The phase constant

\[ \tan \theta = \frac{X_L - X_C}{R} \]  

(phase constant) (31-65)

Defining the impedance \( Z \) of the circuit as

\[ Z = \sqrt{R^2 + (X_L - X_C)^2} \]  

(impedance) (31-61)

allows us to write Eq. 31-60 as \( I = \frac{\xi_m}{Z} \).
** View All Solutions Here **

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Power In a series \( RLC \) circuit, the average power \( P_{\text{avg}} \) of the generator is equal to the production rate of thermal energy in the resistor:

\[
P_{\text{avg}} = I_{\text{rms}}^2 R = \dot{\cal E}_{\text{rms}} I_{\text{rms}} \cos \phi. \quad (31-71, 31-76)
\]

Here \( \text{rms} \) stands for root-mean-square; the \( \text{rms} \) quantities are related to the maximum quantities by \( I_{\text{rms}} = I/\sqrt{2} \) and \( \dot{\cal E}_{\text{rms}} = \dot{\cal E}_m/\sqrt{2} \). The term \( \cos \phi \) is called the power factor of the circuit.

Transformers A transformer (assumed to be ideal) is an iron core on which are wound a primary coil of \( N_p \) turns and a secondary coil of \( N_s \) turns. If the primary coil is connected across an alternating-current generator, the primary and secondary voltages are related by

\[
V_s = V_p \frac{N_s}{N_p} \quad \text{(transformation of voltage)}.
\]

The currents through the coils are related by

\[
I_s = I_p \frac{N_p}{N_s} \quad \text{(transformation of currents)},
\]

and the equivalent resistance of the secondary circuit, as seen by the generator, is

\[
R_{\text{eq}} = \left( \frac{N_p}{N_s} \right)^2 R,
\]

where \( R \) is the resistive load in the secondary circuit. The ratio \( N_s/N_p \) is called the transformer’s turns ratio.

** Questions **

1 Figure 31-19 shows three oscillating \( LC \) circuits with identical inductors and capacitors. Rank the circuits according to the time taken to fully discharge the capacitors during the oscillations, greatest first.

2 Figure 31-20 shows graphs of capacitor voltage \( v_C \) for \( LC \) circuits 1 and 2, which contain identical capacitances and have the same maximum charge \( Q \). Are (a) the inductance \( L \) and (b) the maximum current \( I \) in circuit 1 greater than, less than, or the same as those in circuit 2?

3 A charged capacitor and an inductor are connected at time \( t = 0 \). In terms of the period \( T \) of the resulting oscillations, what is the first later time at which the following reach a maximum: (a) \( U \), (b) the magnetic flux through the inductor, (c) \( di/dt \), and (d) the emf of the inductor?

4 What values of phase constant \( \phi \) in Eq. 31-12 allow situations (a), (c), (e), and (g) of Fig. 31-1 to occur at \( t = 0 \)?

5 Curve a in Fig. 31-21 gives the impedance \( Z \) of a driven \( RC \) circuit versus the driving angular frequency \( \omega \). The other two curves are similar but for different values of resistance \( R \) and capacitance \( C \). Rank the three curves according to the corresponding value of \( R \), greatest first.

6 Charges on the capacitors in three oscillating \( LC \) circuits vary as: (1) \( q = 2 \cos 4t \), (2) \( q = 4 \cos t \), (3) \( q = 3 \cos 4t \) (with \( q \) in coulombs and \( t \) in seconds). Rank the circuits according to (a) the current amplitude and (b) the period, greatest first.

7 An alternating emf source with a certain emf amplitude is connected, in turn, to a resistor, a capacitor, and then an inductor. Once connected to one of the devices, the driving frequency \( f_d \) is varied and the amplitude \( I \) of the resulting current through the device is measured and plotted. Which of the three plots in Fig. 31-22 corresponds to which of the three devices?

8 The values of the phase constant \( \phi \) for four sinusoidally driven series \( RLC \) circuits are (1) \(-15^\circ\), (2) \(+35^\circ\), (3) \(\pi/3\) rad, and (4) \(-\pi/6\) rad. (a) In which is the load primarily capacitive? (b) In which does the current lag the alternating emf?

9 Figure 31-23 shows the current \( i \) and driving emf \( \dot{\cal E} \) for a series \( RLC \) circuit. (a) Is the phase constant positive or negative? (b) To increase the rate at which energy is transferred to the resistive load, should \( L \) be increased or decreased? (c) Should, instead, \( C \) be increased or decreased?

10 Figure 31-24 shows three situations like those of Fig. 31-15. Is the driving angular frequency greater than, less than, or equal to the resonant angular frequency of the circuit in (a) situation 1, (b) situation 2, and (c) situation 3?

11 Figure 31-25 shows the current \( i \) and driving emf \( \dot{\cal E} \) for a series \( RLC \) circuit. Relative to the emf curve, does the current curve
shift leftward or rightward and does the amplitude of that curve increase or decrease if we slightly increase (a) \( L \), (b) \( C \), and (c) \( \omega \)?

12 Figure 31-25 shows the current \( i \) and driving emf \( \varepsilon \) for a series \( RLC \) circuit. (a) Does the current lead or lag the emf? (b) Is the circuit’s load mainly capacitive or mainly inductive? (c) Is the angular frequency \( \omega \) of the emf greater than or less than the natural angular frequency \( \omega \)?

** View All Solutions Here **

** View All Solutions Here **
are the (a) smallest, (b) second smallest, (c) second largest, and (d) largest oscillation frequency that can be set up, by using these elements in various combinations?

**15** *ILW* An oscillating LC circuit consisting of a 1.0 nF capacitor and a 3.0 mH coil has a maximum voltage of 3.0 V. What are (a) the maximum charge on the capacitor, (b) the maximum current through the circuit, and (c) the maximum energy stored in the magnetic field of the coil?

**16** An inductor is connected across a capacitor whose capacitance can be varied by turning a knob. We wish to make the frequency of oscillation of this LC circuit vary linearly with the angle of rotation of the knob, going from 2 × 10⁵ to 4 × 10⁵ Hz as the knob turns through 180°. If L = 1.0 mH, plot the required capacitance C as a function of the angle of rotation of the knob.

**17** *ILW* In Fig. 31-27, \( R = 14.0 \, \Omega \), \( C = 6.20 \, \mu F \), and \( L = 54.0 \, mH \), and the ideal battery has emf \( \xi = 34.0 \, V \). The switch is kept at a for a long time and then thrown to position b. What are the (a) frequency and (b) current amplitude of the resulting oscillations?

**18** An oscillating LC circuit has a current amplitude of 7.50 mA, a potential amplitude of 250 mV, and a capacitance of 220 nF. What are (a) the period of oscillation, (b) the maximum energy stored in the capacitor, (c) the maximum energy stored in the inductor, (d) the maximum rate at which the current changes, and (e) the maximum rate at which the inductor gains energy?

**19** Using the loop rule, derive the differential equation for an LC circuit (Eq. 31-11).

**20** *ILW* In an oscillating LC circuit in which \( C = 4.00 \, \mu F \), the maximum potential difference across the capacitor during the oscillations is 1.50 V and the maximum current through the inductor is 50.0 mA. What are (a) the inductance \( L \) and (b) the frequency of the oscillations? (c) How much time is required for the charge on the capacitor to rise from zero to its maximum value?

**21** *ILW* In an oscillating LC circuit with \( C = 64.0 \, \mu F \), the current is given by \( i = (1.60) \sin(2500t + 0.680) \), where \( t \) is in seconds, \( i \) in amperes, and the phase constant in radians. (a) How soon after \( t = 0 \) will the current reach its maximum value? What are (b) the inductance \( L \) and (c) the total energy?

**22** A series circuit containing inductance \( L_1 \) and capacitance \( C_1 \) oscillates at angular frequency \( \omega_0 \). A second series circuit, containing inductance \( L_2 \) and capacitance \( C_2 \), oscillates at the same angular frequency. In terms of \( \omega_0 \), what is the angular frequency of oscillation of a series circuit containing all four of these elements? Neglect resistance. (Hint: Use the formulas for equivalent capacitance and equivalent inductance; see Section 25-4 and Problem 47 in Chapter 30.)

**23** In an oscillating LC circuit, \( L = 25.0 \, mH \) and \( C = 7.80 \, \mu F \). At time \( t = 0 \) the current is 9.20 mA, the charge on the capacitor is 3.80 \, \mu C, and the capacitor is charging. What are (a) the total energy in the circuit, (b) the maximum charge on the capacitor, and (c) the maximum current? (d) If the charge on the capacitor is given by \( q = Q \cos(\omega t + \phi) \), what is the phase angle \( \phi \)?

Suppose the data are the same, except that the capacitor is discharging at \( t = 0 \). What then is \( \phi \)?

**24** *SSM* A single-loop circuit consists of a 7.20 \, \Omega \) resistor, a 12.0 \, H inductor, and a 3.20 \, \mu F \) capacitor. Initially the capacitor has a charge of 6.20 \mu C and the current is zero. Calculate the charge on the capacitor \( N \) complete cycles later for (a) \( N = 5 \), (b) \( N = 10 \), and (c) \( N = 100 \).

**25** *ILW* What resistance \( R \) should be connected in series with an inductance \( L = 220 \, mH \) and capacitance \( C = 12.0 \, \mu F \) for the maximum charge on the capacitor to decay to 99.0% of its initial value in 50.0 cycles? (Assume \( \omega = \omega_0 \).)

**26** In an oscillating series RLC circuit, find the time required for the maximum energy present in the capacitor during an oscillation to fall to half its initial value. Assume \( q = Q \) at \( t = 0 \).

**27** *SSM* In an oscillating series RLC circuit, show that \( \Delta U/U \), the fraction of the energy lost per cycle of oscillation, is given to a close approximation by \( 2\pi R/\omega L \). The quantity \( \omega L/R \) is often called the quality of the circuit (for quality). A high-Q circuit has low resistance and a low fractional energy loss (\( = 2\pi Q \)) per cycle.

**28** A 1.50 \, \mu F \) capacitor is connected as in Fig. 31-10 to an ac generator with \( \xi_m = 30.0 \, V \). What is the amplitude of the resulting alternating current if the frequency of the emf is (a) 1.00 kHz and (b) 8.00 kHz?

**29** *ILW* A 50.0 mH inductor is connected as in Fig. 31-12 to an ac generator with \( \xi_m = 30.0 \, V \). What is the amplitude of the resulting alternating current if the frequency of the emf is (a) 1.00 kHz and (b) 8.00 kHz?

**30** A 50.0 \, \Omega \) resistor is connected as in Fig. 31-8 to an ac generator with \( \xi_m = 30.0 \, V \). What is the amplitude of the resulting alternating current if the frequency of the emf is (a) 1.00 kHz and (b) 8.00 kHz?

**31** (a) At what frequency would a 6.0 mH inductor and a 10 \, \mu F \) capacitor have the same reactance? (b) What would the reactance be? (c) Show that this frequency would be the natural frequency of an oscillating circuit with the same \( L \) and \( C \).

**32** *ILW* An ac generator has emf \( \xi = \xi_m \sin \omega_0 t \), with \( \xi_m = 25.0 \, V \) and \( \omega_0 = 377 \, \text{rad/s} \). It is connected to a 12.7 H inductor. (a) What is the maximum value of the current? (b) When the current is a maximum, what is the emf of the generator? (c) When the emf of the generator is \( = 12.5 \, V \) and increasing in magnitude, what is the current?

**33** *SSM* An ac generator has emf \( \xi = \xi_m \sin(\omega_0 t - \pi/4) \), where \( \xi_m = 30.0 \, V \) and \( \omega_0 = 350 \, \text{rad/s} \). The current produced in a connected circuit is \( i(t) = I \sin(\omega_0 t - 3\pi/4) \), where \( I = 620 \, mA \). At what time after \( t = 0 \) does (a) the generator emf first reach a maximum and (b) the current first reach a maximum? (c) The circuit contains a single element other than the generator. Is it a capacitor, an inductor, or a resistor? Justify your answer. (d) What is the value of the capacitance, inductance, or resistance, as the case may be?

**34** An ac generator with emf \( \xi = \xi_m \sin \omega_0 t \), where \( \xi_m = 25.0 \, V \) and \( \omega_0 = 377 \, \text{rad/s} \), is connected to a 4.15 \, \mu F \) capacitor. (a) What is the maximum value of the current? (b) When the current is a maximum, what is the emf of the generator? (c) When the emf of the generator is \( = 12.5 \, V \) and increasing in magnitude, what is the current?
sec. 31-9 The Series RLC Circuit

•35 IUW A coil of inductance 88 mH and unknown resistance and a 0.94 µF capacitor are connected in series with an alternating emf of frequency 930 Hz. If the phase constant between the applied voltage and the current is 75°, what is the resistance of the coil?

•36 An alternating source with a variable frequency, a capacitor with capacitance C, and a resistor with resistance R are connected in series. Figure 31-28 gives the impedance Z of the circuit versus the driving angular frequency ωd; the curve reaches an asymptote at 500 rad/s, and the horizontal scale is set by ω0 = 300 rad/s. The figure also gives the reactance Xc for the capacitor versus ωd. What are (a) R and (b) C?

![Fig. 31-28](image1)

Fig. 31-28 Problem 36.

•37 An electric motor has an effective resistance of 32.0 Ω and an inductive reactance of 45.0 Ω when working under load. The rms voltage across the alternating source is 420 V. Calculate the rms current.

•38 The current amplitude I versus driving angular frequency ωd for a driven RLC circuit is given in Fig. 31-29, where the vertical axis scale is set by I = 4.00 A. The inductance is 200 µH, and the emf amplitude is 8.0 V. What are (a) C and (b) R?

![Fig. 31-29](image2)

Fig. 31-29 Problem 38.

•39 Remove the inductor from the circuit in Fig. 31-7 and set R = 200 Ω, L = 230 mH, f0 = 60.0 Hz, and $\xi_m = 36.0$ V. What are (a) Z, (b) φ, and (c) f? (d) Draw a phasor diagram.

•40 An alternating source drives a series RLC circuit with an emf amplitude of 6.00 V, at a phase angle of +50.0°. When the potential difference across the capacitor reaches its maximum positive value of +5.00 V, what is the potential difference across the inductor (sign included)?

•41 SSM In Fig. 31-7, set R = 200 Ω, C = 70.0 µF, L = 230 mH, f0 = 60.0 Hz, and $\xi_m = 36.0$ V. What are (a) Z, (b) φ, and (c) f? (d) Draw a phasor diagram.

•42 An alternating source with a variable frequency, an inductor with inductance L, and a resistor with resistance R are connected in series. Figure 31-30 gives the impedance Z of the circuit versus the driving angular frequency ωd, with the horizontal axis scale set by $\omega_0 = 1600$ rad/s. The figure also gives the reactance $X_L$ for the inductor versus $\omega_d$. What are (a) R and (b) L?

![Fig. 31-30](image3)

Fig. 31-30 Problem 42.

•43 Remove the capacitor from the circuit in Fig. 31-7 and set $R = 200 \ \Omega$, $L = 230 \ \text{mH}$, $f_0 = 60.0 \ \text{Hz}$, and $\xi_m = 36.0 \ \text{V}$. What are (a) Z, (b) φ, and (c) f? (d) Draw a phasor diagram.

•44 A generator with $\xi_m = 220 \ \text{V}$ and operating at 400 Hz causes oscillations in a series RLC circuit having $R = 220 \ \Omega$, $L = 150 \ \text{mH}$, and $C = 24.0 \ \mu\text{F}$. Find (a) the capacitive reactance $X_C$, (b) the impedance $Z$, and (c) the current amplitude $I$. A second capacitor of the same capacitance is then connected in series with the other components. Determine whether the values of (d) $X_C$, (e) $Z$, and (f) $I$ increase, decrease, or remain the same.

•45 IUW (a) In an RLC circuit, can the amplitude of the voltage across an inductor be greater than the amplitude of the generator emf? (b) Consider an RLC circuit with $\xi_m = 10 \ \text{V}$, $R = 10 \ \Omega$, $L = 1.0 \ \text{H}$, and $C = 1.0 \ \mu\text{F}$. Find the amplitude of the voltage across the inductor at resonance.

•46 An alternating emf source with a variable frequency $f_d$ is connected in series with a 50.0 Ω resistor and a 20.0 µF capacitor. The emf amplitude is 12.0 V. (a) Draw a phasor diagram for phasor $V_R$ (the potential across the resistor) and phasor $V_C$ (the potential across the capacitor). (b) At what driving frequency $f_d$ do the two phasors have the same length? At that driving frequency, what are (c) the phase angle in degrees (d) the angular speed at which the phasors rotate, and (e) the current amplitude?

•47 SSM WWW An RLC circuit such as that of Fig. 31-7 has $R = 5.00 \ \Omega$, $C = 20.0 \ \mu\text{F}$, $L = 1.00 \ \text{H}$, and $\xi_m = 30.0 \ \text{V}$. (a) At what angular frequency $\omega_d$ will the current amplitude have its maximum value, as in the resonance curves of Fig. 31-16? (b) What is this maximum value? At what (c) lower angular frequency $\omega_{d1}$ and (d) higher angular frequency $\omega_{d2}$ will the current amplitude be half this maximum value? (e) For the resonance curve for this circuit, what is the fractional half-width $(\omega_{d2} - \omega_{d1})/\omega$?

•48 WWW Figure 31-31 shows a driven RLC circuit that contains two identical capacitors and two switches. The emf amplitude is set at 12.0 V, and the driving frequency is set at 60.0 Hz. With both switches open, the current leads the emf by 30.9°. With both switches closed, the current amplitude is 447 mA. What are (a) R, (b) C, and (c) L?

![Fig. 31-31](image4)

Fig. 31-31 Problem 48.
** View All Solutions Here **

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- **49** In Fig. 31-32, a generator with an adjustable frequency of oscillation is connected to resistance $R = 100 \, \Omega$, inductances $L_1 = 1.70 \, \text{mH}$ and $L_2 = 2.30 \, \text{mH}$, and capacitances $C_1 = \phantom{1.00} \mu\text{F}$, $C_2 = 2.50 \, \mu\text{F}$, and $C_3 = 3.50 \, \mu\text{F}$. (a) What is the resonant frequency of the circuit? (Hint: See Problem 47 in Chapter 30.) What happens to the resonant frequency if (b) $R$ is increased, (c) $L_1$ is increased, and (d) $C_3$ is removed from the circuit?

- **50** An alternating emf source with a variable frequency $f_d$ is connected in series with an $80.0 \, \Omega$ resistor and a $40.0 \, \text{mH}$ inductor. The emf amplitude is $6.00 \, \text{V}$. (a) Draw a phasor diagram for phasor $V_L$ connected in series with an $80.0 \, \Omega$ resistor and a $40.0 \, \text{mH}$ inductor. (b) At what driving frequency $f_d$ do the two phasors have the same length? At that driving frequency, what are (c) the phase angle in degrees, (d) the angular speed at which the phasors rotate, and (e) the current amplitude?

- **51** SSM The fractional half-width $\Delta \omega_0$ of a resonance curve, such as the ones in Fig. 31-16, is the width of the curve at half the maximum value of $I$. Show that $\Delta \omega_0/\omega_0 = R(3C/L)^{1/2}$, where $\omega_0$ is the angular frequency at resonance. Note that the ratio $\Delta \omega_0/\omega_0$ increases with $R$, as Fig. 31-16 shows.

**sec. 31.10 Power in Alternating-Current Circuits**

- **52** An ac voltmeter with large impedance is connected in turn across the inductor, the capacitor, and the resistor in a series circuit having an alternating emf of 100 V (rms); the meter gives the same reading in volts in each case. What is this reading?

- **53** SSM An air conditioner connected to a 120 V rms ac line is equivalent to a 12.0 $\Omega$ resistance and a 1.30 $\Omega$ inductive reactance in series. Calculate (a) the impedance of the air conditioner and (b) the average rate at which energy is supplied to the appliance.

- **54** What is the maximum value of an ac voltage whose rms value is 100 V?

- **55** What direct current will produce the same amount of thermal energy, in a particular resistor, as an alternating current that has a maximum value of 2.60 A?

- **56** A typical light dimmer used to dim the stage lights in a theater consists of a variable inductor $L$ (whose inductance is adjustable between zero and $L_{\text{max}}$) connected in series with a light bulb B, as shown in Fig. 31-33. The electrical supply is 120 V (rms) at 60.0 Hz; the light bulb is rated at 120 V, 1000 W. (a) What $L_{\text{max}}$ is required if the rate of energy dissipation in the light bulb is to be varied by a factor of 5 from its upper limit of 1000 W? Assume that the resistance of the light bulb is independent of its temperature. (b) Could one use a variable resistor (adjustable between zero and $R_{\text{max}}$) instead of an inductor? (c) If so, what $R_{\text{max}}$ is required? (d) Why isn’t this done?

- **57** In an $RLC$ circuit such as that of Fig. 31-7 assume that $R = 5.00 \, \Omega$, $L = 60.0 \, \text{mH}$, $f_d = 60.0 \, \text{Hz}$, and $\epsilon_0 = 30.0 \, \text{V}$. For what values of the capacitance would the average rate at which energy is dissipated in the resistance be (a) a maximum and (b) a minimum? What are (c) the maximum dissipation rate and the corresponding (d) phase angle and (e) power factor? What are (f) the minimum dissipation rate and the corresponding (g) phase angle and (h) power factor?

- **58** For Fig. 31-34, show that the average rate at which energy is dissipated in resistance $R$ is a maximum when $R$ is equal to the internal resistance $r$ of the ac generator. (In the text discussion we tacitly assumed that $r = 0$.)

- **59** In Fig. 31-7, $R = 15.0 \, \Omega$, $C = 4.70 \, \mu\text{F}$, and $L = 25.0 \, \text{mH}$. The generator provides an emf with rms voltage 75.0 V and frequency 550 Hz. (a) What is the rms current? What is the rms voltage across (b) $R$, (c) $C$, (d) $L$, (e) $C$ and $L$ together, and (f) $R$, $C$, and $L$ together? At what average rate is energy dissipated by (g) $R$, (h) $C$, and (i) $L$?

- **60** In a series oscillating $RLC$ circuit, $R = 16.0 \, \Omega$, $C = 31.2 \, \mu\text{F}$, $L = 9.20 \, \text{mH}$, and $\epsilon_m = \epsilon_m \sin \omega_d t$ with $\epsilon_m = 45.0 \, \text{V}$ and $\omega_d = 3000 \, \text{rad/s}$. For time $t = 0.442 \, \text{ms}$ find (a) the rate $P_L$ at which energy is being supplied by the generator, (b) the rate $P_C$ at which the energy in the capacitor is changing, (c) the rate $P_L$ at which energy is being dissipated in the inductor, and (d) the rate $P_R$ at which energy is being dissipated in the resistor. (e) Is the sum of $P_L$, $P_C$, and $P_R$ greater than, less than, or equal to $P_s$?

- **61** SSM WWW Figure 31-35 shows an ac generator connected to a “black box” through a pair of terminals. The box contains an $RLC$ circuit, possibly even a multiloop circuit, whose elements and connections we do not know. Measurements outside the box reveal that $\epsilon(t) = (75.0 \, \text{V}) \sin \omega_d t$ and $i(t) = (1.20 \, \text{A}) \sin(\omega_d t + 42.0^\circ)$.

(a) What is the power factor? (b) Does the current lead or lag the emf? (c) Is the circuit in the box inductive or largely capacitive? (d) Is the circuit in the box in resonance? (e) Must there be a capacitor in the box? (f) An inductor? (g) A resistor? (h) At what average rate is energy delivered to the box by the generator? (i) Why don’t you need to know $\omega_d$ to answer all these questions?

**sec. 31.11 Transformers**

- **62** A generator supplies 100 V to a transformer’s primary coil, which has 50 turns. If the secondary coil has 500 turns, what is the secondary voltage?

- **63** SSM ILW A transformer has 500 primary turns and 10 sec-
ordinary turns. (a) If \( V_p \) is 120 V (rms), what is \( V_L \) with an open circuit? If the secondary now has a resistive load of 15 \( \Omega \), what is the current in the (b) primary and (c) secondary?

**64** Figure 31-36 shows an “autotransformer.” It consists of a single coil (with an iron core). Three taps \( T_i \) are provided. Between taps \( T_1 \) and \( T_2 \) there are 200 turns, and between taps \( T_2 \) and \( T_3 \) there are 800 turns. Any two taps can be chosen as the primary terminals, and any two taps can be chosen as the secondary terminals. For choices producing a step-up transformer, what are the (a) smallest, (b) second smallest, and (c) largest values of the ratio \( V_s/V_p \)? For a step-down transformer, what are the (d) smallest, (e) second smallest, and (f) largest values of \( V_s/V_p \)?

**65** An ac generator provides emf to a resistive load in a remote factory over a two-cable transmission line. An ac generator provides emf to a circuit. What is the phase constant in radians? (b) What is the current amplitude? (c) Is the circuit inductive, capacitive, or in resonance?

71 An RLC circuit is driven by a generator with an emf amplitude of 80.0 V and a current amplitude of 1.25 A. The current leads the emf by 0.650 rad. What are the (a) impedance and (b) resistance of the circuit? (c) Is the circuit inductive, capacitive, or in resonance?

72 A series RLC circuit is driven in such a way that the maximum voltage across the inductor is 1.50 times the maximum voltage across the capacitor and 2.00 times the maximum voltage across the resistor. (a) What is \( \phi \) for the circuit? (b) Is the circuit inductive, capacitive, or in resonance? The resistance is 49.9 \( \Omega \), and the current amplitude is 200 mA. (c) What is the amplitude of the driving emf?

73 A capacitor of capacitance 158 \( \mu F \) and an inductor form an LC circuit that oscillates at 8.15 kHz, with a current amplitude of 4.21 mA. What are (a) the inductance, (b) the total energy in the circuit, and (c) the maximum charge on the capacitor?

74 An oscillating LC circuit has an inductance of 3.00 mH and a capacitance of 10.0 \( \mu F \). Calculate the (a) angular frequency and (b) period of the oscillation. (c) At time \( t = 0 \), the capacitor is charged to 200 \( \mu C \) and the current is zero. Roughly sketch the charge on the capacitor as a function of time.

75 For a certain driven series RLC circuit, the maximum generator emf is 125 V and the maximum current is 3.20 A. If the current leads the generator emf by 0.982 rad, what are the (a) impedance and (b) resistance of the circuit? (c) Is the circuit predominantly capacitive or inductive?

76 A 1.50 \( \mu F \) capacitor has a capacitive reactance of 12.0 \( \Omega \). (a) What must be its operating frequency? (b) What will be the capacitive reactance if the frequency is doubled?

77 SSM In Fig. 31-37, a three-phase generator \( G \) produces electrical power that is transmitted by means of three wires. The electric potentials (each relative to a common reference level) are \( V_1 = A \sin \omega t \) for wire 1, \( V_2 = A \sin (\omega t - 120°) \) for wire 2, and \( V_3 = A \sin (\omega t - 240°) \) for wire 3. Some types of industrial equipment (for example, motors) have three terminals and are designed to be connected directly to these three wires. To use a more conventional two-terminal device (for example, a lightbulb), one connects it to any two of the three wires. Show that the potential difference between any two of the wires (a) oscillates sinusoidally with angular frequency \( \omega_0 \) and (b) has an amplitude of \( A \sqrt{3} \).

78 An electric motor connected to a 120 V, 60.0 Hz ac outlet does mechanical work at the rate of 0.100 hp (1 hp = 746 W). (a) If the motor draws an rms current of 0.650 A, what is its effective resistance, relative to power transfer? (b) Is this the same as the resistance of the motor’s coils, as measured with an ohmmeter with the motor disconnected from the outlet?

79 SSM (a) In an oscillating LC circuit, in terms of the maximum charge \( Q \) on the capacitor, what is the charge there when the energy in the electric field is 50.0% of that in the magnetic field? (b) What fraction of a period must elapse following the time the capacitor is fully charged for this condition to occur?
A series RLC circuit is driven by an alternating source at a frequency of 400 Hz and an emf amplitude of 90.0 V. The resistance is 20.0 Ω, the capacitance is 12.1 μF, and the inductance is 24.2 mH. What is the rms potential difference across (a) the resistor, (b) the capacitor, and (c) the inductor? (d) What is the average rate at which energy is dissipated?

In a certain series RLC circuit being driven at a frequency of 60.0 Hz, the maximum voltage across the inductor is 2.00 times the maximum voltage across the resistor and 2.00 times the maximum voltage across the capacitor. (a) By what angle does the current lag the generator emf? (b) If the maximum generator emf is 30.0 V, what should be the resistance of the circuit to obtain a maximum current of 300 mA?

A 1.50 mH inductor in an oscillating LC circuit stores a maximum energy of 10.0 mJ. What is the maximum current?

A generator with an adjustable frequency of oscillation is wired in series to an inductor of L = 2.50 mH and a capacitor of C = 3.00 μF. At what frequency does the generator produce the largest possible current amplitude in the circuit?

A series RLC circuit has a resonant frequency of 6.00 kHz. When it is driven at 8.00 kHz, it has an impedance of 1.00 kΩ and a phase constant of 45°. What are (a) R, (b) L, and (c) C for this circuit?

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