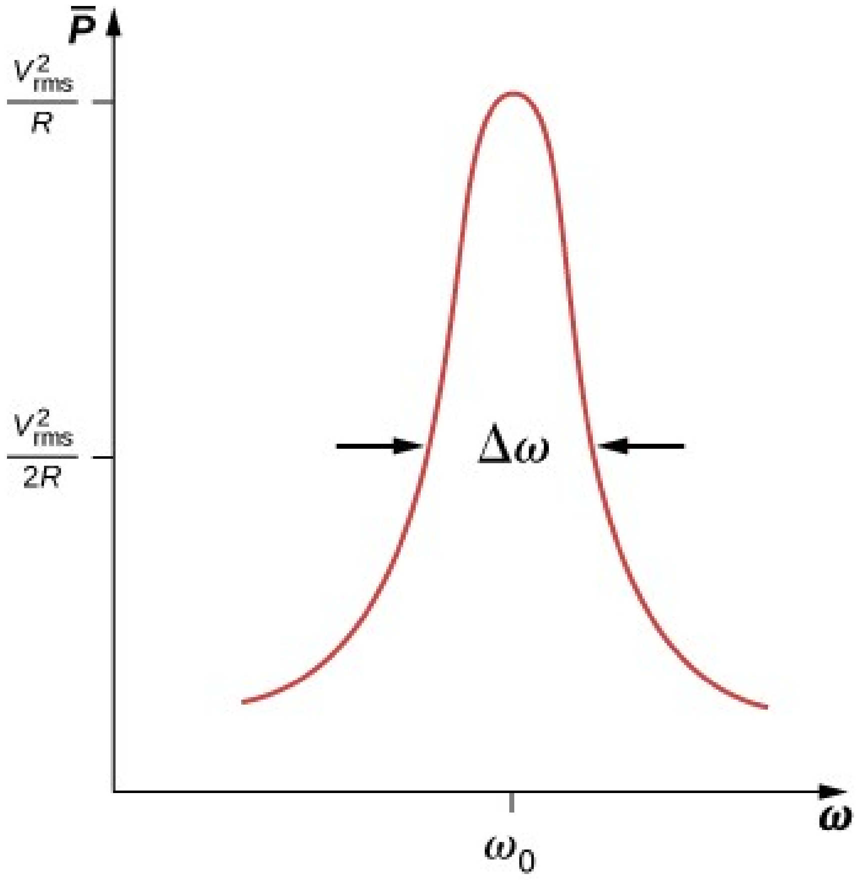


At an *RLC* circuit's resonant frequency, , the current amplitude is at its maximum value.

$$I_0 = \frac{V_0}{\sqrt{R^2 + (\omega L - 1/\omega C)^2}}$$

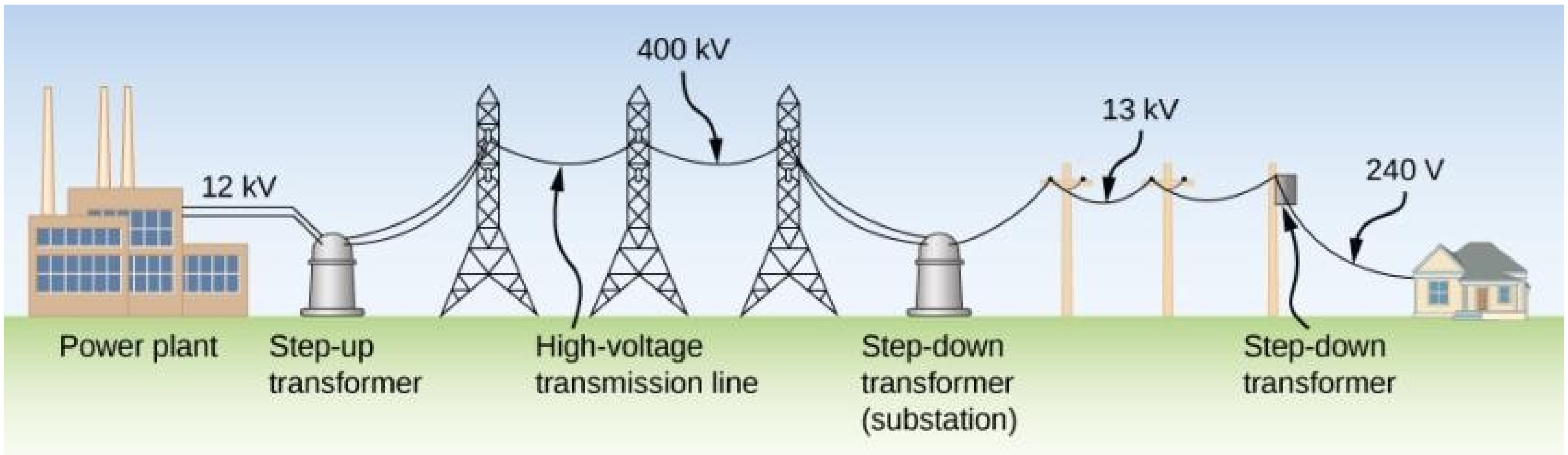
FIGURE 15.18

Like the current, the average power transferred from an ac generator to an *RLC* circuit peaks at the resonant frequency.



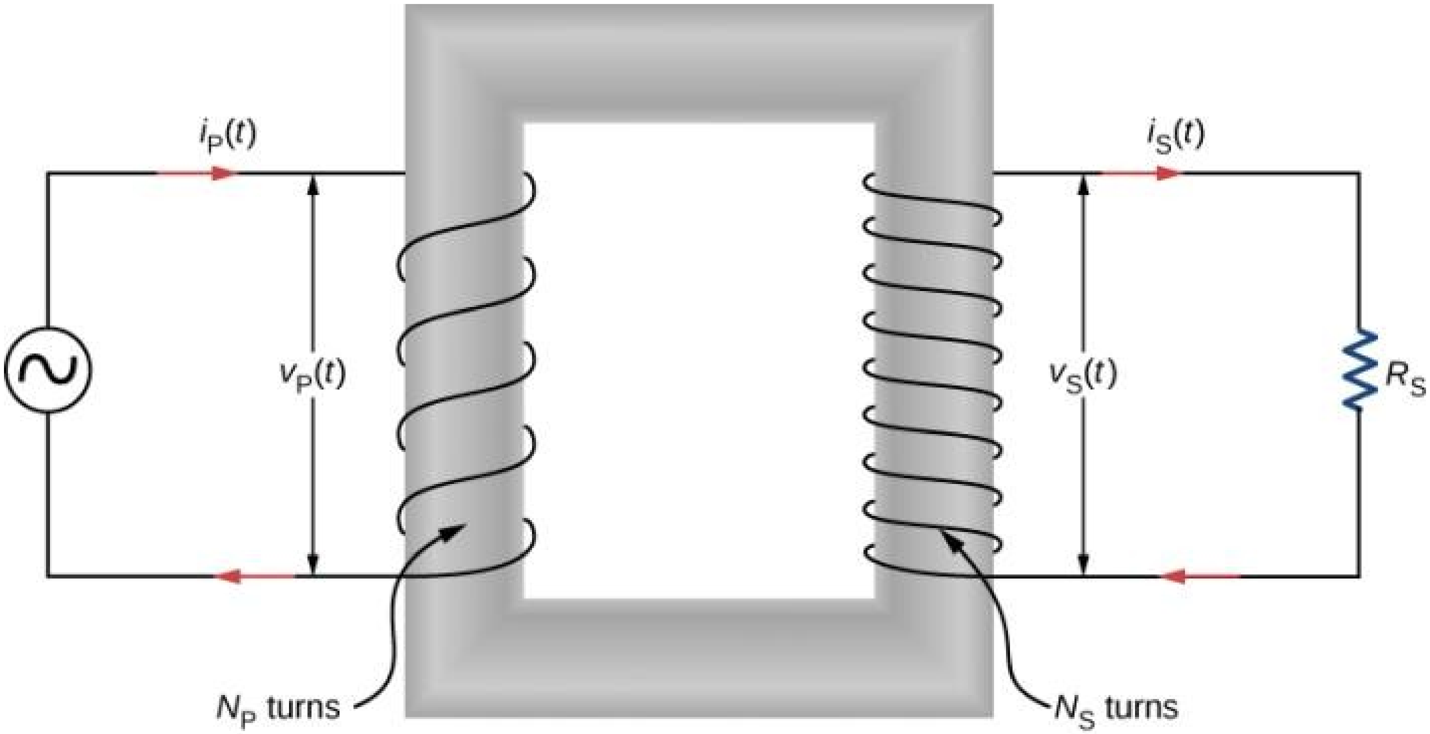
Transformers

FIGURE 15.20



The rms voltage from a power plant eventually needs to be stepped down from 12 kV to 240 V so that it can be safely introduced into a home. A high-voltage transmission line allows a low current to be transmitted via a substation over long distances.

FIGURE 15.22

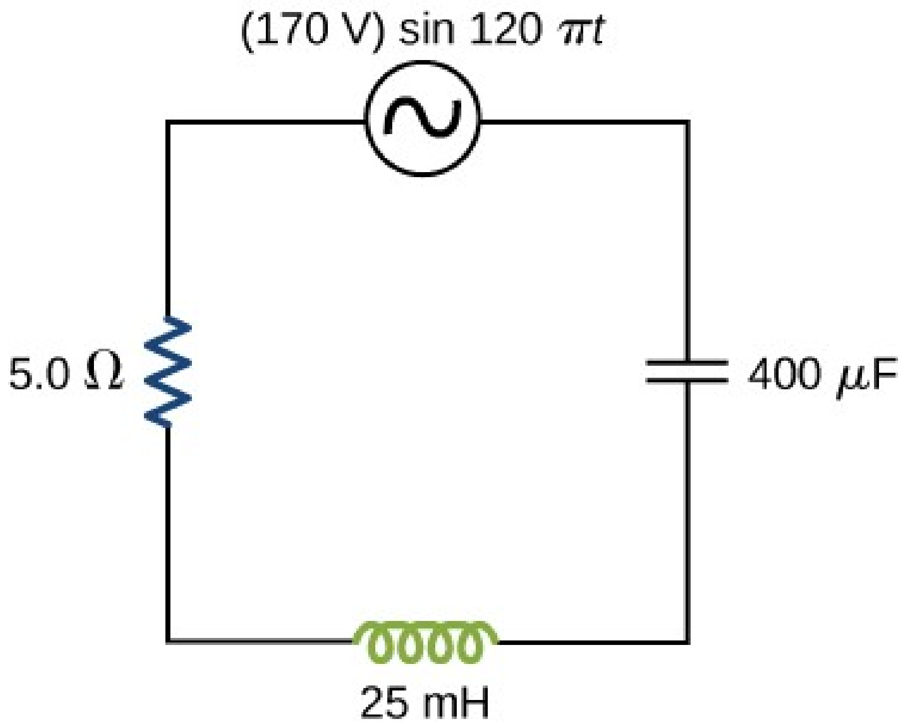


A step-up transformer (more turns in the secondary winding than in the primary winding). The two windings are wrapped around a soft iron core.

$$\frac{V_S}{V_P} = \frac{N_S}{N_P}$$

Examples

EXERCISE 29



A 1.5-kΩ resistor and 30-mH inductor are connected in series, as shown below, across a 120-V (rms) ac power source oscillating at 60-Hz frequency. (a) Find the current in the circuit. (b) Find the voltage drops across the resistor and inductor. (c) Find the impedance of the circuit. (d) Find the power dissipated in the resistor. (e) Find the power dissipated in the inductor. (f) Find the power produced by the source.

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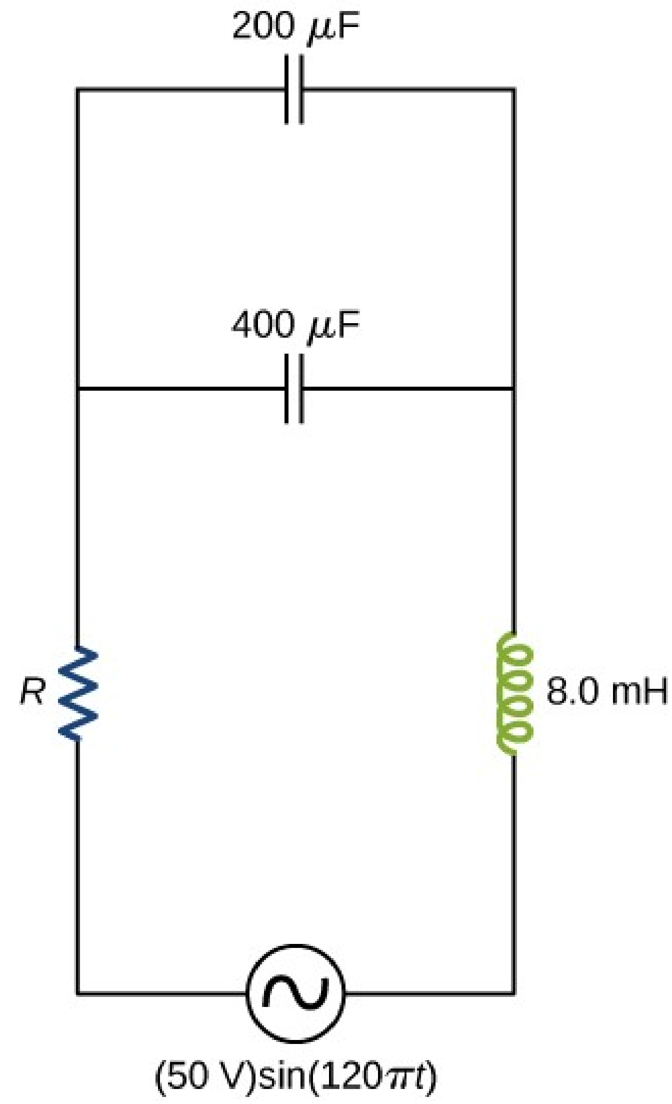
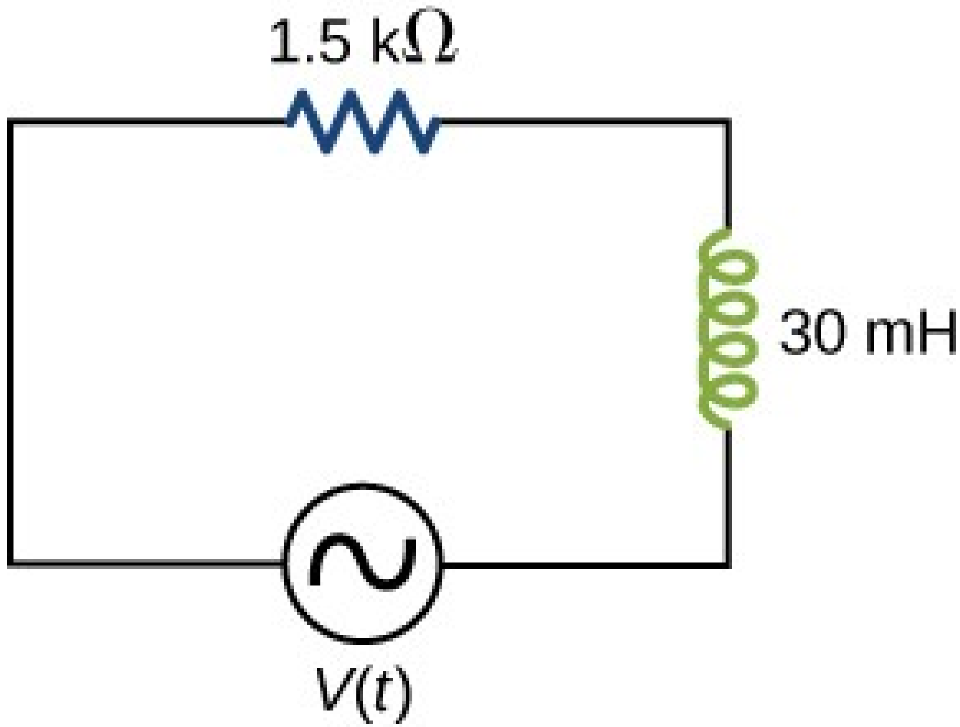
EXERCISE 55

What is the resistance R in the circuit shown below if the amplitude of the ac through the inductor is 4.24 A?



EXERCISE 62



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