Chapter 28: Alternating-Current Circuits
Tuesday November 8th

Mini-exam 5 next Thursday (AC circuits and EM waves)

- Review of Mini Exam 4
- Review of *LRC* circuits
    - Voltage/phase relations
    - Impedance
    - Resonance
    - Power in *LRC* circuits
- Example problem
- Transformers
- Maxwell's equations (Ch. 29 – if time)

Reading: up to page 515 in the text book (Ch. 28/29)

AC Circuits and R, L and C: a Summary

Table 28.1 Amplitude and Phase Relations in Circuit Elements

Circuit Element	Peak Current versus Voltage	Phase Relation
Resistor	$I_p = \dfrac{V_p}{R}$	V and I in phase
Capacitor	$I_p = \dfrac{V_p}{X_C} = \dfrac{V_p}{1/\omega C}$	I leads V by 90°
Inductor	$I_p = \dfrac{V_p}{X_L} = \dfrac{V_p}{\omega L}$	V leads I by 90°

Capacitive reactance: $X_C = 1/\omega C$ (units - Ω)

Inductive reactance: $X_L = \omega L$ (units - Ω)

Phasor Diagrams: Adding the Voltages

$$V_{\mathrm{p}} = \sqrt{I_{\mathrm{p}} R^2 + \left(I_{\mathrm{p}} X_L - I_{\mathrm{p}} X_C\right)^2}$$

Modified Ohm's law:

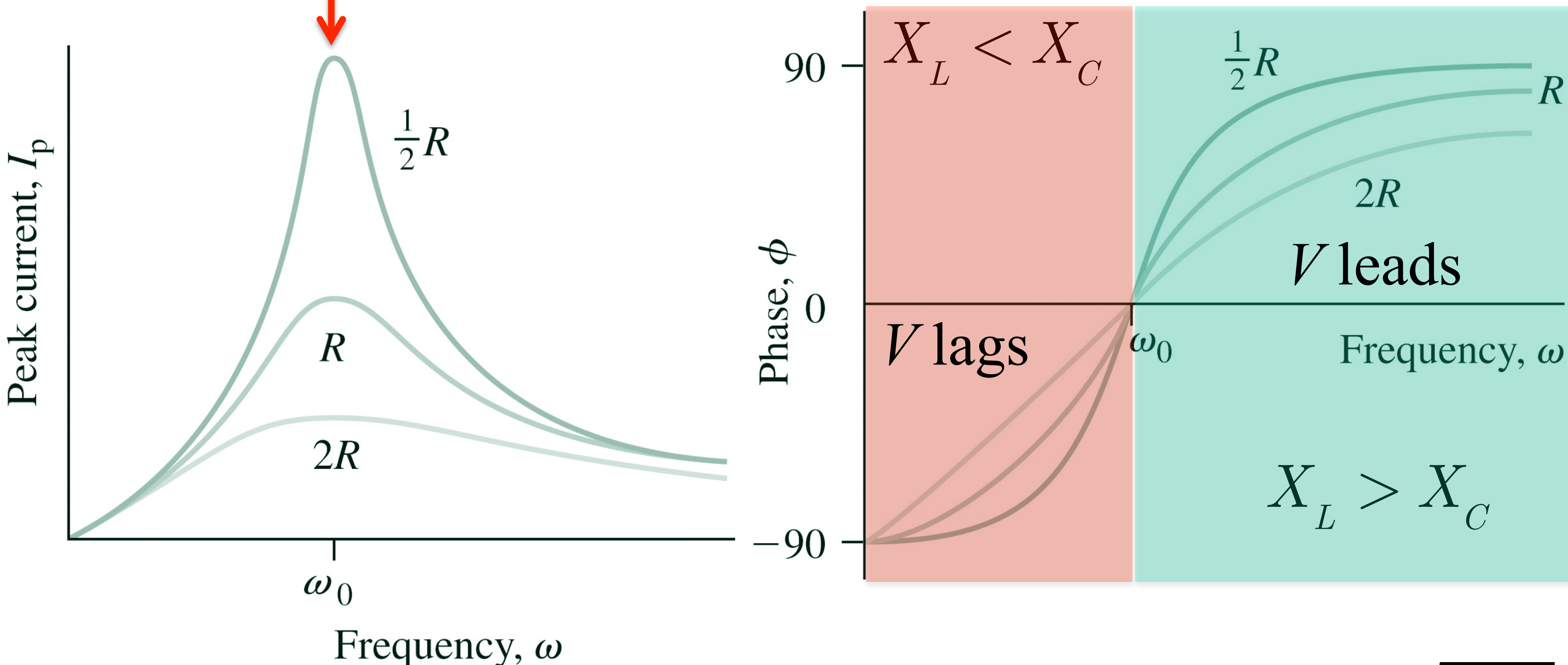
$$\Rightarrow I_{\mathrm{p}} = \frac{V_{\mathrm{p}}}{\sqrt{R^2 + \left(X_L - X_C\right)^2}} = \frac{V_{\mathrm{p}}}{Z}$$

Impedance: $$Z = \sqrt{R^2 + \left(X_L - X_C\right)^2} \qquad \left[\begin{matrix}\text{Units:} \\ \text{ohms}\end{matrix}\right]$$

Phase: $$\tan\phi = \frac{X_L - X_C}{R} = \frac{\omega L - 1/\omega C}{R}$$

Resonance

$$X_L = X_C$$

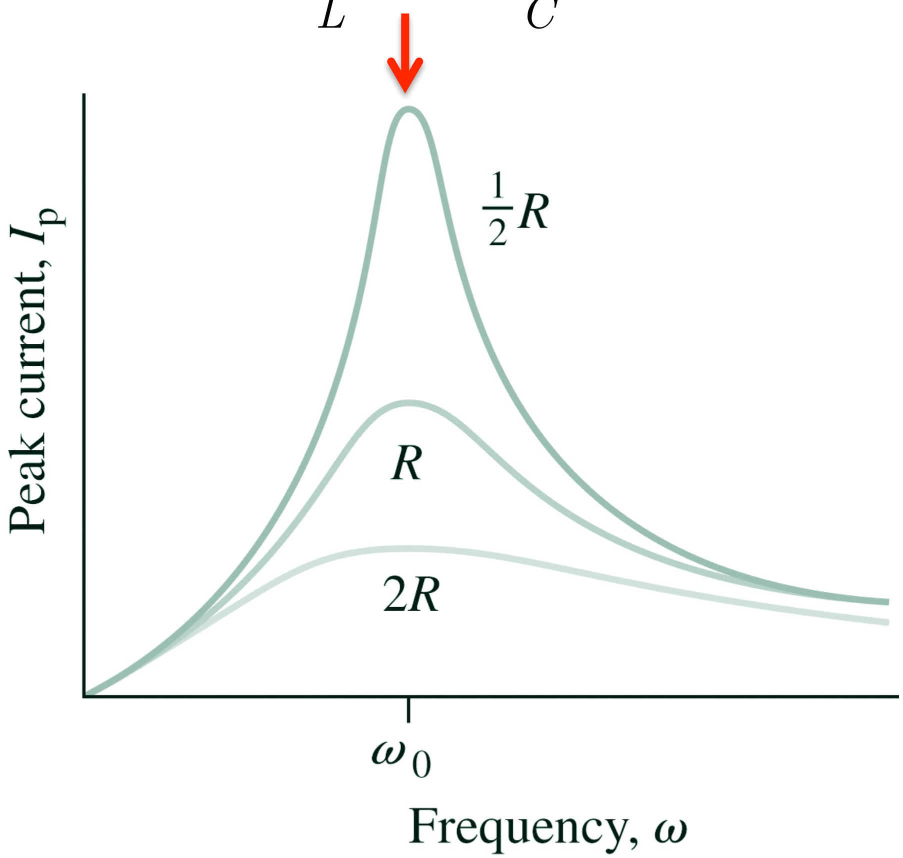


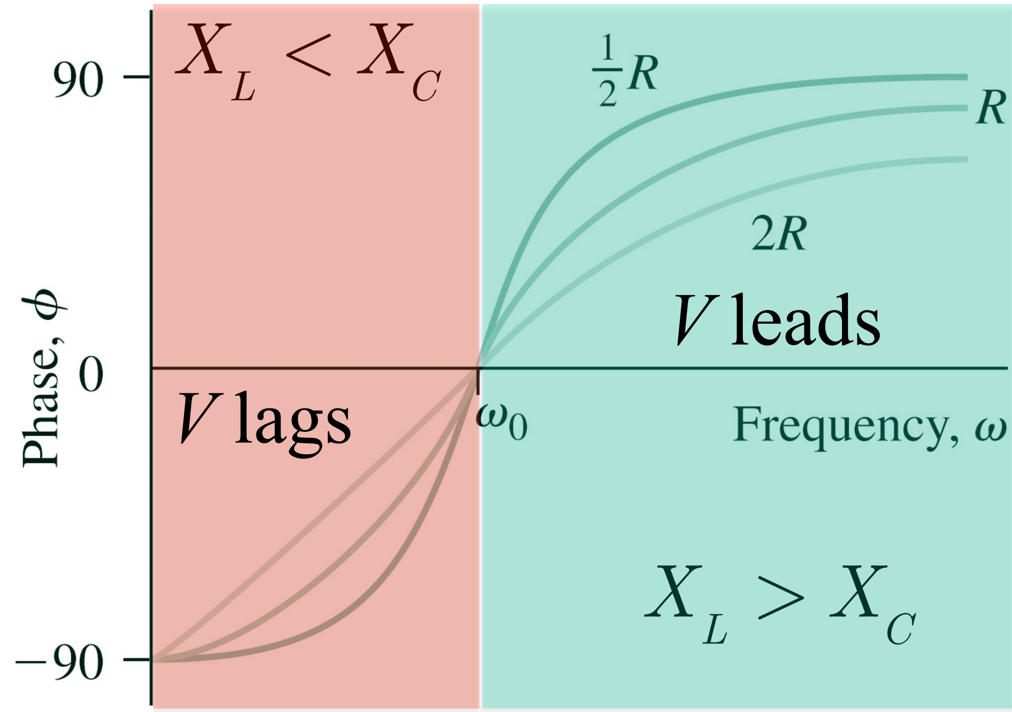
$$I_p = \frac{V_p}{\sqrt{R^2 + \left(X_L - X_C\right)^2}} \qquad \tan\phi = \frac{X_L - X_C}{R} \qquad \omega_o = \sqrt{\frac{1}{LC}}$$

At resonance, $Z = R$, and $\phi = 0$ (just like a DC circuit)

Resonance

$$X_L = X_C$$

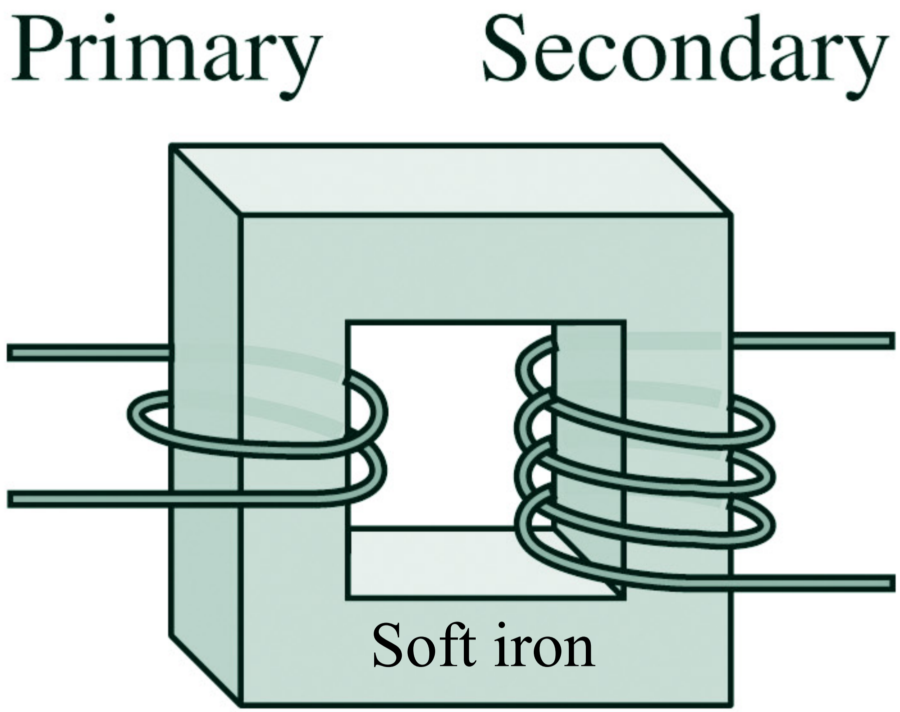


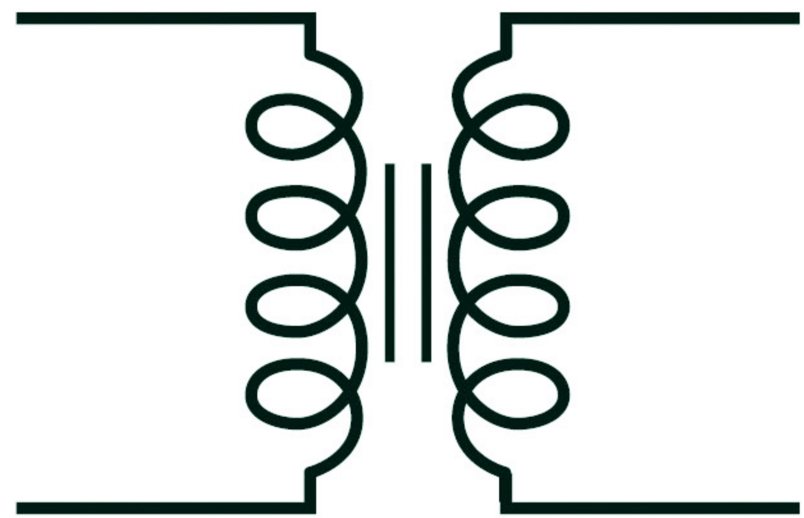


Power delivered to the circuit:

$$\langle P \rangle = \tfrac{1}{2} I_p V_p \cos\phi = I_{rms} V_{rms} \cos\phi$$

Transformers

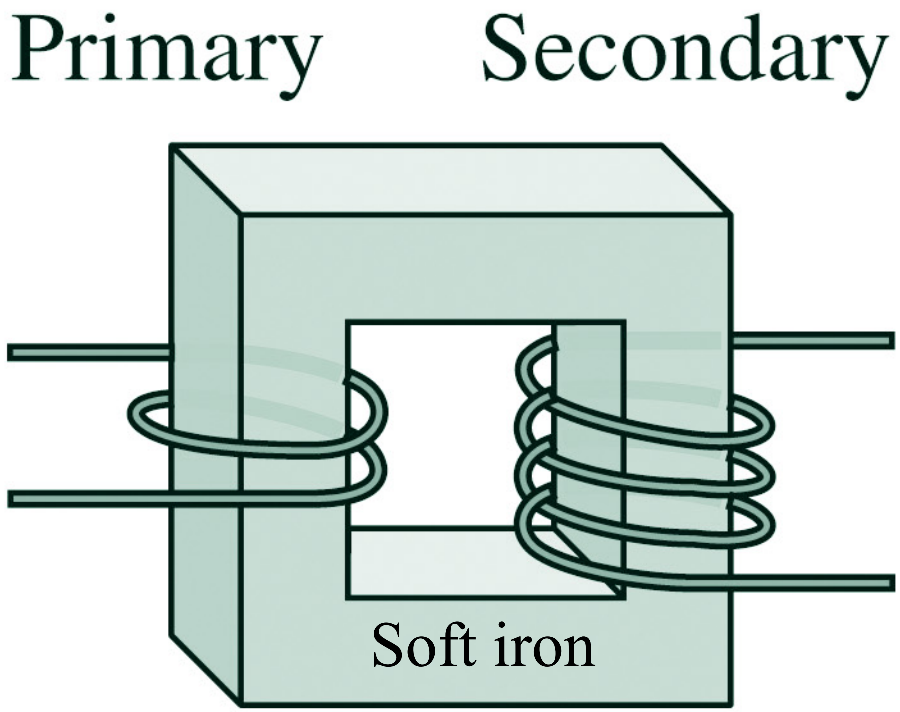


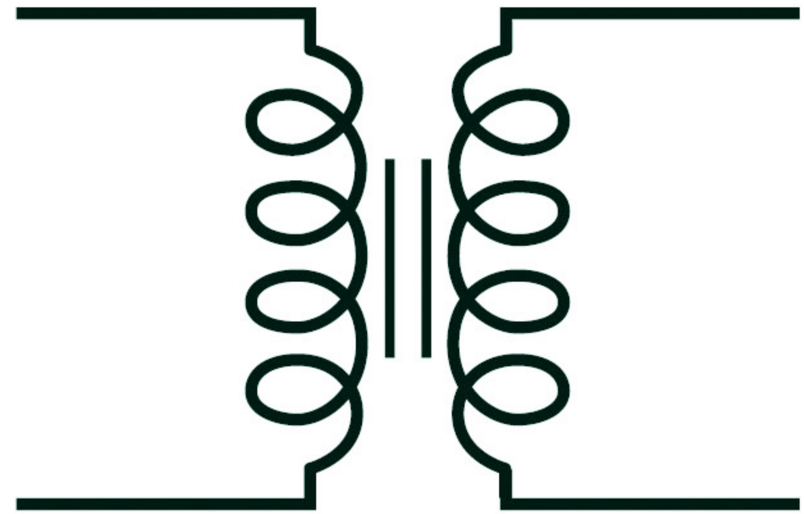


- Flux the same on both sides, but number of turns, N, is different
- Total flux through primary and secondary coils depends on N_1 and N_2

$$V_1 = N_1\Phi; \qquad V_2 = N_2\Phi; \qquad \Rightarrow \frac{V_2}{V_1} = \frac{N_2}{N_1}$$

Transformers





- Energy must be conserved, so ‘power in’ must equal ‘power out’
- Therefor, $I_1 V_1 = I_2 V_2$

$$\Rightarrow \frac{V_2}{V_1} = \frac{I_1}{I_2} = \frac{N_2}{N_1}$$