HW 4 Solutions

32.4 $L = \mu_0 n^2 A \ell$ so $n = \sqrt{\dfrac{L}{\mu_0 A \ell}} = \boxed{7.80 \times 10^3 \text{ turns/m}}$

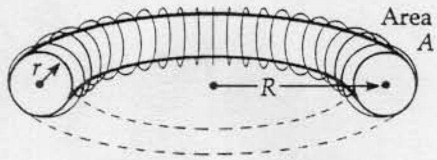
32.11 $|\mathcal{E}| = L\dfrac{dI}{dt} = (90.0 \times 10^{-3})\dfrac{d}{dt}(t^2 - 6t)$ V

(a) At $t = 1.00$ s, $\mathcal{E} = \boxed{360 \text{ mV}}$

(b) At $t = 4.00$ s, $\mathcal{E} = \boxed{180 \text{ mV}}$

(c) $\mathcal{E} = (90.0 \times 10^{-3})(2t - 6) = 0$ when $\boxed{t = 3.00 \text{ s}}$

32.14 $L = \dfrac{N\Phi_B}{I} = \dfrac{NBA}{I} \approx \dfrac{NA}{I} \cdot \dfrac{\mu_0 N I}{2\pi R} = \boxed{\dfrac{\mu_0 N^2 A}{2\pi R}}$



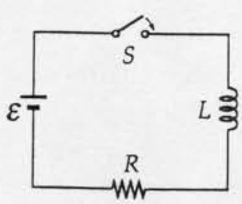
32.16 $I = \dfrac{\mathcal{E}}{R}(1 - e^{-Rt/L})$

$0.900\dfrac{\mathcal{E}}{R} = \dfrac{\mathcal{E}}{R}\left[1 - e^{-R(3.00\text{ s})/2.50\text{ H}}\right]$

$\exp\left(-\dfrac{R(3.00\text{ s})}{2.50\text{ H}}\right) = 0.100$

$R = \dfrac{2.50\text{ H}}{3.00\text{ s}}\ln 10.0 = \boxed{1.92\ \Omega}$

32.24 $I = I_{\max}\left(1 - e^{-t/\tau}\right)$



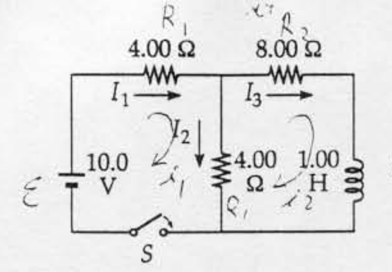
$0.980 = 1 - e^{-3.00\times10^{-3}/\tau}$

$0.0200 = e^{-3.00\times10^{-3}/\tau}$

$\tau = -\dfrac{3.00\times10^{-3}}{\ln(0.0200)} = 7.67\times10^{-4}$ s

$\tau = L/R$, so $L = \tau R = (7.67\times10^{-4})(10.0) = \boxed{7.67 \text{ mH}}$

32.25 Name the currents as shown. By Kirchhoff's laws:



$$I_1 = I_2 + I_3 \qquad (1)$$

$$+10.0\text{ V} - 4.00 I_1 - 4.00 I_2 = 0 \qquad (2)$$

$$+10.0\text{ V} - 4.00 I_1 - 8.00 I_3 - (1.00)\frac{dI_3}{dt} = 0 \qquad (3)$$

From (1) and (2), $+10.0 - 4.00 I_1 - 4.00 I_1 + 4.00 I_3 = 0$ and $I_1 = 0.500 I_3 + 1.25\text{ A}$

Then (3) becomes $10.0\text{ V} - 4.00(0.500 I_3 + 1.25\text{ A}) - 8.00 I_3 - (1.00)\frac{dI_3}{dt} = 0$

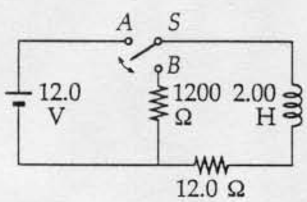
$$(1.00\text{ H})(dI_3/dt) + (10.0\ \Omega)I_3 = 5.00\text{ V}$$

We solve the differential equation using Equations 32.6 and 32.7:

$$I_3(t) = \frac{5.00\text{ V}}{10.0\ \Omega}\left[1 - e^{-(10.0\ \Omega)t/1.00\text{ H}}\right] = \boxed{(0.500\text{ A})\left[1 - e^{-10t/\text{s}}\right]}$$

$$I_1 = 1.25 + 0.500 I_3 = \boxed{1.50\text{ A} - (0.250\text{ A})e^{-10t/\text{s}}}$$

32.28 (a) $I = \frac{\mathcal{E}}{R} = \frac{12.0\text{ V}}{12.0\ \Omega} = \boxed{1.00\text{ A}}$



(b) Initial current is 1.00 A, : $\Delta V_{12} = (1.00\text{ A})(12.00\ \Omega) = \boxed{12.0\text{ V}}$

$\Delta V_{1200} = (1.00\text{ A})(1200\ \Omega) = \boxed{1.20\text{ kV}}$

$\Delta V_L = \boxed{1.21\text{ kV}}$

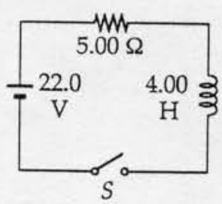
(c) $I = I_{\max} e^{-Rt/L}$: $\quad \frac{dI}{dt} = -I_{\max}\frac{R}{L}e^{-Rt/L}$ $\quad$ and $\quad -L\frac{dI}{dt} = \Delta V_L = I_{\max} R e^{-Rt/L}$

Solving $\quad 12.0\text{ V} = (1212\text{ V})e^{-1212t/2.00}$ $\quad$ so $\quad 9.90 \times 10^{-3} = e^{-606t}$

Thus, $\quad \boxed{t = 7.62\text{ ms}}$

32.31 $L = \frac{N\Phi_B}{I} = \frac{200(3.70 \times 10^{-4})}{1.75} = 42.3\text{ mH}$ $\quad$ so $\quad U = \frac{1}{2}LI^2 = \frac{1}{2}(0.423\text{ H})(1.75\text{ A})^2 = \boxed{0.0648\text{ J}}$

***32.36** (a) $U = \frac{1}{2}LI^2 = \frac{1}{2}(4.00\text{ H})(0.500\text{ A})^2 = \boxed{0.500\text{ J}}$



(b) $\frac{dU}{dt}$ ~~$= LI = (4.00\text{ H})(1.00\text{ A}) = 4.00\text{ J/s} = \boxed{4.00\text{ W}}$~~

(c) $\mathcal{P} = (\Delta V)I = (22.0\text{ V})(0.500\text{ A}) = \boxed{11.0\text{ W}}$

32.42 $M = \left|\frac{\mathcal{E}_2}{dI_1/dt}\right| = \frac{96.0 \text{ mV}}{1.20 \text{ A/s}} = \boxed{80.0 \text{ mH}}$

32.52 $f = \frac{1}{2\pi\sqrt{LC}}$: $L = \frac{1}{(2\pi f)^2 C} = \frac{1}{(2\pi \cdot 120)^2 (8.00\times 10^{-6})} = \boxed{0.220 \text{ H}}$

32.56 (a) $\omega_d = \sqrt{\frac{1}{LC} - \left(\frac{R}{2L}\right)^2} = \sqrt{\frac{1}{\left(2.20\times 10^{-3}\right)\left(1.80\times 10^{-6}\right)} - \left(\frac{7.60}{2\left(2.20\times 10^{-3}\right)}\right)^2} = 1.58\times 10^4 \text{ rad/s}$

Therefore, $f_d = \frac{\omega_d}{2\pi} = \boxed{2.51 \text{ kHz}}$

(b) $R_c = \sqrt{\frac{4L}{C}} = \boxed{69.9\ \Omega}$