Chapter 31

Alternating Current

PowerPoint® Lectures for
University Physics, Thirteenth Edition
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Goals for Chapter 31

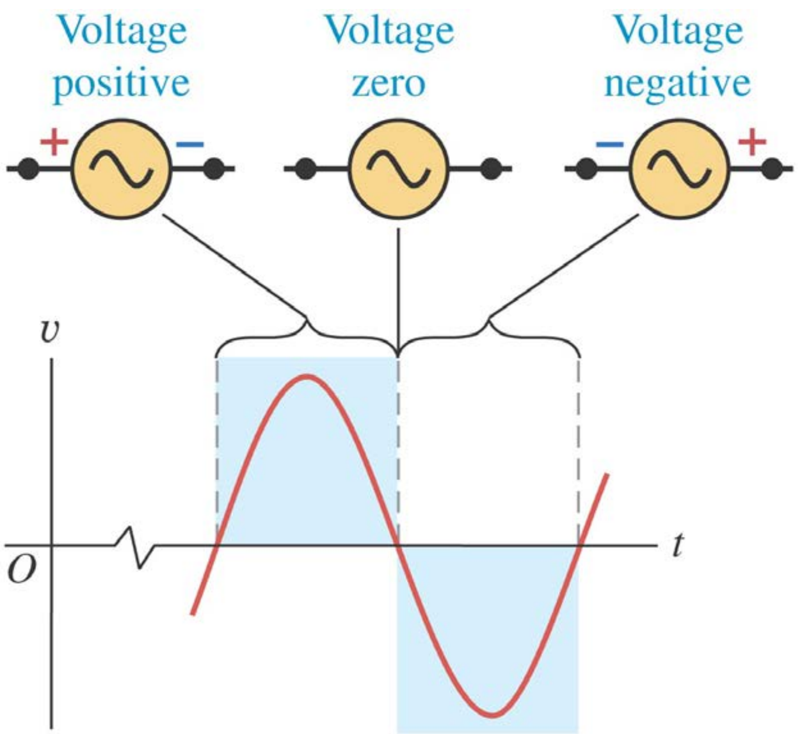
- To use phasors to describe sinusoidally varying quantities
- To use reactance to describe voltage in a circuit
- To analyze an *L*-*R*-*C* series circuit
- To determine power in ac circuits
- To see how an *L*-*R*-*C* circuit responds to frequency
- To learn how transformers work

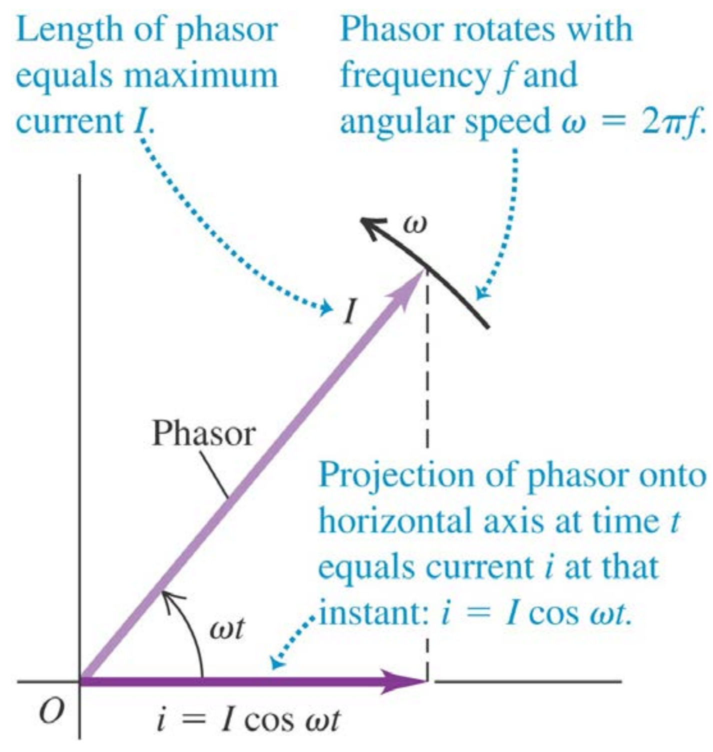
Introduction

- How does a radio tune to a particular station?
- How are ac circuits different from dc circuits?
- We shall see how resistors, capacitors, and inductors behave with a sinusoidally varying voltage source.

Phasors and alternating currents

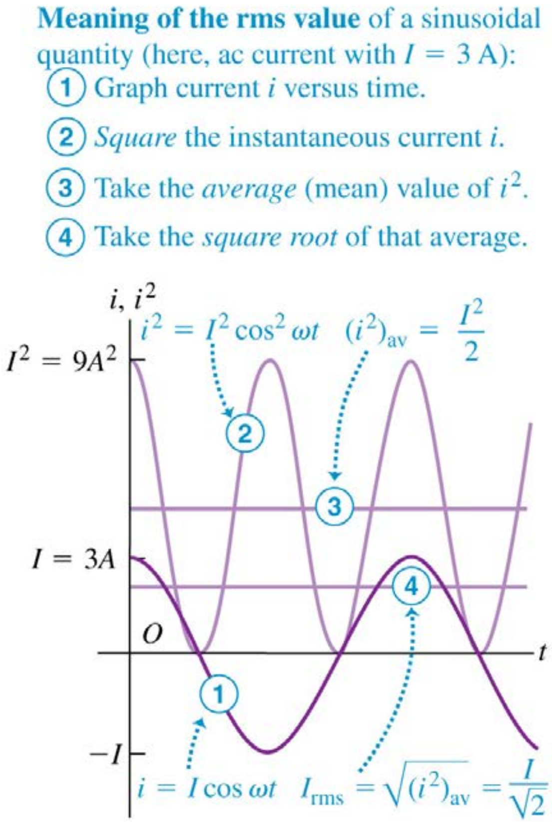
- Follow the text discussion of alternating current and phasors using Figures 31.1 (which shows ac voltage) and 31.2 (which shows a phasor diagram) below.

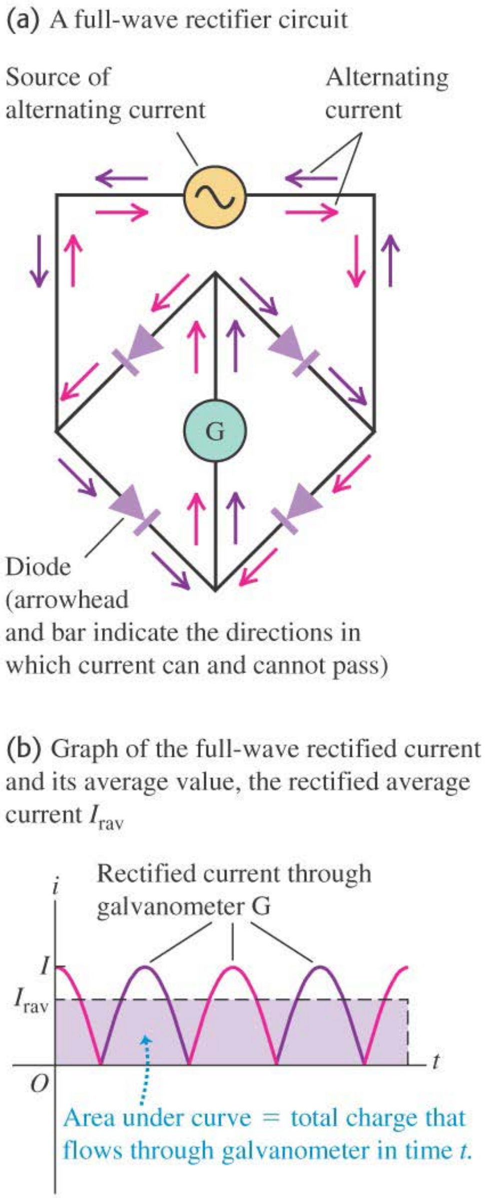




Root-mean-square values

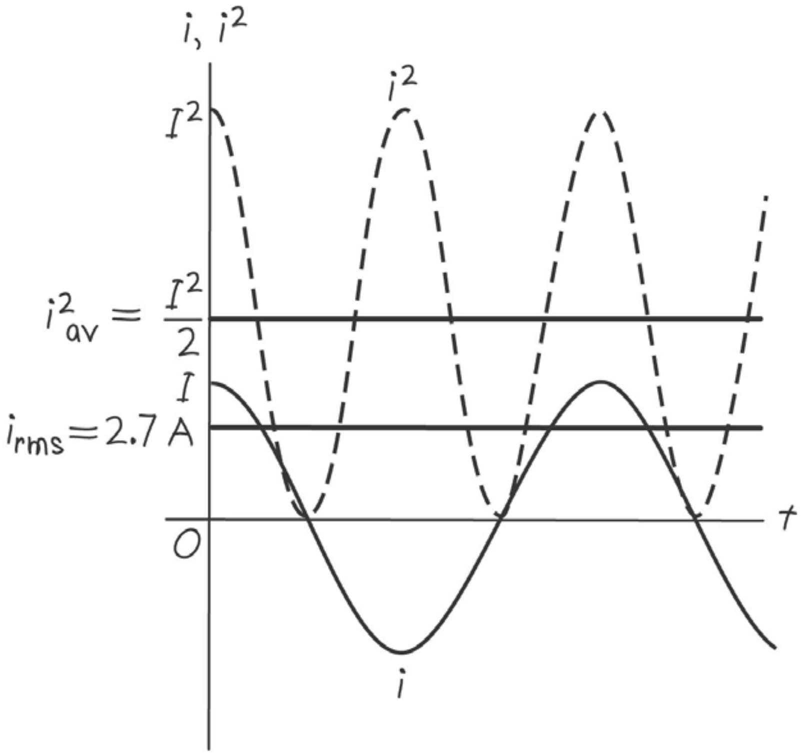
- Follow the text discussion of rectified alternating current, rms current, and rms voltage. Use Figures 31.3 (right) and 31.4 (below).





Current in a personal computer

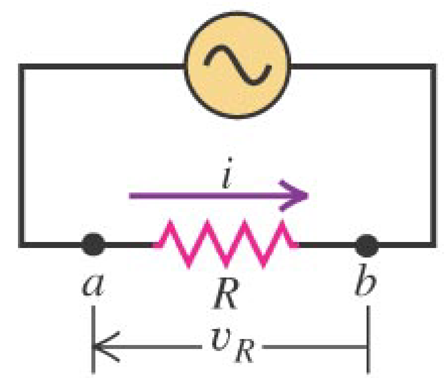
- Follow Example 31.1 using Figure 31.6 below.



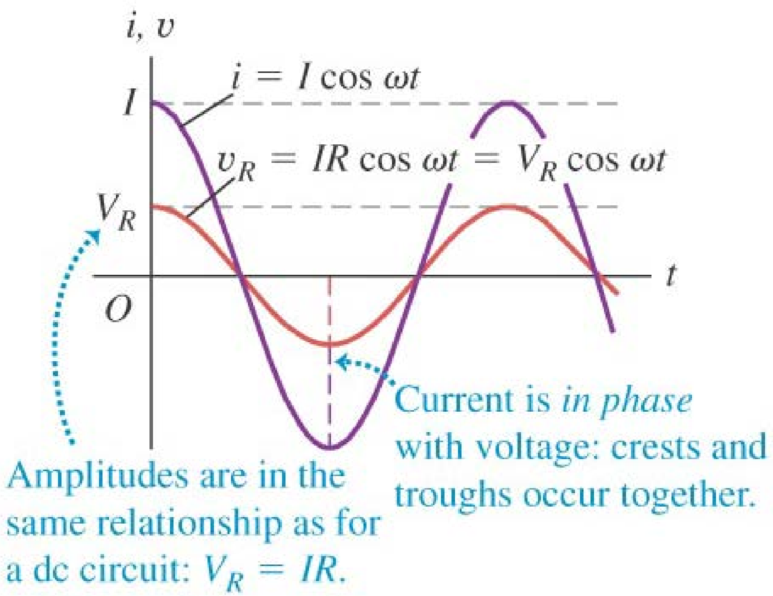
Resistor in an ac circuit

- Ohm's Law gives the voltage amplitude across a resistor: $V_R = IR$.
- Figure 31.7 shows the circuit, the current and voltage as functions of time, and a phasor.

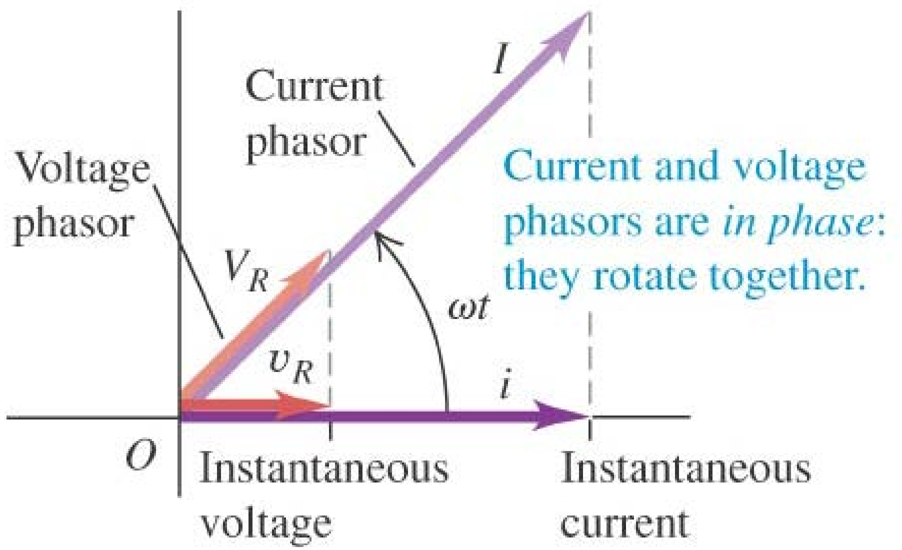
(a) Circuit with ac source and resistor



(b) Graphs of current and voltage versus time

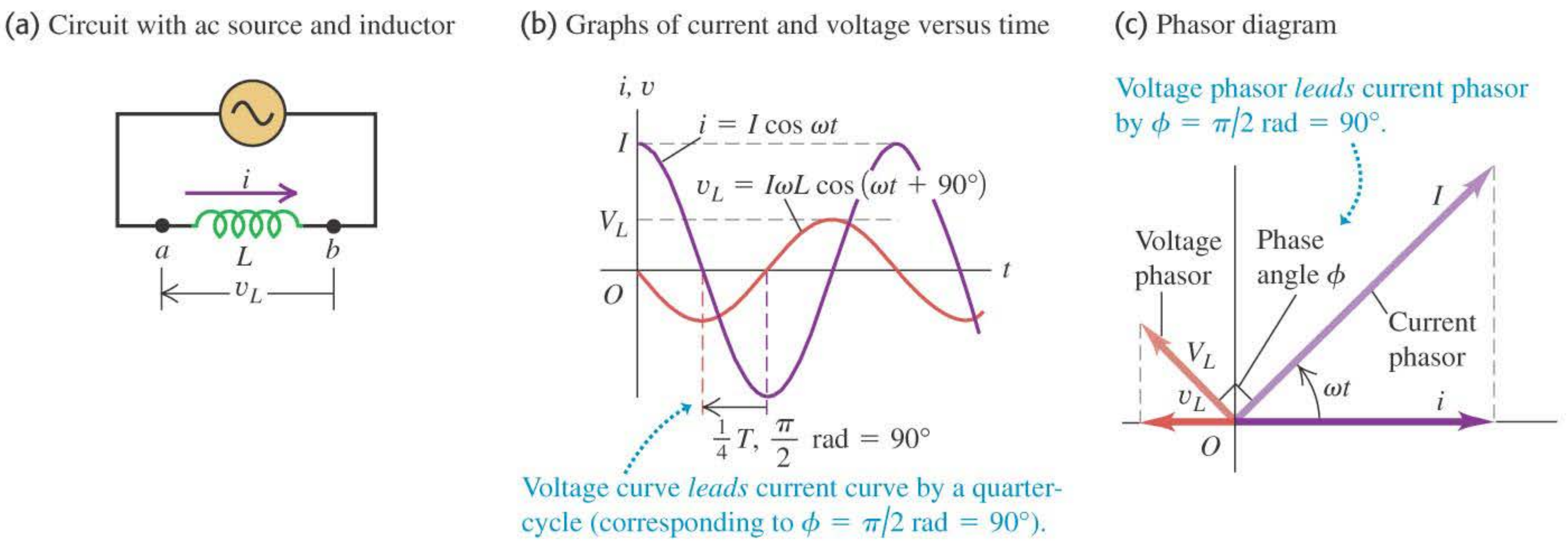


(c) Phasor diagram



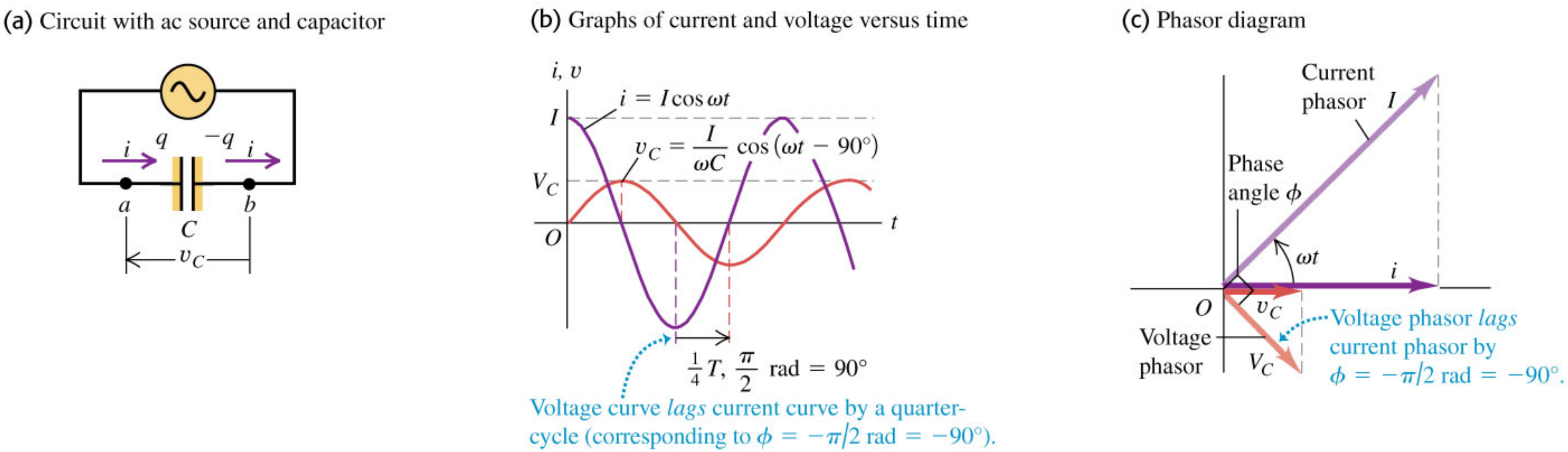
Inductor in an ac circuit

- Follow the text analysis of an inductor in an ac circuit using Figure 31.8 below. The voltage amplitude across the inductor is $V_L = IX_L$.
- Follow Example 31.2.



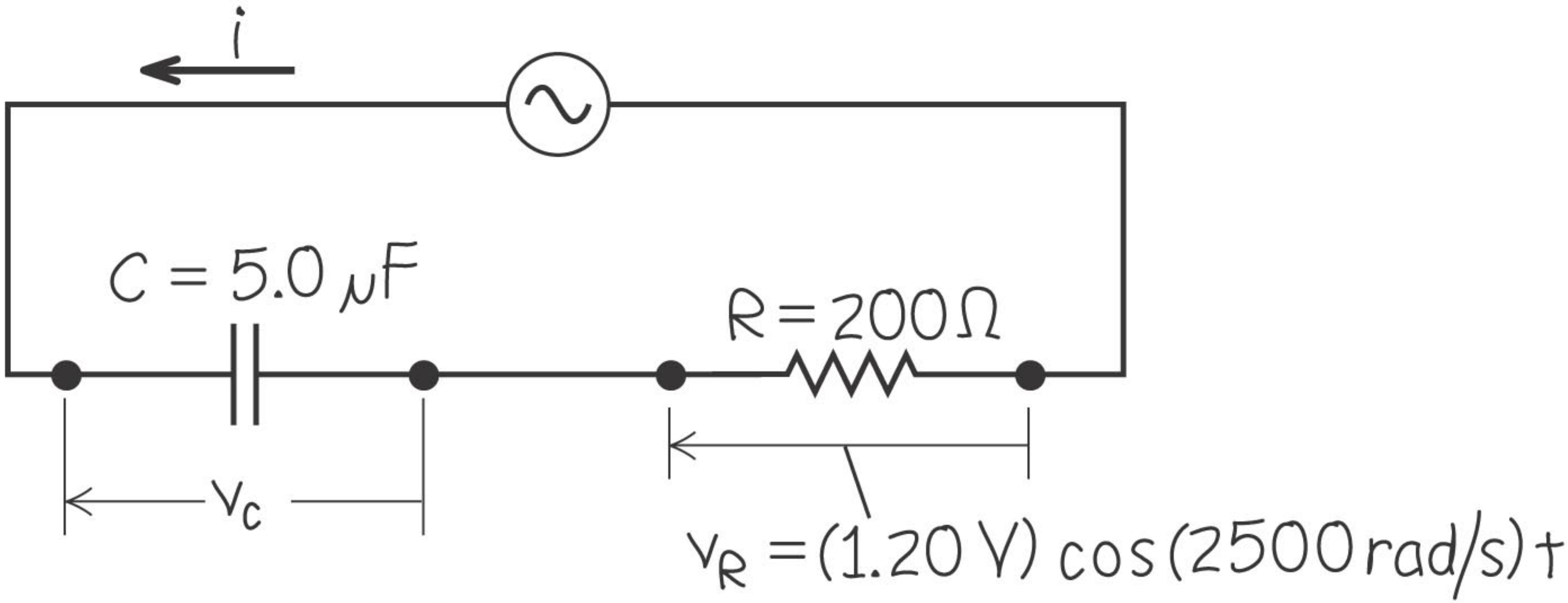
Capacitance in an ac circuit

- Follow the text analysis of a capacitor in an ac circuit using Figure 31.9 below. The voltage amplitude across the capacitor is $V_C = IX_C$.



A resistor and a capacitor in an ac circuit

- Follow Example 31.3, which combines a resistor and a capacitor in an ac circuit. Refer to Figure 31.10 below.



Comparing ac circuit elements

- Table 31.1 summarizes the characteristics of a resistor, an inductor, and a capacitor in an ac circuit.
- Figure 31.11 (below) shows graphs of resistance and reactance.

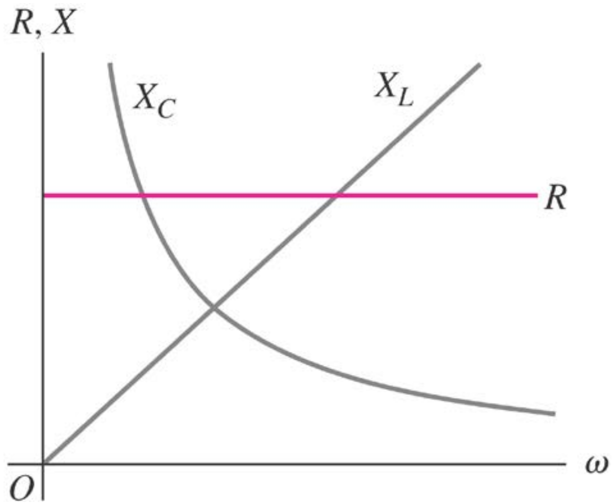


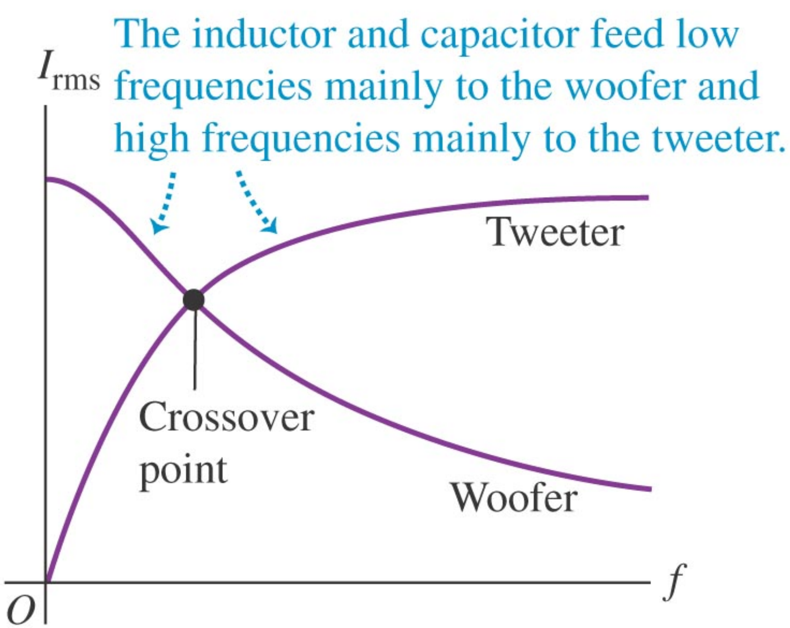
Table 31.1 Circuit Elements with Alternating Current

Circuit Element	Amplitude Relationship	Circuit Quantity	Phase of v
Resistor	$V_R = IR$	R	In phase with i
Inductor	$V_L = IX_L$	$X_L = \omega L$	Leads i by 90°
Capacitor	$V_C = IX_C$	$X_C = 1/\omega C$	Lags i by 90°

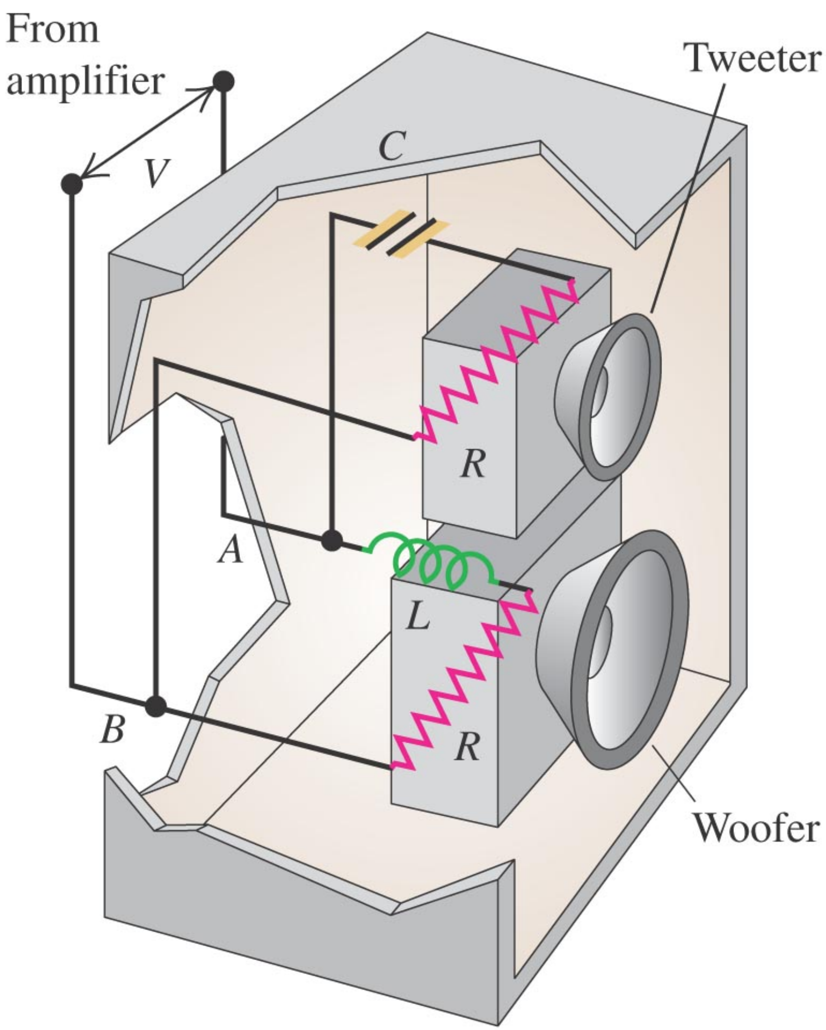
A useful application: the loudspeaker

- The woofer (low tones) and the tweeter (high tones) are connected in parallel across the amplifier output. (See Figure 31.12 shown here.)

Graphs of rms current as functions of frequency for a given amplifier voltage

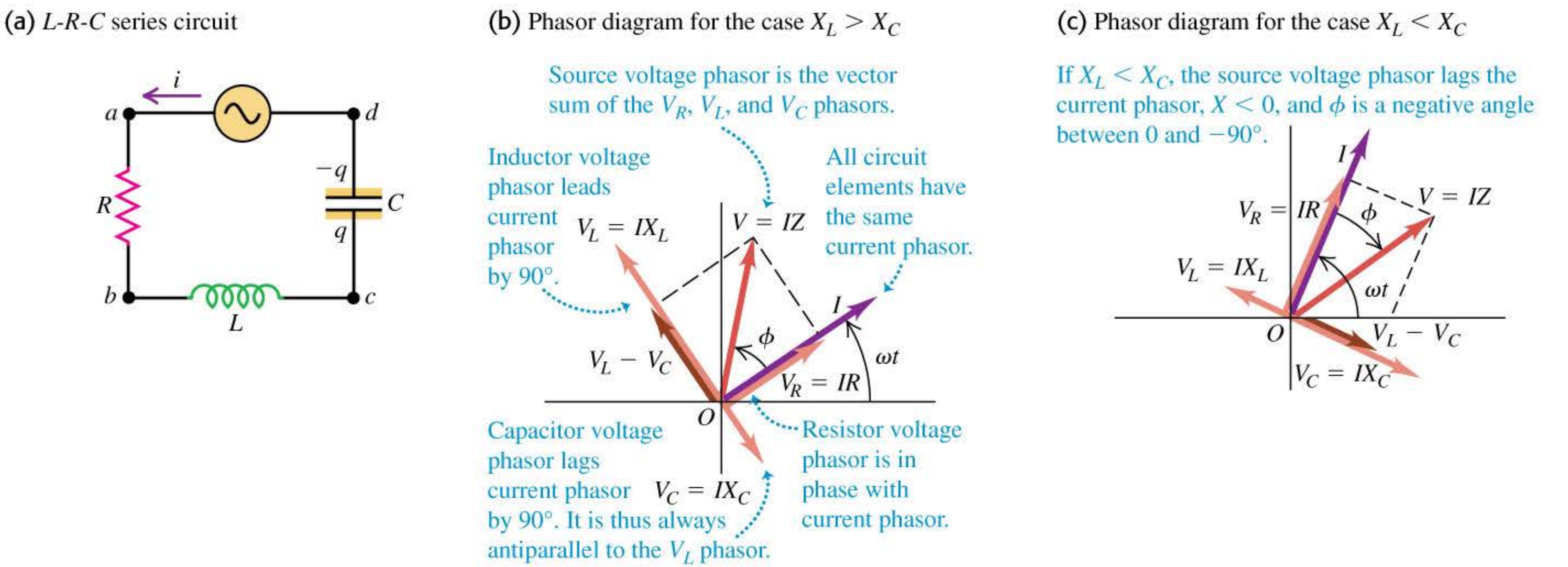


A crossover network in a loudspeaker system



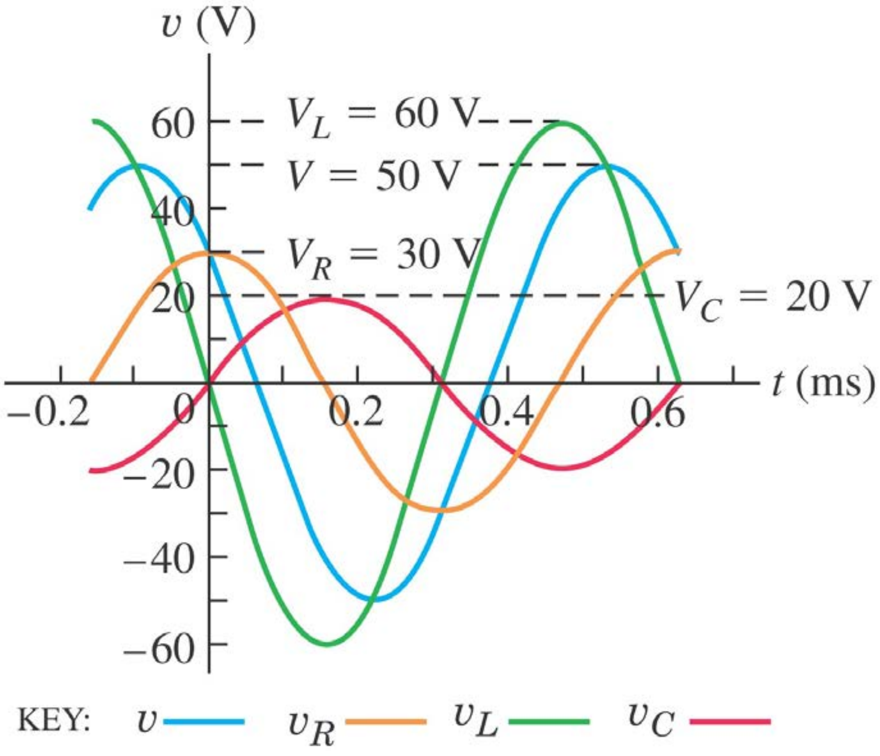
The *L-R-C* series circuit

- Follow the text analysis of the *L-R-C* series circuit, including impedance and phase angle, using Figure 31.13 below.
- The voltage amplitude across an ac circuit is $V = IZ$.



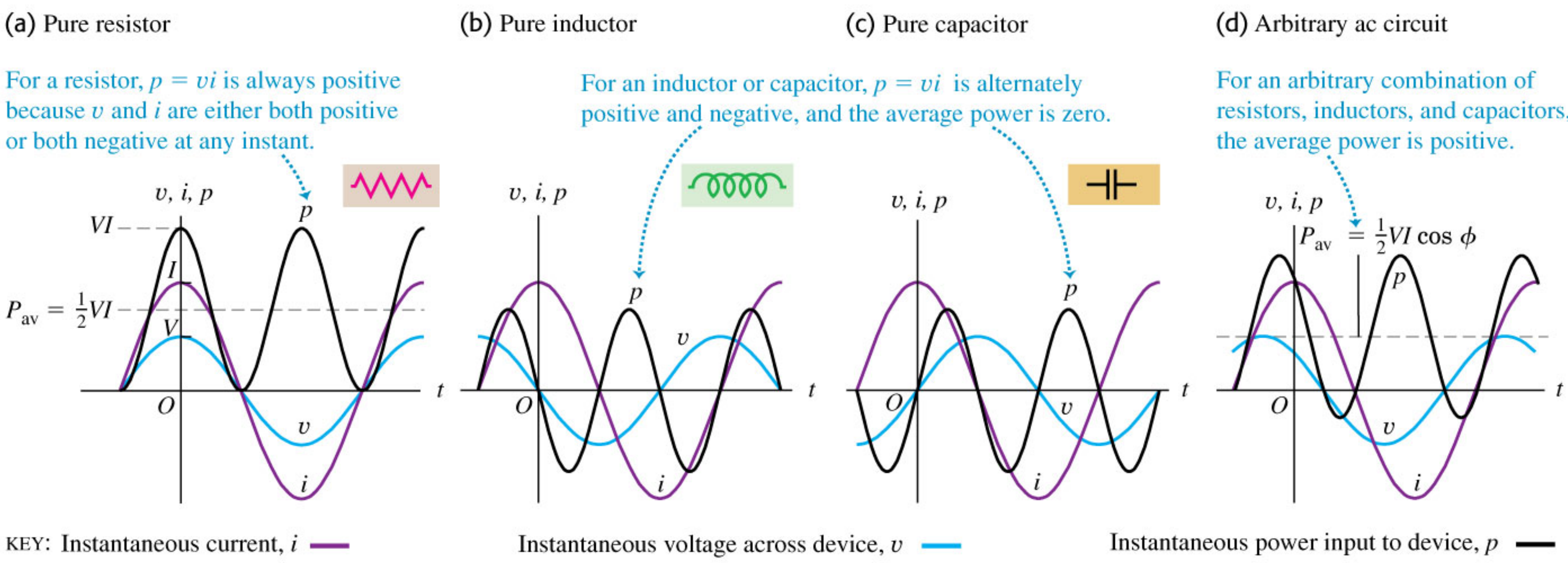
An *L-R-C* series circuit

- Read Problem-Solving Strategy 31.1.
- Follow Example 31.4.
- Follow Example 31.5 using Figure 31.15 at the right.



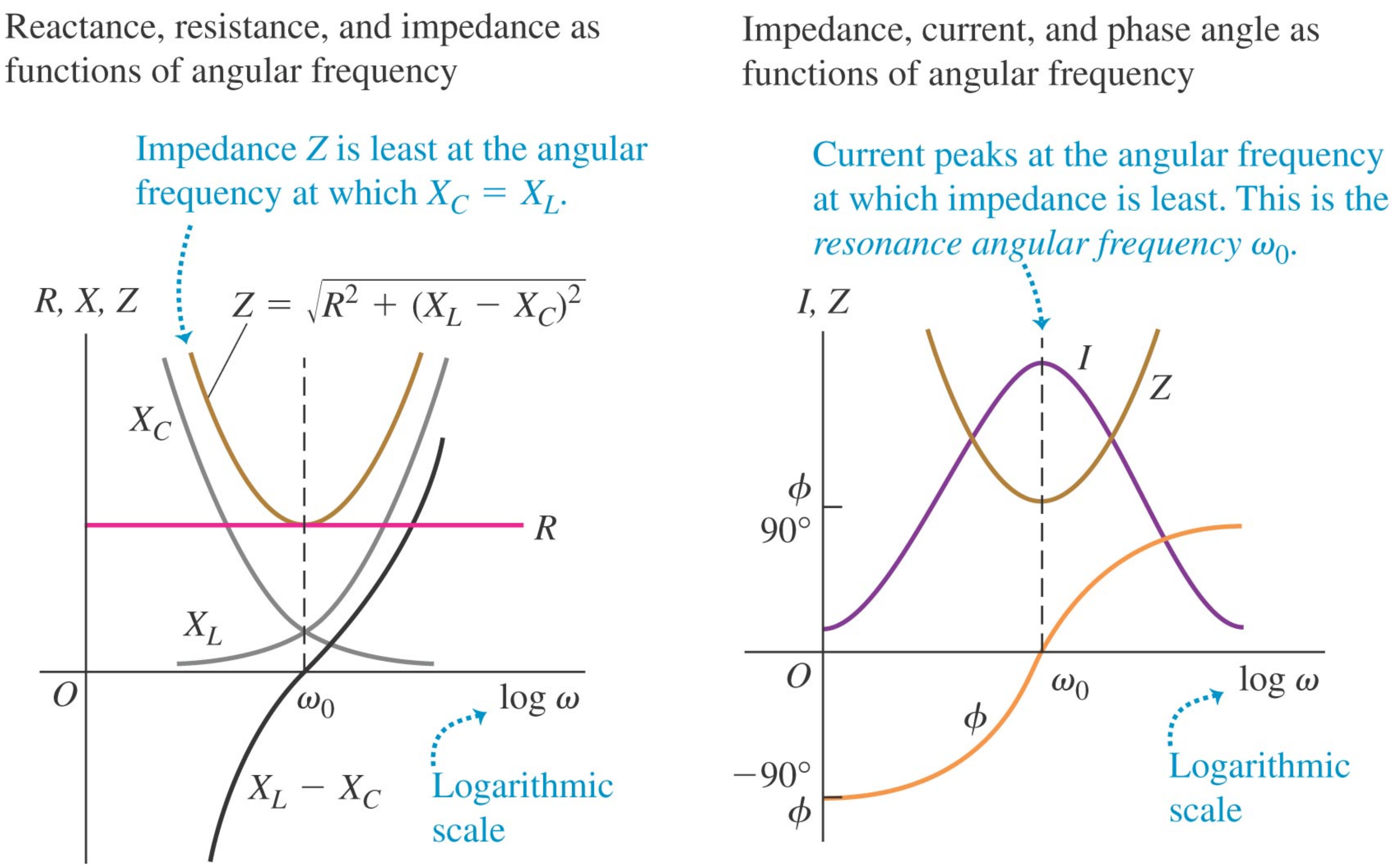
Power in ac circuits

- Follow the text discussion of power in alternating-current circuits using Figure 31.16 below.
- Note that the net energy transfer over one cycle is zero for an inductor and a capacitor.
- Follow Example 31.6 and Example 31.7.



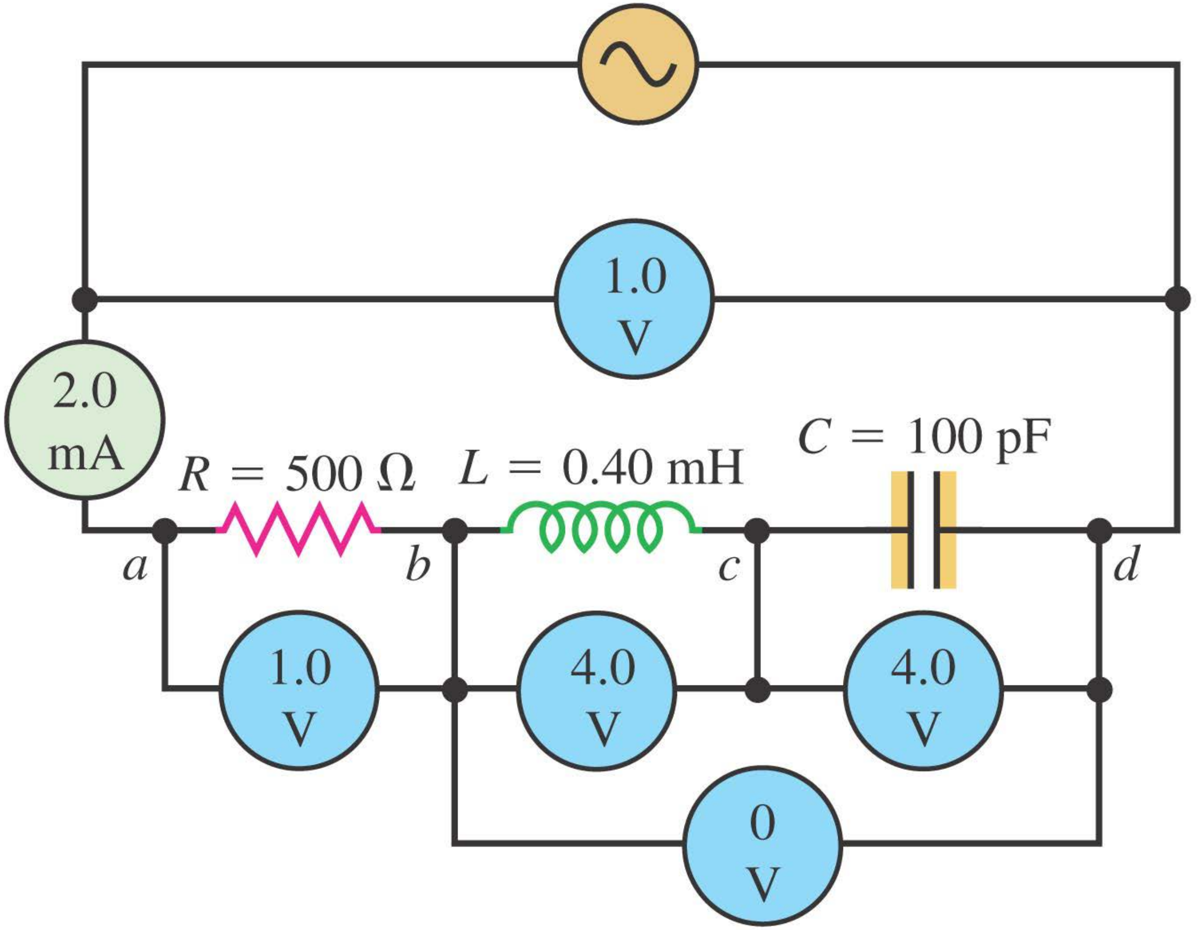
Resonance in ac circuits

- At the *resonance angular frequency* ω_0, the inductive reactance equals the capacitive reactance and the current amplitude is greatest. (See Figure 31.18 below.)



Tuning a radio

- Follow Example 31.8 using Figure 31.20 below.

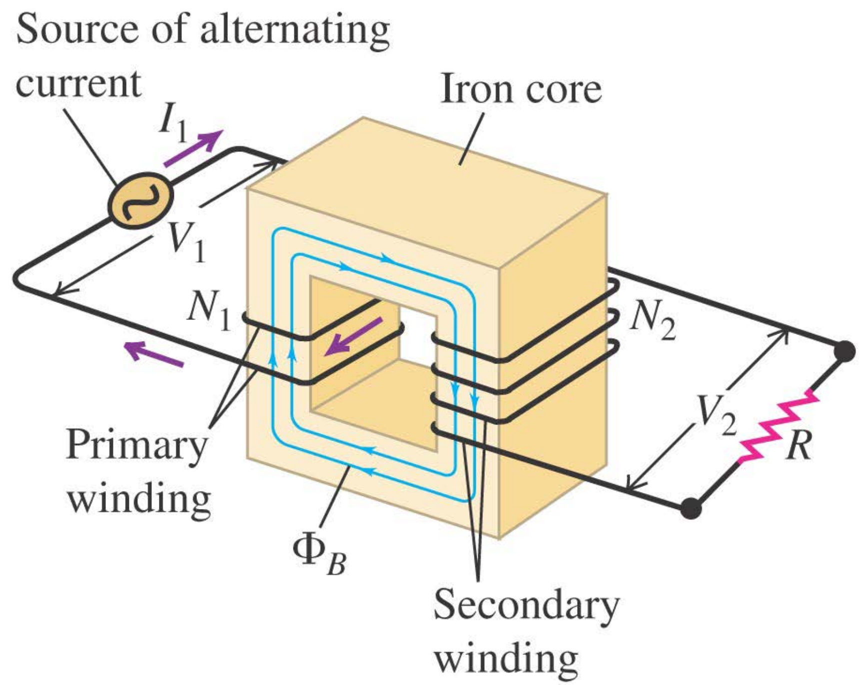


Transformers

- Power is supplied to the *primary* and delivered from the *secondary*. See Figure 31.21 at the right.
- Terminal voltages:
  $V_2/V_1 = N_2/N_1$.
- Currents in primary and secondary:
  $V_1 I_1 = V_2 I_2$.

The induced emf *per turn* is the same in both coils, so we adjust the ratio of terminal voltages by adjusting the ratio of turns:

$$\frac{V_2}{V_1} = \frac{N_2}{N_1}$$



Real transformers

- Real transformers always have some power losses, as illustrated in Figure 31.24 below.
- Follow Example 31.9.