PHYS 104

CH 30

1. A circular loop of wire of radius 12.0 cm is placed in a magnetic field directed perpendicular to the plane of the loop as in Figure P30.1. If the field decreases at the rate of 0.050 0 T/s in some time interval, find the magnitude of the emf induced in the loop during this interval.

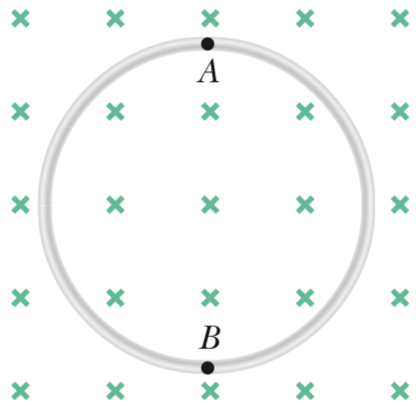


Figure P30.1

$$\mathcal{E} = -N\frac{d\Phi}{dt} = -N\frac{d}{dt}(BA)$$

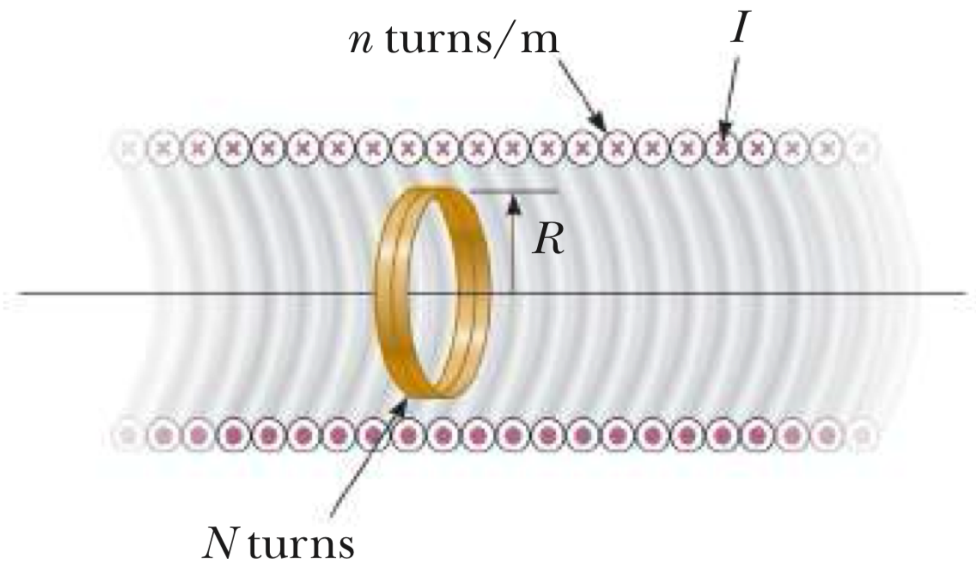
$$= -NA\frac{dB}{dt}$$

$$\Rightarrow \boxed{\mathcal{E} = -N(\pi r^2)\frac{dB}{dt}}$$

$$N = 1, \quad r = 0.12\,m, \quad \frac{dB}{dt} = 0.05\ T/s$$

$$\Rightarrow \boxed{|\mathcal{E}| = 2.26 \times 10^{-3}\ V}$$

4. T A long solenoid has $n = 400$ turns per meter and carries a current given by $I = 30.0(1 - e^{-1.60t})$, where I is in amperes and t is in seconds. Inside the solenoid and coaxial with it is a coil that has a radius of $R = 6.00$ cm and consists of a total of $N = 250$ turns of fine wire (Fig. P30.4). What emf is induced in the coil by the changing current?



$$\mathcal{E} = -N\frac{d\Phi}{dt} = -N\frac{d}{dt}(BA) = -NA\frac{dB}{dt}$$

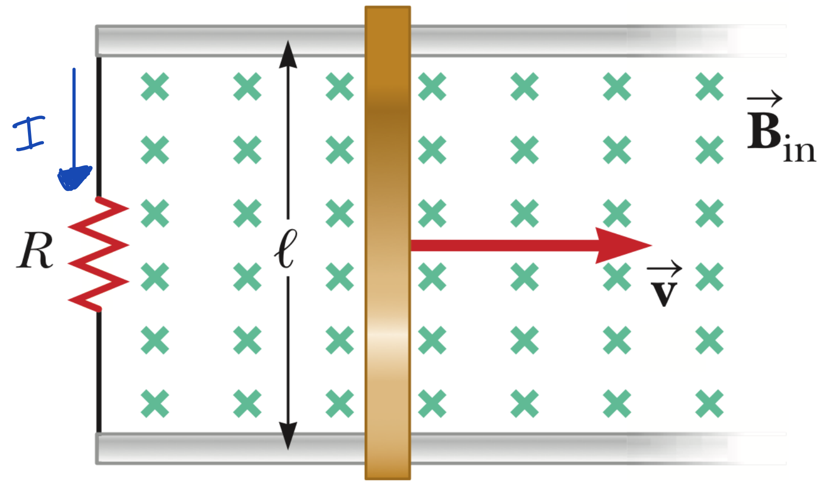
Since B of a Solenoid is: $B = \mu_0 n I$

$$\Rightarrow \boxed{\mathcal{E} = -NA\,\mu_0 n \frac{dI}{dt}}$$

$\rightarrow$ $\frac{dI}{dt} = 48\, e^{-1.6t}$, $N = 250$, $A = \pi R^2$, $n = 400$

$$\Rightarrow \boxed{|\mathcal{E}| = (68.2 \times 10^{-3})\, e^{-1.6t}}$$

15. **Q|C** A conducting bar of length ℓ moves to the right on two frictionless rails as shown in Figure P30.15. A uniform magnetic field directed into the page has a magnitude of 0.300 T. Assume $R = 9.00\ \Omega$ and $\ell = 0.350$ m. (a) At what constant speed should the bar move to produce an 8.50-mA current in the resistor? (b) What is the direction of the induced current? (c) At what rate is energy delivered to the resistor? (d) Explain the origin of the energy being delivered to the resistor.



a) $\mathcal{E} = -B\ell v \Rightarrow v = \frac{|\mathcal{E}|}{B\ell} = \frac{IR}{B\ell} = 0.73$ m/s

b) Counte Clockwise, Becaus $B_{induced}$ has to be opposite to $B_{applied}$.

c) The Power $P = \frac{dE}{dt} = I\mathcal{E} = I^2R = 6.5\times10^{-4}$ W

D) Mechanical work is transformed to electrical energy.

CH 31

3. An emf of 24.0 mV is induced in a 500-turn coil when the current is changing at the rate of 10.0 A/s. What is the magnetic flux through each turn of the coil at an instant when the current is 4.00 A?

$$L = N\frac{\Phi_B}{i} \Rightarrow \boxed{\Phi_B = \frac{i\,L}{N}}$$

$$\rightarrow \quad i = 4\,A, \quad N = 500, \quad L = \frac{|\mathcal{E}_L|}{di/dt} = \frac{24\ mV}{10\ A/s}$$

$$\Rightarrow \boxed{\Phi_B = 19.2 \times 10^{-6}\ T\cdot m^2}$$

4. A 40.0-mA current is carried by a uniformly wound air-core solenoid with 450 turns, a 15.0-mm diameter, and 12.0-cm length. Compute (a) the magnetic field inside the solenoid, (b) the magnetic flux through each turn, and (c) the inductance of the solenoid. (d) **What If?** If the current were different, which of these quantities would change?

a) $B = \mu_0 n I = \mu_0 \frac{N}{\ell} I = (4\pi \times 10^{-7})\left(\frac{450}{0.12}\right)(40 \times 10^{-3})$

$\Rightarrow \boxed{B = 189 \times 10^{-6} \text{ T}}$

b) $\Phi_B = BA = B\left[\pi\left(\frac{d}{2}\right)^2\right] = 3.33 \times 10^{-8} \text{ T.m}^2$

c) $\boxed{L = N\frac{\Phi_B}{I} = 0.38 \text{ mH}}$ or $\boxed{L = \mu_0 n^2 A \ell = \cdots}$

d) $\boxed{B \;\&\; \Phi_B}$

20. Calculate the energy associated with the magnetic field of a 200-turn solenoid in which a current of 1.75 A produces a magnetic flux of $3.70 \times 10^{-4}\ \mathrm{T \cdot m^2}$ in each turn.

N i

$$U_B = \frac{1}{2} L i^2 = \frac{1}{2}\left[N\frac{\Phi_B}{i}\right] i^2 = \frac{1}{2} N \Phi_B i$$

$$= 64.8\ \mathrm{mJ}$$

21. An air-core solenoid with 68 turns is 8.00 cm long and has a diameter of 1.20 cm. When the solenoid carries a current of 0.770 A, how much energy is stored in its magnetic field?

N l d i

$$U_B = \frac{1}{2} L i^2 = \frac{1}{2}\left[\mu_0 n^2 A l\right] i^2$$

$$\longrightarrow \quad n = \frac{N}{l} = \frac{68}{0.08} \ ; \quad A = \pi\left(\frac{d}{2}\right)^2$$

$$\Rightarrow \quad U_B = 2.44 \times 10^{-6}\ \mathrm{J}$$

CH 32

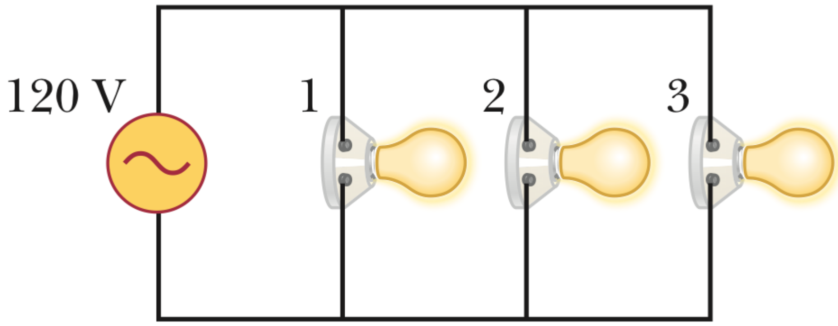
1. (a) What is the resistance of a lightbulb that uses an average power of 75.0 W when connected to a 60.0-Hz power source having a maximum voltage of 170 V? (b) **What If?** What is the resistance of a 100-W lightbulb?

a) $P_{avg} = \frac{V_{rms}^2}{R} \Rightarrow R = \frac{V_{rms}^2}{P_{avg}}$

$\rightarrow V_{rms} = \frac{V_{max}}{\sqrt{2}} \Rightarrow \boxed{R = \frac{V_{max}^2}{2 P_{avg}} = 193\ \Omega}$

b) $\boxed{R = 144\ \Omega}$

4. Figure P32.4 shows three lightbulbs connected to a 120-V AC (rms) household supply voltage. Bulbs 1 and 2 have a power rating of 150 W, and bulb 3 has a 100-W rating. Find (a) the rms current in each bulb and (b) the resistance of each bulb. (c) What is the total resistance of the combination of the three lightbulbs?



* We know that V_{rms} is the same for all three lightbulbs.

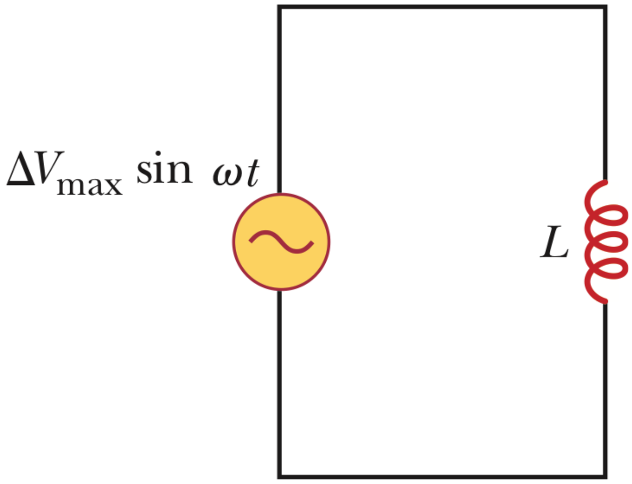
a) $I_{rms} = \dfrac{P_{avg}}{V_{rms}} = \dfrac{150}{120} = 1.25\ A$ { 1 & 2 }

$= \dfrac{100}{120} = 0.83\ A$ { 3 }

b) $R = \dfrac{V_{rms}}{I_{rms}} = 96\ \Omega$ & $144\ \Omega$

c) $\dfrac{1}{R_{eq}} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3} \Rightarrow R_{eq} = 36\ \Omega$

6. In a purely inductive AC circuit as shown in Figure P32.6, $\Delta V_{max} = 100$ V. (a) The maximum current is 7.50 A at $f =$ 50.0 Hz. Calculate the inductance L. (b) **What If?** At what angular frequency ω is the maximum current 2.50 A?



a) $X_L = \omega L = \frac{V_{max}}{I_{max}} \Rightarrow \boxed{L = \frac{V_{max}}{\omega I_{max}} = 42.4 \text{ mH}}$

$\omega = 2\pi f = 2\pi(50)$

b) $I_{max} = \frac{V_{max}}{X_L} = \frac{V_{max}}{\omega L} \Rightarrow \omega = \frac{V_{max}}{(2.5A) L}$

$\boxed{\omega = 943 \text{ rad/s}}$

$f = \frac{\omega}{2\pi} = \ldots$

9. An AC source has an output rms voltage of 78.0 V at a frequency of 80.0 Hz. If the source is connected across a 25.0-mH inductor, what are (a) the inductive reactance of the circuit, (b) the rms current in the circuit, and (c) the maximum current in the circuit?

(a) $X_L = \omega L = 2\pi f L = 12.6\ \Omega$

(b) $I_{rms} = \dfrac{V_{rms}}{X_L} = \dfrac{78}{12.6} = 6.21\ A$

(c) $I_{max} = \sqrt{2}\, I_{rms} = 8.78$

12. **Q|C** An AC source with an output rms voltage of 36.0 V at a frequency of 60.0 Hz is connected across a 12.0-μF capacitor. Find (a) the capacitive reactance, (b) the rms current, and (c) the maximum current in the circuit. (d) Does the capacitor have its maximum charge when the current has its maximum value? Explain.

(a) $X_c = \dfrac{1}{\omega C} = \dfrac{1}{2\pi f C} = 221\ \Omega$

(b) $I_{rms} = \dfrac{V_{c,rms}}{X_c} = 0.163\ A$

c) $I_{max} = \sqrt{2}\, I_{rms} = 0.23\ A$

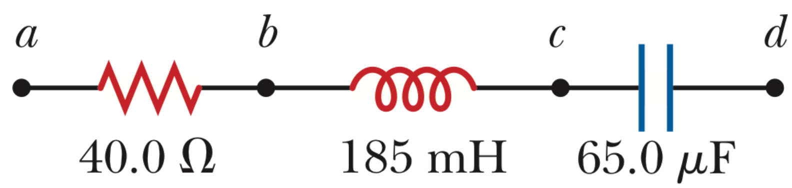
d) No, because current leads voltage.

13. What is the maximum current in a 2.20-μF capacitor when it is connected across (a) a North American electrical outlet having $\Delta V_{rms} = 120$ V and $f = 60.0$ Hz and (b) a European electrical outlet having $\Delta V_{rms} = 240$ V and $f = 50.0$ Hz?

$$I_{max} = \sqrt{2}\, I_{rms} = \sqrt{2}\, \frac{V_{rms}}{X_c} = \sqrt{2}\, V_{rms} (2\pi f C)$$

a) $I_{max} = 141$ mA ; (B) $I_{max} = 235$ mA

16. An AC source with $\Delta V_{max} = 150$ V and $f = 50.0$ Hz is connected between points a and d in Figure P32.16. Calculate



the maximum voltages between (a) points a and b, (b) points b and c, (c) points c and d, and (d) points b and d.

First, let's find:

$$X_C = \frac{1}{\omega C} = 49\,\Omega$$

$$X_L = \omega L = 58.1\,\Omega$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = 41\,\Omega$$

$$I_{max} = \frac{V_{max}}{Z} = 3.66\ A$$

(a) $V_R = I_{max} R = 146 \text{ V}$

(b) $V_L = I_{max} X_L = 212 \text{ V}$

(c) $V_c = I_{max} X_c = 179 \text{ V}$

(d) $V_L - V_c = 33.4 \text{ V}$

19. An *RLC* circuit consists of a 150-Ω resistor, a 21.0-μF capacitor, and a 460-mH inductor connected in series with a 120-V, 60.0-Hz power supply. (a) What is the phase angle between the current and the applied voltage? (b) Which reaches its maximum earlier, the current or the voltage?

$$X_L = 2\pi f L = 173\ \Omega$$

$$X_c = \frac{1}{2\pi f C} = 126\ \Omega$$

(a)

$$\phi = \tan^{-1}\left[\frac{X_L - X_c}{R}\right] = 17.4^\circ$$

(b) since $\phi > 0$, Voltage leads the current.

20. **Q|C** A 60.0-Ω resistor is connected in series with a 30.0-μF capacitor and a source whose maximum voltage is 120 V, operating at 60.0 Hz. Find (a) the capacitive reactance of the circuit, (b) the impedance of the circuit, and (c) the maximum current in the circuit. (d) Does the voltage lead or lag the current? (e) How will adding an inductor in series with the existing resistor and capacitor affect the current? Explain.

(a) $X_C = 88.4\ \Omega$

(b) $Z = 107\ \Omega$

(c) $I_{max} = \frac{V_{max}}{Z} = 1.12\ A$

(d) $\phi = -55.8^\circ < 0$

Current leads the voltage.

21. A series *RLC* circuit has a resistance of 45.0 Ω and an impedance of 75.0 Ω. What average power is delivered to this circuit when $\Delta V_{\text{rms}} = 210$ V?

R

Z

* Detailed answer

$$P = V_{rms} I_{rms} \cos\phi$$

$$I_{rms} = \frac{V_{rms}}{Z} = \frac{210}{75} = 2.8 \text{ A}$$

$$\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$$

$$X_L - X_C = \sqrt{Z^2 - R^2} = 60\ \Omega$$

$$\Rightarrow \phi = 53.1^\circ$$

$$\Rightarrow P = (210)(2.8)\cos(53.1^\circ)$$

$$= 353 \text{ W}$$

But the average power can be found directly by the following

$\Downarrow$

* Short & quick answer

$$P_{avg} = I_{rms}^2 R = (2.8)^2 (45) = 353 \text{ W}$$

23. A series *RLC* circuit has a resistance of 22.0 Ω and an impedance of 80.0 Ω. If the rms voltage applied to the circuit is 160 V, what average power is delivered to the circuit?

R Z V_{rms}

$$P_{avg} = I_{rms}^2 R = \left(\frac{V_{rms}}{Z}\right)^2 R = 88 \text{ W}$$

V_{max} $\omega = 2\pi f$

24. An AC voltage of the form $\Delta v = 90.0 \sin 350t$, where Δv is in volts and t is in seconds, is applied to a series *RLC* circuit. If $R = 50.0\ \Omega$, $C = 25.0\ \mu\text{F}$, and $L = 0.200$ H, find (a) the impedance of the circuit, (b) the rms current in the circuit, and (c) the average power delivered to the circuit.

a) $Z = \sqrt{R^2 + (X_L - X_C)^2}$; $X_L = \omega L$; $X_C = \frac{1}{\omega C}$

$$\Rightarrow \boxed{Z = 66.8\ \Omega}$$

b) $$I_{rms} = \frac{V_{rms}}{Z} = \frac{V_{max}}{\sqrt{2}\, Z} = 0.953 \text{ A}$$

c) $$P_{avg} = I_{rms}^2 R = 45.4 \text{ W}$$

25. The *LC* circuit of a radar transmitter oscillates at 9.00 GHz (f_0). (a) What inductance is required for the circuit to resonate at this frequency if its capacitance is 2.00 pF (C)? (b) What is the inductive reactance of the circuit at this frequency?

a)

$$\omega_0^2 = \frac{1}{LC} \Rightarrow L = \frac{1}{\omega_0^2 C} = \frac{1}{(2\pi f_0)^2 C} = 156 \text{ PH}$$

b) At resonance

$$X_L = X_C = \omega_0 L = \frac{1}{\omega_0 C} = 8.84\ \Omega$$

End

تم، مع تمنياتي لكم بالتوفيق

عبدالعزيز صالح القاسم

2026