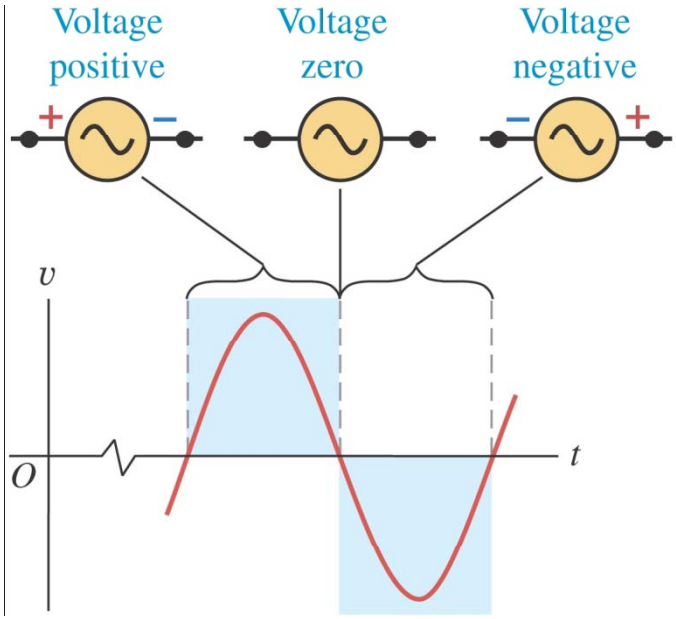
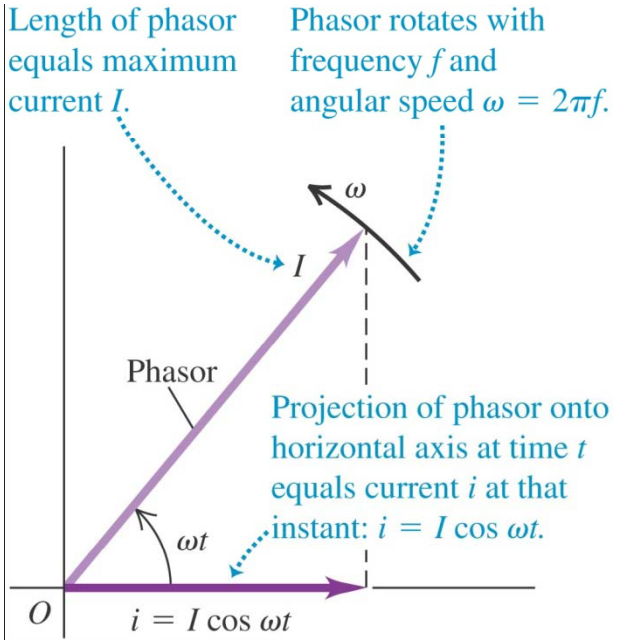
Chapter 31 – Alternating Current

AC power is what drives most of our electrical economy

AC current

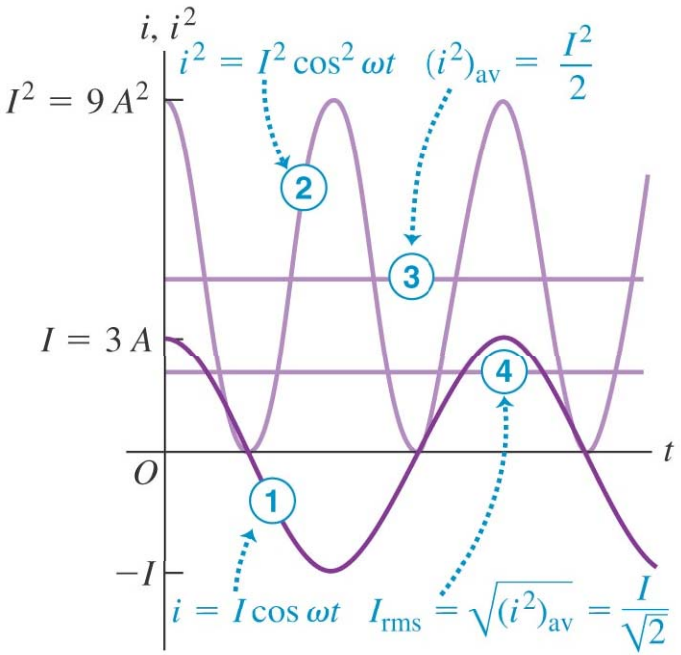

Voltage positive
Voltage zero
Voltage negative
+
−
−
+
v
O
t


Length of phasor equals maximum current I.
Phasor rotates with frequency f and angular speed ω = 2πf.
ω
I
Phasor
Projection of phasor onto horizontal axis at time t equals current i at that instant: i = I cos ωt.
ωt
O
i = I cos ωt

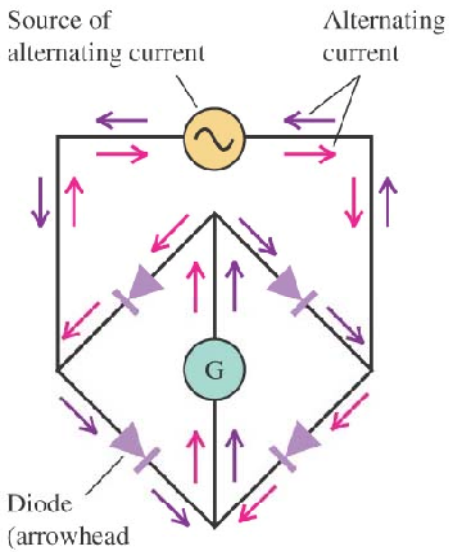
A full-wave rectifier circuit

Meaning of the rms value of a sinusoidal quantity (here, ac current with $I = 3$ A):

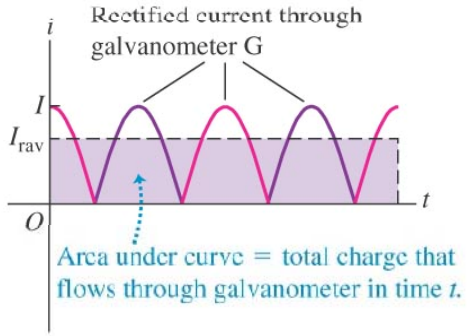
1. Graph current i versus time.
2. *Square* the instantaneous current i.
3. Take the *average* (mean) value of i^2.
4. Take the *square root* of that average.



(a) A full-wave rectifier circuit

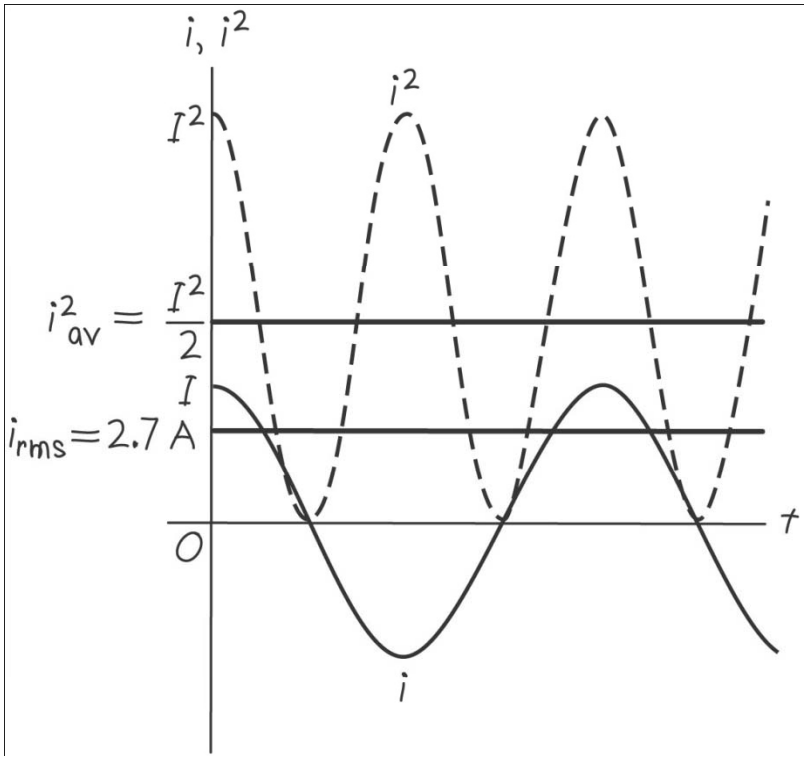


(b) Graph of the full-wave rectified current and its average value, the rectified average current I_{rav}



Current in the device I'm using right now

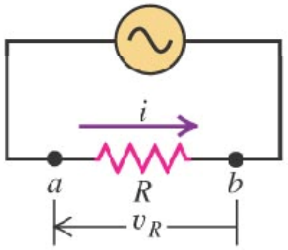
- A desktop PC draws current from a plug to the wall, but what are the details?



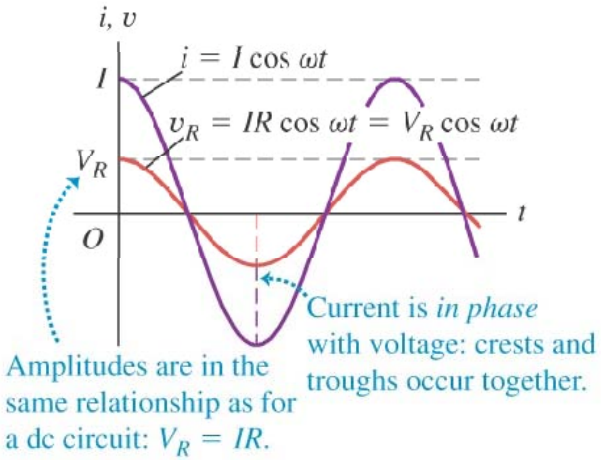
Resistors in an AC circuit

- Ohm's Law applied in oscillatory fashion.

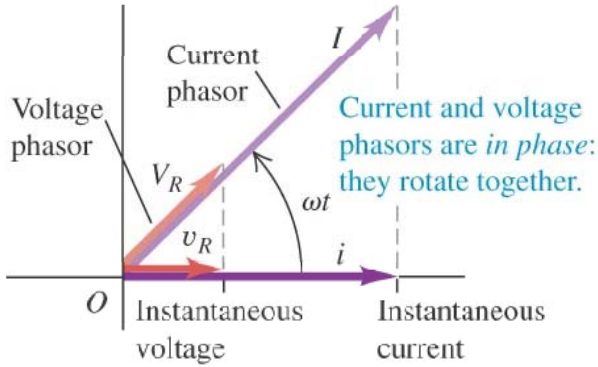
(a) Circuit with ac source and resistor



(b) Graphs of current and voltage versus time



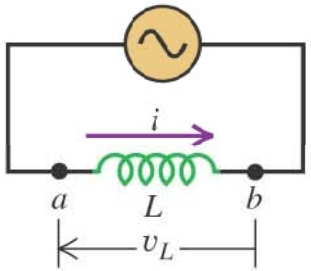
(c) Phasor diagram



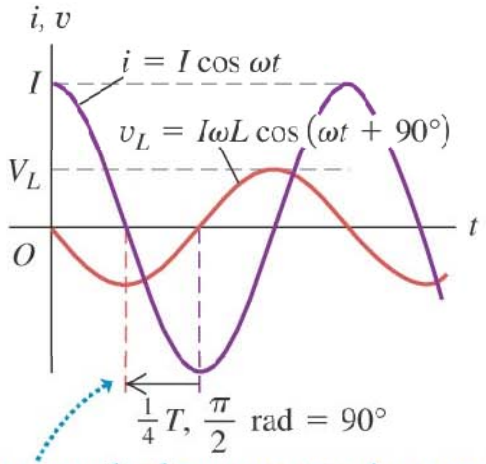
Inductors in an AC circuit

- Replace the resistor in the previous slide with an inductor.

(a) Circuit with ac source and inductor



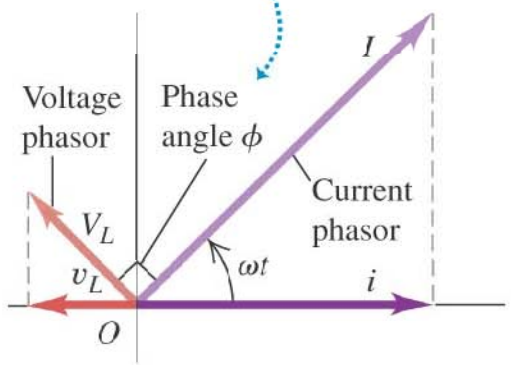
(b) Graphs of current and voltage versus time



Voltage curve *leads* current curve by a quarter-cycle (corresponding to $\phi = \pi/2$ rad = 90°).

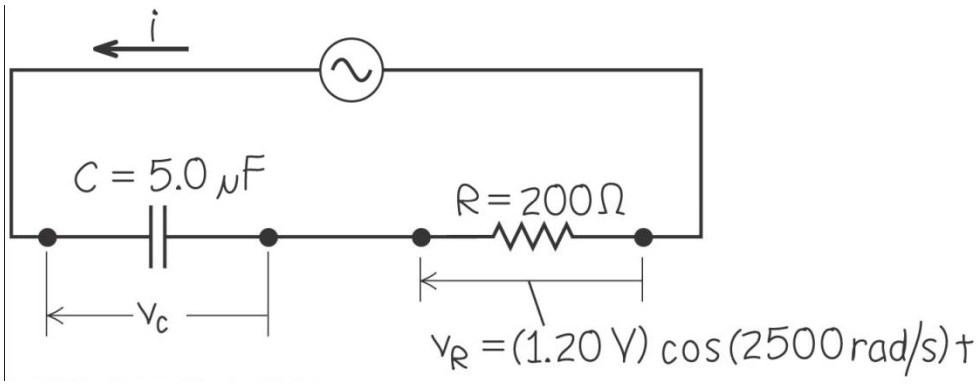
(c) Phasor diagram

Voltage phasor *leads* current phasor by $\phi = \pi/2$ rad = 90°.

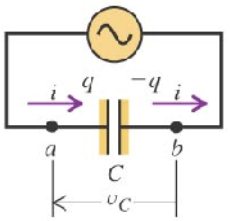


Capacitance in an AC circuit

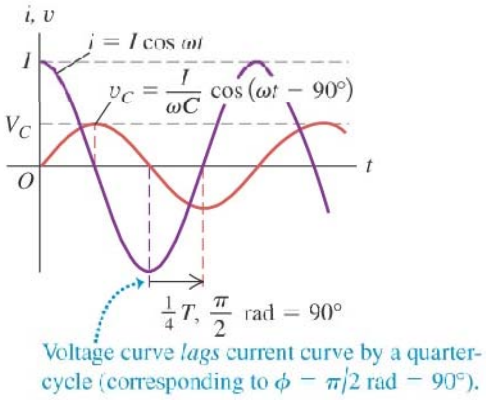
- Because this is a series circuit, the current is the same through the capacitor as through the resistor just considered.



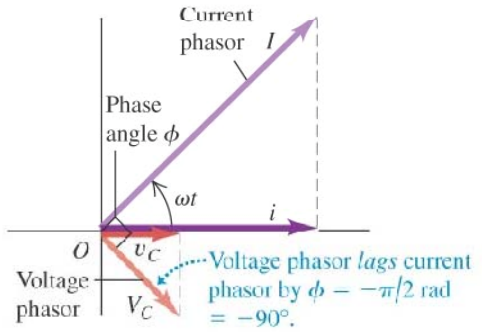
(a) Circuit with ac source and capacitor



(b) Graphs of current and voltage versus time



(c) Phasor diagram



Comparing AC circuit elements

- Summary of circuit elements.
- Frequency dependence of reactance

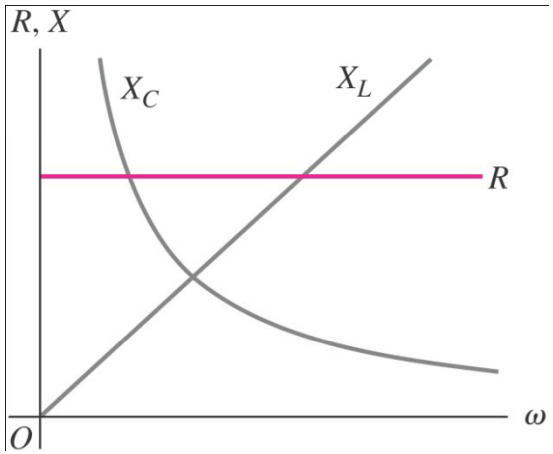


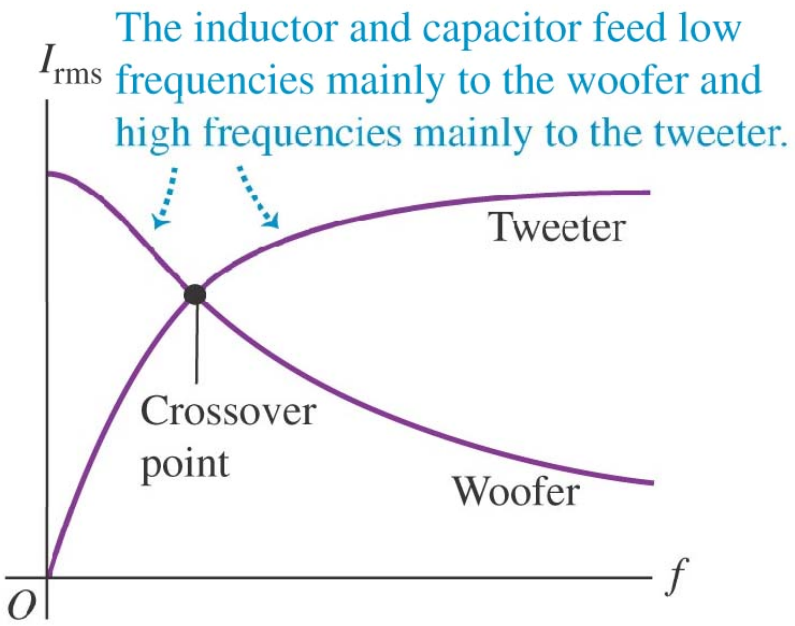
Table 31.1 Circuit Elements with Alternating Current

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°

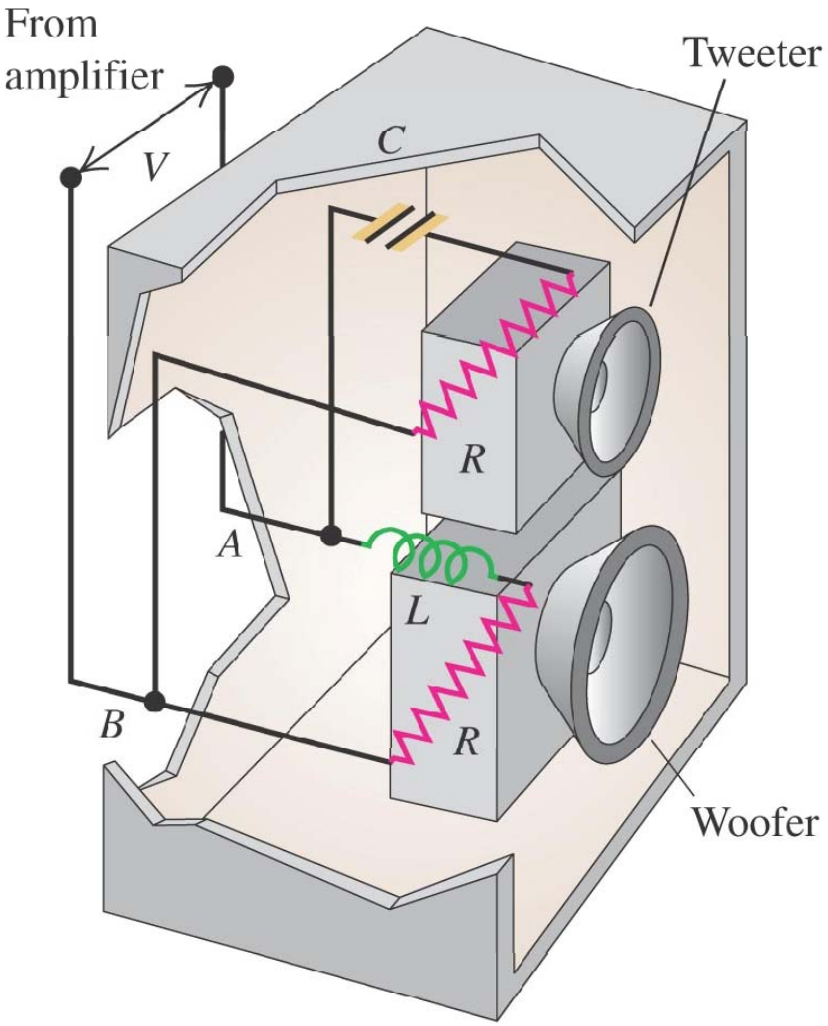
The loudspeaker, a useful application

- The woofer (low tones) and the tweeter (high tones) connect in parallel through a “crossover.”

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

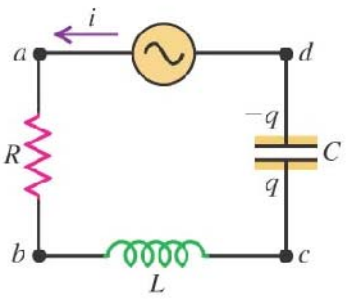


A crossover network in a loudspeaker system

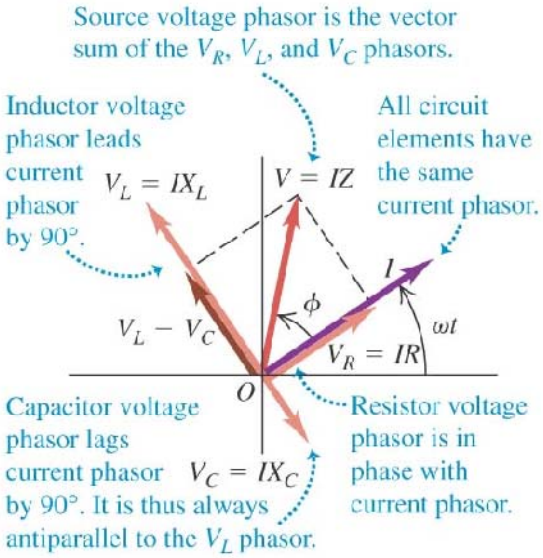


The L-R-C circuit

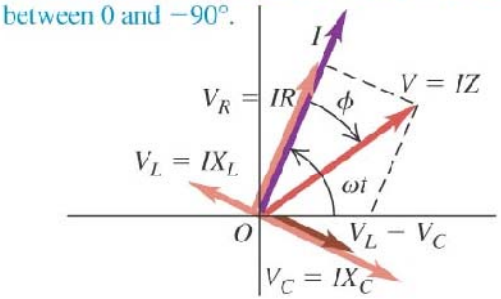
(a) Series *R-L-C* circuit



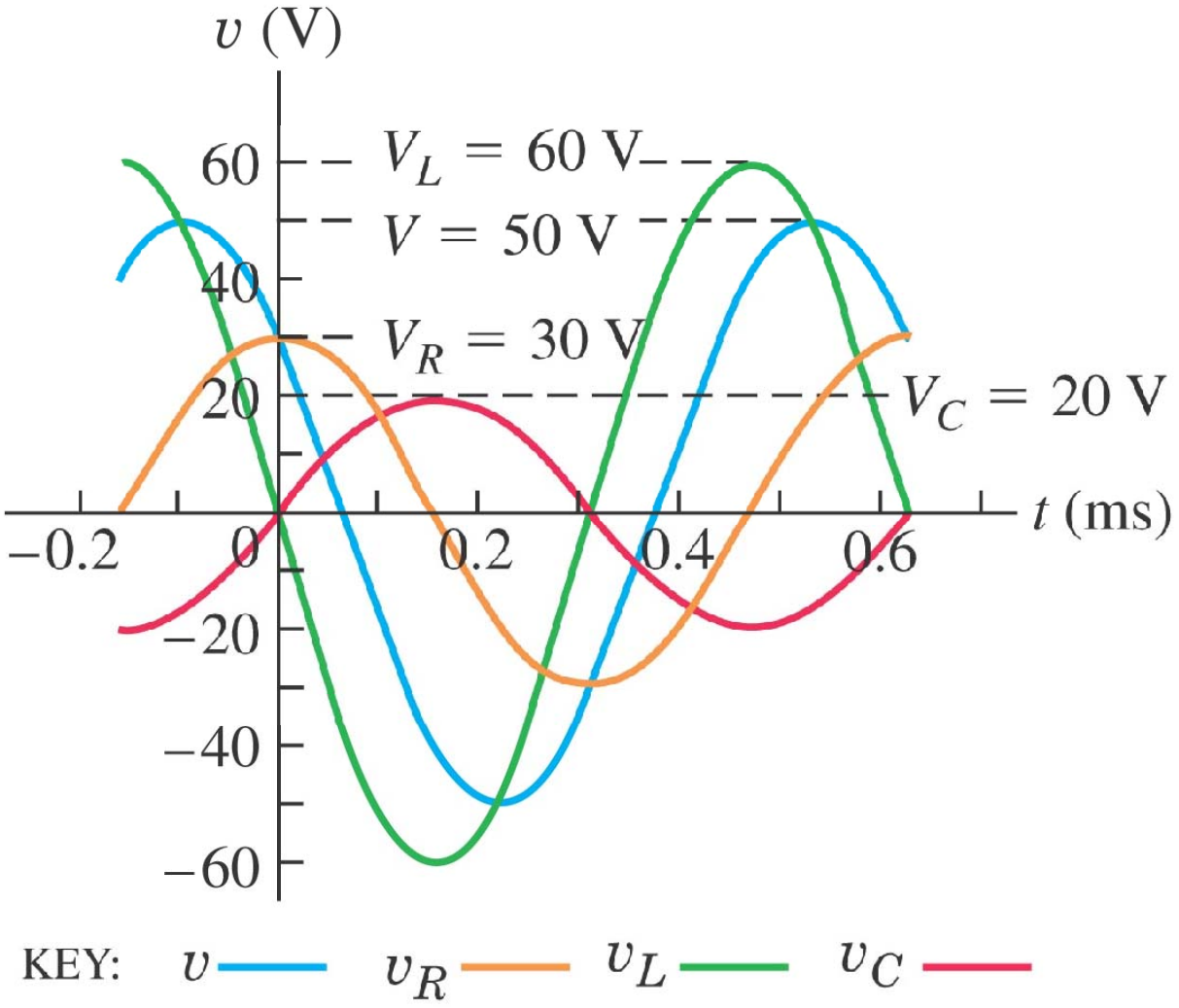
(b) Phasor diagram for the case $X_L > X_C$



(c) Phasor diagram for the case $X_L < X_C$

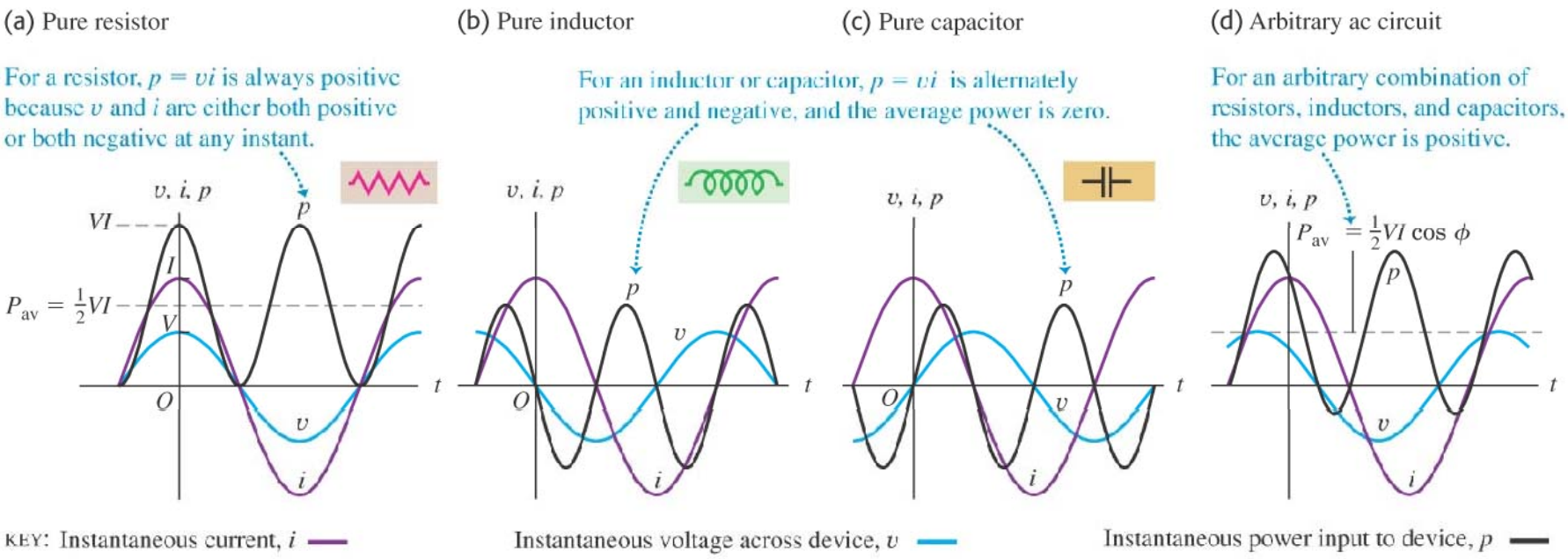


An L-R-C circuit II



Power in an inductor

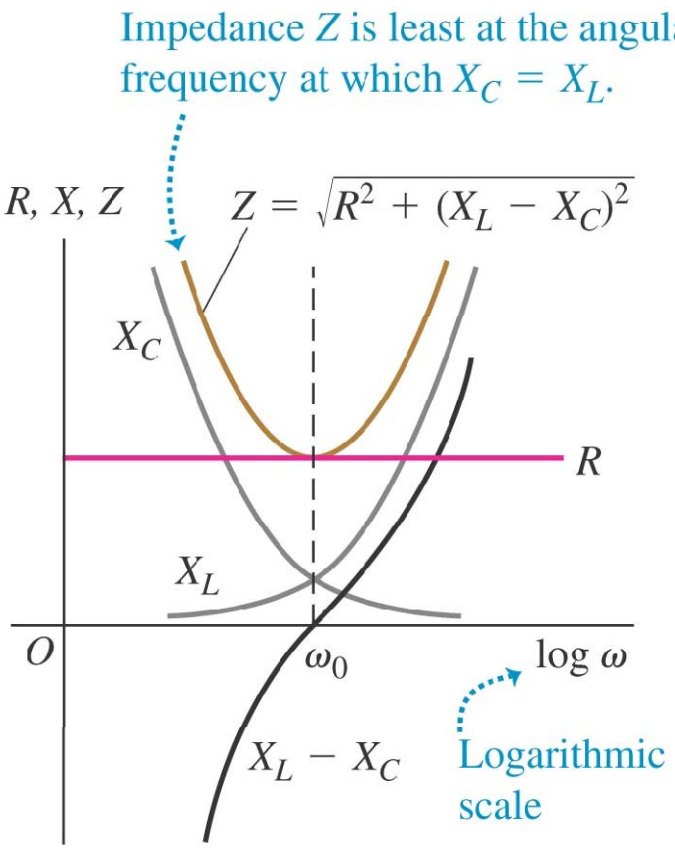
- Consider current, voltage, and power as functions of time.



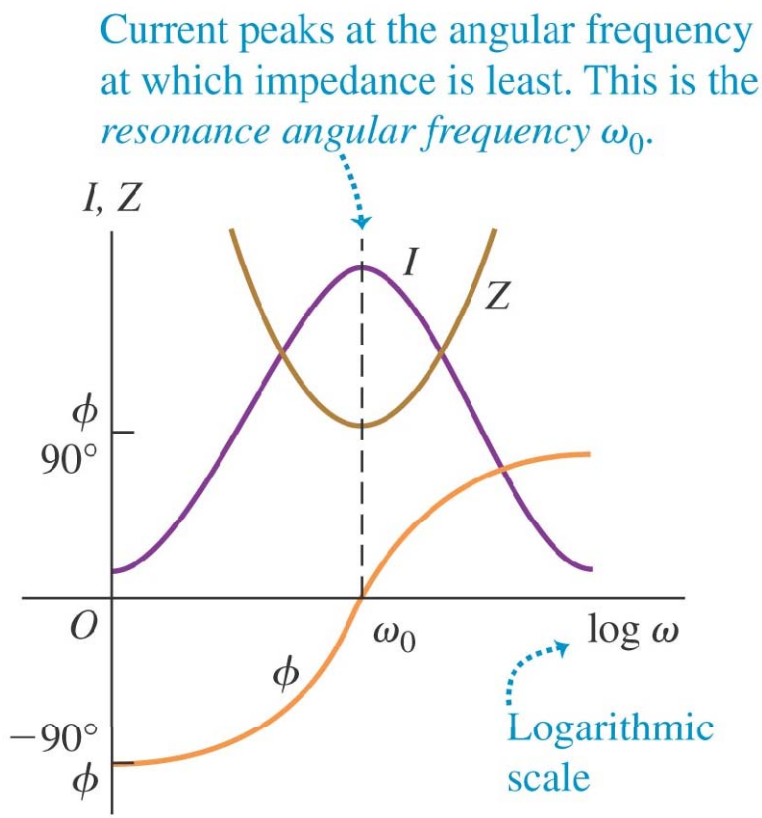
Circuit behavior at resonance

- Look at the maximum I when the impedance is a minimum.

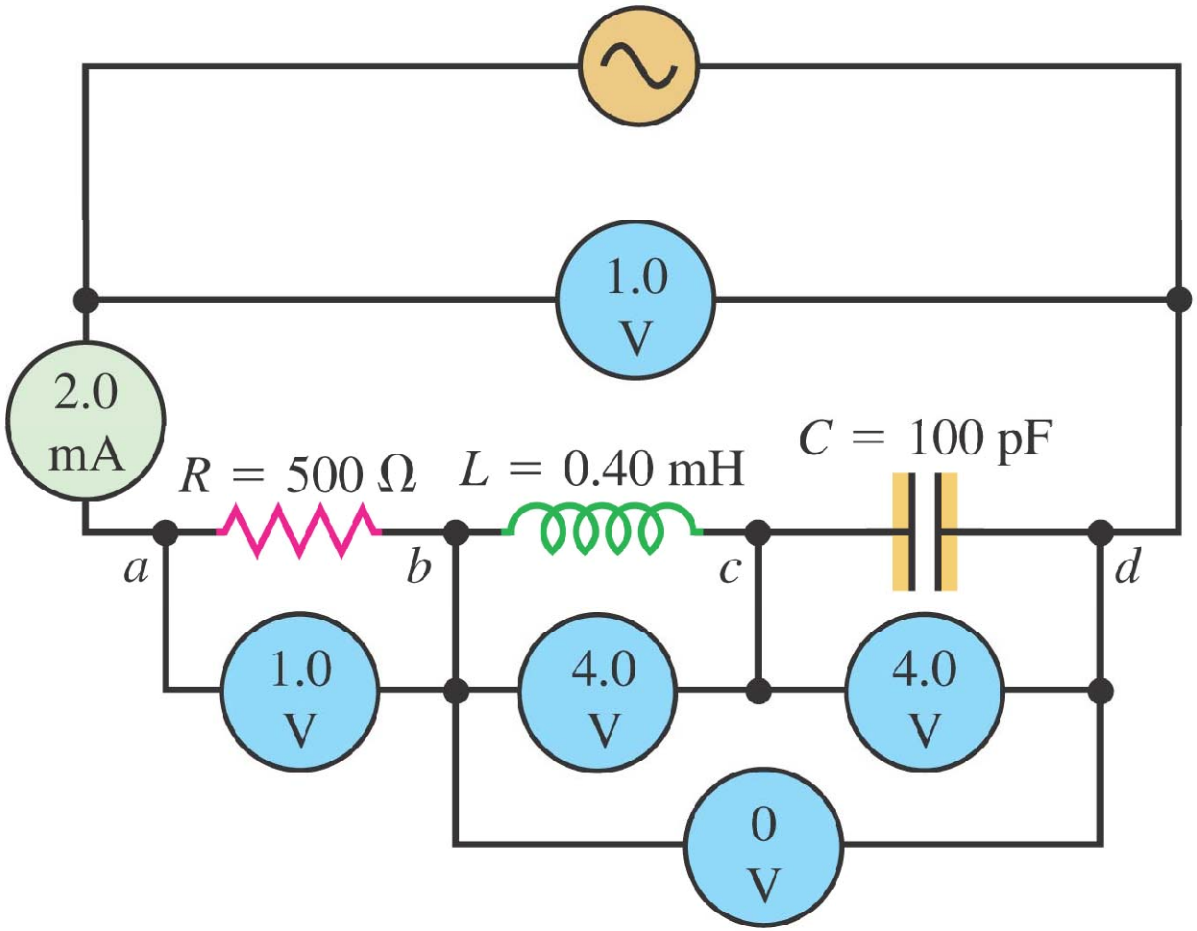
Reactance, resistance, and impedance as functions of angular frequency



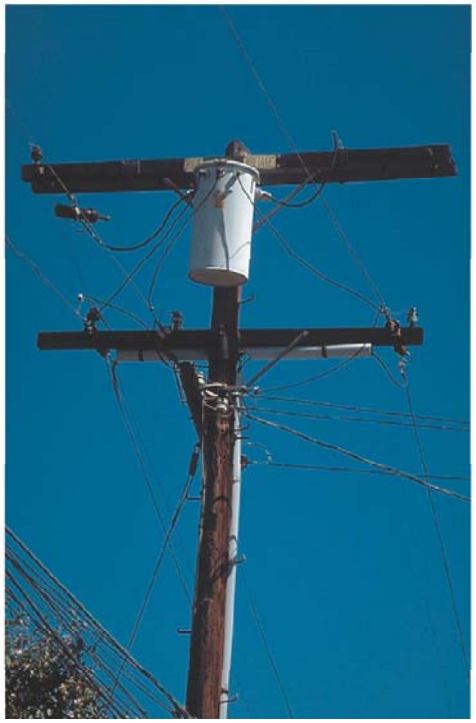
Impedance, current, and phase angle as functions of angular frequency



Tuning a radio

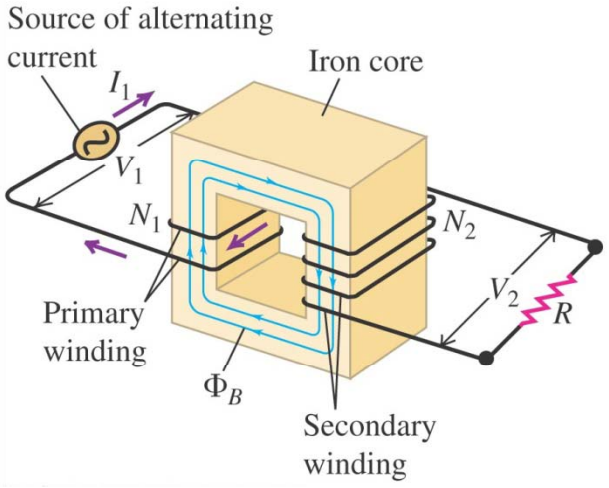


Transformers



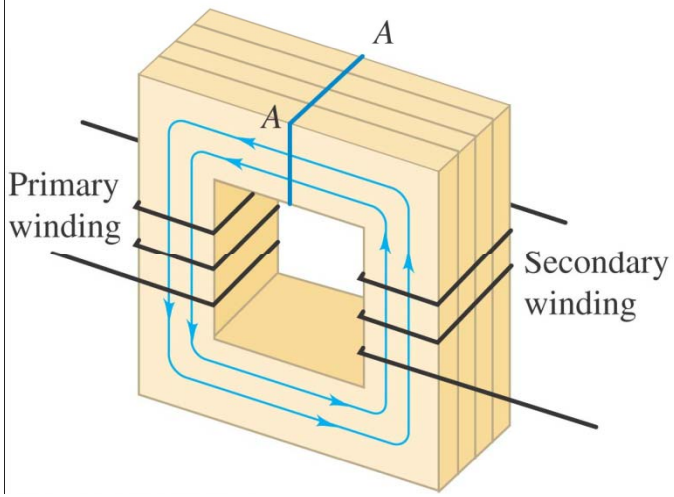
The induced emf *per turn* is the same in both coils, so we adjust the ratio of terminal voltages by adjusting the ratio of turns:

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

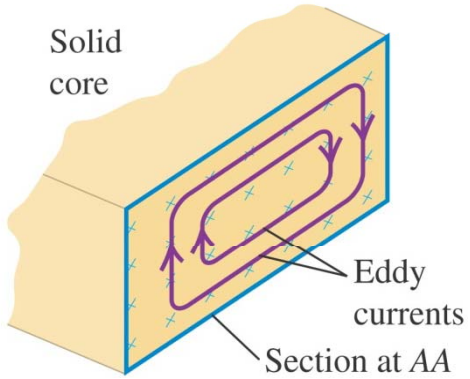


Transformers II

Schematic transformer



Large eddy currents in solid core



Smaller eddy currents in laminated core