PHYS 1304, Ch 32, 7th Ed Solutions

P32.3 $\varepsilon_{back} = -\varepsilon = L\dfrac{dI}{dt} = L\dfrac{d}{dt}(I_{max}\sin\omega t) = L\omega I_{max}\cos\omega t = (10.0\times10^{-3})(120\pi)(5.00)\cos\omega t$

$\varepsilon_{back} = (6.00\pi)\cos(120\pi t) = \boxed{(18.8\text{ V})\cos(377t)}$

P32.12 8 $L = \dfrac{N\Phi_B}{I} = \dfrac{NBA}{I} \approx \dfrac{NA}{I}\cdot\dfrac{\mu_0 NI}{2\pi R} = \boxed{\dfrac{\mu_0 N^2 A}{2\pi R}}$

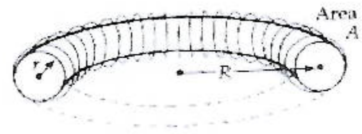

FIG. P32.12

P32.15 (a)

At time t, $I(t) = \dfrac{\varepsilon\left(1-e^{-t/\tau}\right)}{R}$

where $\tau = \dfrac{L}{R} = 0.200$ s.

After a long time, $I_{max} = \dfrac{\varepsilon\left(1-e^{-\infty}\right)}{R} = \dfrac{\varepsilon}{R}$.

At $I(t) = 0.500 I_{max}$ $(0.500)\dfrac{\varepsilon}{R} = \dfrac{\varepsilon\left(1-e^{-t/0.200\text{ s}}\right)}{R}$

so $0.500 = 1 - e^{-t/0.200\text{ s}}$.

Isolating the constants on the right, $\ln\left(e^{-t/0.200\text{ s}}\right) = \ln(0.500)$

and solving for t, $-\dfrac{t}{0.200\text{ s}} = -0.693$

or $t = \boxed{0.139\text{ s}}$.

(b) Similarly, to reach 90% of I_{max}, $0.900 = 1 - e^{-t/\tau}$

and $t = -\tau\ln(1-0.900)$.

Thus, $t = -(0.200\text{ s})\ln(0.100) = \boxed{0.461\text{ s}}$.

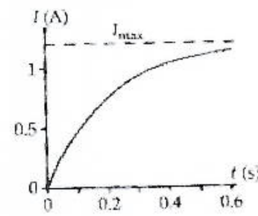

FIG. P32.15

P32.23 $L = \mu_0\dfrac{N^2A}{\ell} = \mu_0\dfrac{(68.0)^2\left[\pi\left(0.600\times10^{-2}\right)^2\right]}{0.0800} = 8.21\ \mu\text{H}$

$U = \dfrac{1}{2}LI^2 = \dfrac{1}{2}\left(8.21\times10^{-6}\text{ H}\right)(0.770\text{ A})^2 = \boxed{2.44\ \mu\text{J}}$

P32.39 When the switch has been closed for a long time, battery, resistor, and coil carry constant current $I_{max} = \dfrac{\varepsilon}{R}$. When the switch is opened, current in battery and resistor drops to zero, but the coil carries this same current for a moment as oscillations begin in the LC loop.

We interpret the problem to mean that the voltage amplitude of these oscillations is ΔV, in $\dfrac{1}{2}C(\Delta V)^2 = \dfrac{1}{2}LI_{max}^2$.

Then, $L = \dfrac{C(\Delta V)^2}{I_{max}^2} = \dfrac{C(\Delta V)^2R^2}{\varepsilon^2} = \dfrac{\left(0.500\times10^{-6}\text{ F}\right)(150\text{ V})^2(250\ \Omega)^2}{(50.0\text{ V})^2} = \boxed{0.281\text{ H}}$.

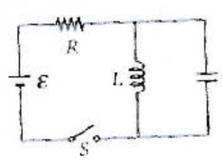

FIG. P32.50

*P32.59 48 (a) Let Q represent the magnitude of the opposite charges on the plates of a parallel plate capacitor, the two plates having area A and separation d. The negative plate creates electric field $\mathbf{E} = \dfrac{Q}{2\epsilon_0 A}$ toward itself. It exerts on the positive plate force $\mathbf{F} = \dfrac{Q^2}{2\epsilon_0 A}$ toward the negative plate. The total field between the plates is $\dfrac{Q}{\epsilon_0 A}$. The energy density is

$u_E = \dfrac{1}{2}\epsilon_0 E^2 = \dfrac{1}{2}\epsilon_0 \dfrac{Q^2}{\epsilon_0^2 A^2} = \dfrac{Q^2}{2\epsilon_0 A^2}$. Modeling this as a negative or inward pressure, we have for the force on one plate $F = PA = \dfrac{Q^2}{2\epsilon_0 A^2}$, in agreement with our first analysis.

(b) The lower of the two current sheets shown creates above it magnetic field $\mathbf{B} = \dfrac{\mu_0 J_s}{2}\left(-\hat{\mathbf{k}}\right)$. Let ℓ and w represent the length and width of each sheet. The upper sheet carries current $J_s w$ and feels force

$$\mathbf{F} = I\boldsymbol{\ell}\times\mathbf{B} = J_s w\ell \frac{\mu_0 J_s}{2}\hat{\mathbf{i}}\times\left(-\hat{\mathbf{k}}\right) = \frac{\mu_0 w\ell J_s^2}{2}\hat{\mathbf{j}}.$$

The force per area is $P = \dfrac{F}{\ell w} = \boxed{\dfrac{\mu_0 J_s^2}{2}}$.

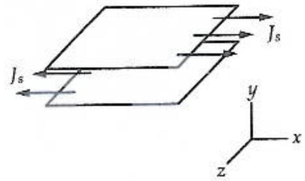

FIG. P32.59(b)

(c) Between the two sheets the total magnetic field is $\dfrac{\mu_0 J_s}{2}\left(-\hat{\mathbf{k}}\right) + \dfrac{\mu_0 J_s}{2}\left(-\hat{\mathbf{k}}\right) = \mu_0 J_s \hat{\mathbf{k}}$, with magnitude $\boxed{B = \mu_0 J_s}$. Outside the space they enclose, the fields of the separate sheets are in opposite directions and add to $\boxed{\text{zero}}$.

(d) $$u_B = \frac{1}{2\mu_0}B^2 = \frac{\mu_0^2 J_s^2}{2\mu_0} = \boxed{\frac{\mu_0 J_s^2}{2}}$$

(e) This energy density agrees with the magnetic pressure found in part (b).

P32.63 51 $\dfrac{1}{2}\dfrac{Q^2}{C} = \dfrac{1}{2C}\left(\dfrac{Q}{2}\right)^2 + \dfrac{1}{2}LI^2$ so $I = \sqrt{\dfrac{3Q^2}{4CL}}$.

The flux through each turn of the coil is $\Phi_B = \dfrac{LI}{N} = \boxed{\dfrac{Q}{2N}\sqrt{\dfrac{3L}{C}}}$

where N is the number of turns.

P32.73 66 $\mathscr{P} = I\Delta V$ $\quad I = \dfrac{\mathscr{P}}{\Delta V} = \dfrac{1.00\times10^9\ \text{W}}{200\times10^3\ \text{V}} = 5.00\times10^3\ \text{A}$

From Ampere's law, $B(2\pi r) = \mu_0 I_{\text{enclosed}}$ or $B = \dfrac{\mu_0 I_{\text{enclosed}}}{2\pi r}$.

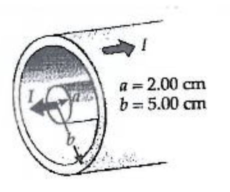

FIG. P32.73

(a) At $r = a = 0.020\,0\ \text{m}$, $I_{\text{enclosed}} = 5.00\times10^3\ \text{A}$

and $$B = \frac{\left(4\pi\times10^{-7}\ \text{T}\cdot\text{m/A}\right)\left(5.00\times10^3\ \text{A}\right)}{2\pi(0.020\,0\ \text{m})} = 0.050\,0\ \text{T} = \boxed{50.0\ \text{mT}}.$$

(b) At $r = b = 0.050\,0\ \text{m}$, $I_{\text{enclosed}} = I = 5.00\times10^3\ \text{A}$

and $$B = \frac{\left(4\pi\times10^{-7}\ \text{T}\cdot\text{m/A}\right)\left(5.00\times10^3\ \text{A}\right)}{2\pi(0.050\,0\ \text{m})} = 0.020\,0\ \text{T} = \boxed{20.0\ \text{mT}}.$$

(c) $$U = \int u\,dV = \int_a^b \frac{[B(r)]^2(2\pi r\ell dr)}{2\mu_0} = \frac{\mu_0 I^2\ell}{4\pi}\int_a^b \frac{dr}{r} = \frac{\mu_0 I^2\ell}{4\pi}\ln\left(\frac{b}{a}\right)$$

$$U = \frac{\left(4\pi\times10^{-7}\ \text{T}\cdot\text{m/A}\right)\left(5.00\times10^3\ \text{A}\right)^2\left(1\,000\times10^3\ \text{m}\right)}{4\pi}\ln\left(\frac{5.00\ \text{cm}}{2.00\ \text{cm}}\right) = 2.29\times10^6\ \text{J} = \boxed{2.29\ \text{MJ}}$$

(d) The magnetic field created by the inner conductor exerts a force of repulsion on the current in the outer sheath. The strength of this field, from part (b), is 20.0 mT. Consider a small rectangular section of the outer cylinder of length ℓ and width w.

It carries a current of $\left(5.00\times10^3\ \text{A}\right)\left(\dfrac{w}{2\pi(0.050\,0\ \text{m})}\right)$

and experiences an outward force

$$F = I\ell B\sin\theta = \frac{\left(5.00\times10^3\ \text{A}\right)w}{2\pi(0.050\,0\ \text{m})}\ell\left(20.0\times10^{-3}\ \text{T}\right)\sin 90.0^\circ.$$

The pressure on it is $P = \dfrac{F}{A} = \dfrac{F}{w\ell} = \dfrac{\left(5.00\times10^3\ \text{A}\right)\left(20.0\times10^{-3}\ \text{T}\right)}{2\pi(0.050\,0\ \text{m})} = \boxed{318\ \text{Pa}}$.

P2