Week 10 Homework

Physics 1B

March 15, 2007

1 Serway 21.14

No, a circuit consisting of a capacitor and an inductor would not dissipate energy. Both capacitors and inductors store energy without net dissipation, so the energy is available for later use.

2 Serway 21.17

Varying the resistance has no effect on the resonant frequency, however changing the capacitance and inductance can change it. If both are doubled, then the new resonant frequency is half the initial resonant frequency.

3 Serway 21.18

Components of RLC circuits don't experience their maximum voltage drops simultaneously, so Kirchoff's rules are not violated.

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10. $\Delta V_{max} = I_{max} X_c$ where $X_c = \frac{1}{2\pi f C}$

$$I_{max} = \Delta V_{max} \cdot 2\pi f C$$

$$= (48.0\ V)(2\pi)(90.0\ Hz)(3.70 \times 10^{-6}\ F)$$

$$\boxed{I_{max} = 0.10\ A}$$

16. $\Delta V_{RMS} = I_{RMS} X_L$ where $X_L = 2\pi f L$

$$L = \frac{\Delta V_{RMS}}{2\pi f I_{RMS}}$$

$$= \frac{\sqrt{2}\,\Delta V_{RMS}}{2\pi f I_{max}}$$

$$= \frac{\sqrt{2}(50.0\ V)}{2\pi(20.0\ Hz)(80.0 \times 10^{-3}\ A)}$$

$$= 7.03\ H$$

L must be greater than 7.03 H to keep the current less than 800 mA.

83. To tune a radio, we pick values of L & C so that the radio frequency and the circuit's natural frequency are equal:

$$f_{natural} = \frac{1}{2\pi\sqrt{LC}}$$

$$L = \frac{1}{4\pi^2 C f_{natural}^2}$$

$$= \frac{1}{4\pi^2(1.40 \times 10^{-12}\ F)(88.9 \times 10^6\ Hz)^2}$$

$$\boxed{L = 2.29 \times 10^{-6}\ H}$$

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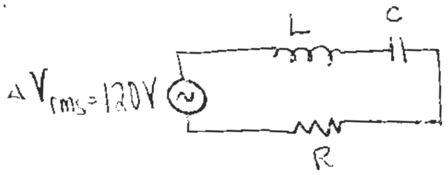
36.



$$P_{av} = I_{RMS}^2 R$$

$$I_{RMS} = \frac{\Delta V_{RMS}}{Z}$$

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

$$f_{natural} = \frac{1}{2\pi\sqrt{LC}}$$

$$X_L = 2\pi f L$$

$$X_C = \frac{1}{2\pi f C}$$

$$\therefore P_{av} = \frac{(\Delta V_{RMS})^2 R}{R^2 + \left(2\pi f L - \frac{1}{2\pi f C}\right)^2}$$

where $R = 30.0\,\Omega$
$\Delta V_{RMS} = 120\,V$
$C = 3.00 \times 10^{-6}\,F$
$L = 3.00\,H$

a) $f = f_{natural} = 53.05\,Hz$

$P_{av} = 480\,W$

b) $f = \frac{1}{2} f_{natural} = 26.5\,Hz$

$P_{av} = 0.192\,W$

c) $f = \frac{1}{4} f_{natural} = 13.3\,Hz$

$P_{av} = 3.07 \times 10^{-2}\,W$

d) $f = 2 f_{natural} = 106\,Hz$

$P_{av} = 0.192\,W$

e) $f = 4 f_{natural} = 212\,Hz$

$P_{av} = 3.07 \times 10^{-2}\,W$

Power delivered to circuit is maximized when generator frequency & circuit natural frequency are equal.

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44. $c = \dfrac{1}{\sqrt{\mu_0 \varepsilon_0}}$

$= \dfrac{1}{\sqrt{(4\pi \times 10^{-7}\ N \cdot s^2/C^2)(8.854 \times 10^{-12}\ C^2/N \cdot m^2)}}$

$\boxed{c = 2.998 \times 10^8\ m/s}$

51. $\lambda = c/f$

a) $f = 540 \times 10^3$ Hz $\rightarrow$ 555 m
$f = 1600 \times 10^3$ Hz $\rightarrow$ 187 m

$\boxed{187\ m \leq \text{AM wavelengths} \leq 555\ m}$

b) $f = 88 \times 10^6$ Hz $\rightarrow$ 3.4 m
$f = 108 \times 10^6$ Hz $\rightarrow$ 2.8 m

$\boxed{2.8\ m \leq \text{FM Wavelengths} \leq 3.4\ m}$

52. Radio time: $t = \dfrac{100 \times 10^3\ m}{2.998 \times 10^8\ m/s}$

$t = 0.333\ ms$

Newsroom time: $t = \dfrac{3.0\ m}{343\ m/s}$

$t = 8.75\ ms$

The radio listeners hear it first.

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62. a) $\lambda = c f \rightarrow f = c/\lambda$

$$= \frac{2.998\times10^{8}\ m/s}{3.0\times10^{-2}\ m}$$

$$= 9.99\times10^{9}\ Hz$$

Make this $f_{natural}$ for circuit

$$f_n = \frac{1}{2\pi\sqrt{LC}}$$

$$C = \frac{1}{2^2\pi^2 L f_n^2}$$

$$\boxed{C = 0.63\ pF}$$

b) $C = \frac{\epsilon_0 l^2}{d}$

$$l = \sqrt{\frac{Cd}{\epsilon_0}}$$

$$= \sqrt{\frac{(0.634\times10^{-12}\ F)(1.0\ mm)}{8.854\times10^{-12}\ C^2/N\ m^2}}$$

$$\boxed{l = 8.5\ mm}$$

c) $X_L = 2\pi f L$

$$= 2\pi(9.99\times10^{9}\ Hz)(400\times10^{-12}\ H)$$

$$\boxed{X_L = 25\ \Omega}$$

Note: $X_c = \frac{1}{2\pi f C}$

$$= \frac{1}{2\pi(9.99\times10^{9}\ Hz)(0.63\times10^{-12}\ F)}$$

$$= 25\ \Omega$$ ✓

IB HW Week 10

63. a) $\frac{E_{max}}{B_{max}} = c$

$$B_{max} = \frac{0.20 \times 10^{-6}\ V/m}{2.998 \times 10^{8}\ m/s}$$

$$\boxed{B_{max} = 6.7 \times 10^{-16}\ T}$$

b) $I = \frac{E_{max}^2}{2 \mu_0 c}$

$$= \frac{(0.20 \times 10^{-6}\ V/m)^2}{2(4\pi \times 10^{-7}\ Ns^2/c^2)(2.998 \times 10^{8}\ m/s)}$$

$$\boxed{I = 5.3 \times 10^{17}\ W/m^2}$$

c) $P_{av} = IA$

$$= (5.3 \times 10^{-17}\ W/m^2)\left[\pi \left(\frac{20.0\ m}{2}\right)^2\right]$$

$$\boxed{P_{av} = 1.7 \times 10^{-14}\ W}$$