

PH213 - Chapter 30 Homework Solutions

6)  $L = 180 \text{ mH} = 0.180 \text{ H}$        $E(\text{induced}) = (-)L \frac{dI}{dt} = (-)L \frac{\Delta I}{\Delta t}$   
 $E(\text{induced}) = (-)(0.180) \frac{(38.0 - 20.0)(10^{-3})}{(340)(10^{-3})} = (-) 9.53 \times 10^{-3} \text{ V}$

$E(\text{induced}) = (-) 9.53 \text{ mV}$

10)  $E = L \frac{\Delta I}{\Delta t} = L \frac{(I_0 - 0)}{\Delta t} = \frac{LI_0}{\Delta t}$        $I_0 = \frac{E \Delta t}{L}$

$I_0 = \frac{(35.0)(3.00 \times 10^{-3})}{(150 \times 10^{-3})} = 0.700 \text{ A}$

14)  $R = 2.70 \Omega$        $L = 0.418 \text{ H}$        $I = 5.00 \text{ A}$        $\frac{dI}{dt} = +4.50 \text{ A/s}$

Since the current is increasing, both voltages are decreasing.

$V = ?$        $V = V_R + V_L = IR + L \frac{dI}{dt} = (5.00)(2.70) + (0.418)(4.50)$

$V = 13.5 + 1.881 = \del{13.5} 15.4 \text{ V}$

18)  $U_L = ?$        $L = 400 \text{ mH} = 0.400 \text{ H}$        $I = 9.00 \text{ A}$

$U_L = \frac{1}{2} LI^2 = \frac{1}{2} (0.400)(9.00)^2 = 16.2 \text{ J}$

25)  $I = I_0 e^{-t/\tau}$        $\tau = \frac{L}{R}$        $V_R = IR = I_0 R e^{-t/\tau}$        $t = ?$

$V = V_0 e^{-t/\tau}$        $V = \frac{V_0}{100} = V_0 e^{-t/\tau}$        $\frac{1}{100} = e^{-t/\tau}$

$\ln(1/100) = -\frac{t}{\tau}$        $t = \tau \ln 100$        $\frac{t}{\tau} = \ln 100 = 4.61$

26) It is also going into heat dissipated by the resistor.

$$\text{Battery Power} = \text{Inductor Power} + \text{Resistor Power}$$

(This is the same as energy conservation, except all three terms have been divided by the elapsed time.)

$$\left. \begin{aligned} P_B &= IV = IV(\text{total}) = IV_0 \\ P_L &= \frac{dU}{dt} = LI \frac{dI}{dt} = I(V_0 - RI) \\ P_R &= \cancel{IV} = I(IR) = I^2R \end{aligned} \right\} \begin{aligned} IV_0 &= I(V_0 - RI) + I^2R \\ IV_0 &= IV_0 - I^2R + I^2R \\ IV_0 &= IV_0 \quad \checkmark \end{aligned}$$

$$31) (a) \quad \omega_0 = \frac{1}{\sqrt{LC}} \quad f_0 = \frac{1}{2\pi} \frac{1}{\sqrt{LC}}$$

$$\frac{f_{02}}{f_{01}} = \frac{\frac{1}{2\pi\sqrt{LC_2}}}{\frac{1}{2\pi\sqrt{LC_1}}} \quad \frac{f_{02}}{f_{01}} = \sqrt{\frac{C_1}{C_2}} \quad C_2 = C_1 \left( \frac{f_{01}}{f_{02}} \right)^2$$

$$C_2 = (1800 \text{ pF}) \left( \frac{550}{1600} \right)^2 = 213 \text{ pF}$$

$$(b) \quad f_0 = \frac{1}{2\pi} \frac{1}{\sqrt{LC}} \quad f_0^2 = \frac{1}{4\pi^2 LC}$$

$$L = \frac{1}{4\pi^2 f_0^2 C} = \left( 4\pi^2 (550 \times 10^3)^2 (1800 \times 10^{-12}) \right)^{-1}$$

$$L = 4.65 \times 10^{-5} \text{ H} = 46.5 \mu\text{H}$$

$$32)(a) \quad Q = Q_0 \cos(\omega t + \phi) \quad Q=0 \text{ at } t=0$$

$$Q(t) = Q_0 \sin(\omega t)$$

$$I(t) = \frac{dQ(t)}{dt} = Q_0 \omega \cos(\omega t)$$

$$I_0 = I(0) = Q_0 \omega = I_0$$

(b) Start a current running, and then remove the battery from the circuit just when the capacitor has no charge.

$$33) \text{ Units of } L = \text{Henry} \quad V_L = L \frac{\Delta I}{\Delta t} \quad \text{Volts} = \text{Henry} \frac{\text{Amp}}{\text{sec}}$$

$$\text{Units of } L = \frac{\text{Volt} \cdot \text{sec}}{\text{Amp}}$$

$$\text{Units of } C = \text{Farad}$$

$$V_C = \frac{Q}{C} \quad \text{Volts} = \frac{\text{Coulomb}}{\text{Farad}}$$

$$\text{Units of } C = \frac{\text{Coulomb}}{\text{Volt}}$$

$$\begin{aligned} \text{Units of } \frac{1}{\sqrt{LC}} &= (LC)^{-1/2} = \left( \frac{\text{Volt sec}}{\text{amp}} \frac{\text{Coulomb}}{\text{Volt}} \right)^{-1/2} \\ &= \left( \frac{\text{Coulomb sec}}{\text{amp}} \right)^{-1/2} = \left( \frac{\text{C} \cdot \text{sec}}{\text{C/sec}} \right)^{-1/2} = (\text{sec}^2)^{-1/2} = \text{sec}^{-1} \end{aligned}$$

$$35) \quad Q = Q_0 \cos(\omega t) \quad I = -\omega Q_0 \sin(\omega t) \quad U_L = U_C$$

$$U_L = \frac{1}{2} L I^2 = U_C = \frac{1}{2} Q V = \frac{1}{2} Q \left( \frac{Q}{C} \right) = \frac{1}{2} \frac{Q^2}{C} \quad L I^2 = \frac{Q^2}{C}$$

$$(a) \quad Q = I \sqrt{LC} = \frac{I}{\omega} \quad Q_0 \cos(\omega t) = \frac{-\omega Q_0 \sin(\omega t)}{\omega}$$

$$\sin(\omega t) = -\cos(\omega t) \quad \frac{\sin(\omega t)}{\cos(\omega t)} = -1 \quad \tan(\omega t) = -1$$

$$35(a) \quad \tan \theta = -1 \quad \theta = -\frac{\pi}{4} = \omega t$$

$$Q = Q_0 \cos(\omega t) = Q_0 \cos(-\pi/4) = Q_0 \frac{\sqrt{2}}{2} = \frac{\sqrt{2} Q_0}{2}$$

$$(b) \quad |\omega t| = \frac{\pi}{4} \quad t = \frac{\pi}{4\omega} \quad \omega = \frac{2\pi}{T}$$

$$t = \frac{\pi}{4\left(\frac{2\pi}{T}\right)} = \frac{\pi}{1} \frac{T}{8\pi} = \frac{T}{8}$$

$$38) \text{ Eq. 30-17} \quad L \frac{d^2 Q}{dt^2} + R \frac{dQ}{dt} + \frac{1}{C} Q = 0 \quad \text{take } \frac{d}{dt} \text{ of both sides}$$

$$(a) \quad L \frac{d^2 I}{dt^2} + R \frac{dI}{dt} + \frac{1}{C} I = 0$$

$$(b) \quad I = I_0 e^{-\frac{R}{2L}t} \cos(\omega' t + \phi) \quad \omega' = \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$$