By symmetry, B field is parallel to surface, and is perpendicular to direction of current. Take loop as shown, calculate $\int B \cdot \ dl$. Vertical sides do not contribute to integral. Contribution of horizontal sides is $B2L$. Current through loop is $\sigma L$. Therefore Ampere's law gives:

$$2BL = \int B \cdot dl = \mu_0 I = \mu_0 \sigma L \Rightarrow B = \frac{\mu_0 \sigma}{2}$$

From problem 7, B-field from each plate is of magnitude $\mu_0 \sigma / 2$. However, in the $y > 0$, $z > 0$, and $y < 0$, $z < 0$, segments, the fields of the two plates are in opposite directions, hence cancel. In other two segments, the magnitude is twice that of single plate, $\mu_0 \sigma$ (in direction shown).
\[ B = \mu_0 I n \quad n = \frac{260}{2} / \text{cm} = 130 / \text{cm} = 13,000 / \text{m} \]

\[ B = \left( 4\pi \times 10^{-7} \right) 8 \times 13,000 \quad T = 0.13 \text{T} \]

\[ \text{At radius } \frac{3}{2} R, \quad B = \frac{\mu_0 I}{2\pi \left( \frac{3}{2} R \right)} \quad \text{where } I = \text{current inside } \frac{3}{2} R \]

\[ I = I \left[ \frac{\frac{9}{4} R^2 - R^2}{4R^3 - R^2} \right] = I \left( \frac{5}{12} \right) \]

and

\[ B = \frac{\mu_0 \frac{5}{12} I}{3\pi R} = \frac{5\mu_0}{36\pi R} \]

At \( 3R \),

\[ B = \frac{\mu_0 I}{2\pi (3R)} = \frac{\mu_0 I}{6\pi R} \]

\[ \text{First thing to note is that, by symmetry, the forces on the } \]

\[ \text{18 cm part of the loop are equal and opposite for opposite sides, and hence cancel. Force on 12 cm side near wire is given by} \]

\[ F_1 = B_1 I' L \]

\[ B = \frac{\mu_0 I_0}{2\pi R} \]

\[ = 2.0 \times 10^{-7} \times \frac{40}{0.06} \quad T = 1.3 \times 10^{-4} \text{T} \]
4 continued

\[ F_1 = (1.3 \times 10^{-4} \times 60 \times 0.12) N = 9.6 \times 10^{-4} N \]

Force on other side is

\[ F_2 = B_2 l' L, B_2 = 2.0 \times 10^{-7} \times \frac{40}{0.24} - 3.33 \times 10^{-5} T \]

\[ F_2 = 3.33 \times 10^{-5} \times 60 \times 0.12 N = 2.4 \times 10^{-4} N \]

Since forces are in opposite directions, net force is

\[ 9.6 \times 10^{-4} - 2.4 \times 10^{-4} N = 7.2 \times 10^{-4} N \text{ towards long wire} \]

5 31-40

\[ B(x) = \frac{\mu_0 I}{2\pi} \left( \frac{1}{x} + \frac{1}{10r-x} \right) \]

\[ F = \int_0^r dF = \frac{\mu_0 I^2}{2\pi} \int_0^r \left( \frac{1}{x} + \frac{1}{10r-x} \right) dx \]

\[ = \frac{\mu_0 I^2}{2\pi} \left[ \ln x - \ln(10r-x) \right] \bigg|_{x=0}^{x=r} \]

\[ = \frac{2\mu_0 I^2}{2\pi} \ln 10 = \ln 10 = 0.2 \times 10^5 = 2 \times 10^4 N \]

\[ I = \sqrt{\frac{2 \times 10^4 \times \pi}{\mu_0 \ln 9}} = 1.5 \times 10^5 A \]
Antiparallel: \( U = mB \); parallel: \( U = -mB \) Therefore,
\[
\Delta U = 2mB = 2 \times 9.3 \times 10^{-24} \times 0.8 = 1.5 \times 10^{-23} J = 9.3 \times 10^{-5} \text{ eV}
\]

Magnet sweeps by coil inducing EMF due to changing B field. When EMF is large enough a spark will jump between the ends of the wire loop which are held very close to one another at the business end of the spark plug.

\[
\varepsilon = vBe; \text{ therefore, } v = \frac{\varepsilon}{Be} \quad B = 0.70 \text{ gauss} = 0.70 \times 10^{-4} \text{ Tm}
\]
\[
v = \frac{7.0 \times 10^{-3} \text{ V}}{(0.70 \times 10^{-4} \times 290) \text{ Tm}} = 0.5 \text{ ms}^{-1}
\]
32-4

By [Example 1 in the text], \( \varepsilon = Be^2\omega \pi \Rightarrow \psi = \frac{\varepsilon}{Be^2\pi} \)

\[
= \frac{6.0 \, \psi}{6.0 \times 10^{-2} \, T \times (1.2)^2 \pi \, s^{-1}} = 22 \, s^{-1}
\]

32-7

As in [Example 1], \( \varepsilon = Be^2\omega / 2 \), here \( \varepsilon \) = radius of star = 10,000 m

\[
\varepsilon = \frac{Be^2\omega \psi}{2} = Be^2\omega \pi = (10^3 T)(10,000)^2 \, m^2 \times (30 \times 1^{-1}) \pi = 9 \times 10^{17} \, V
\]

As in [Problem 6], \( \varepsilon = Be^2\omega \psi = 0.65 \times 10^{-4} \times (4.0)^2 \times 3 \times \pi = 9.8 \times 10^{-3} \, V
\]

32-10

\( \varepsilon = B\alpha \omega \sin \omega t \) (12); therefore, amplitude of the voltage is \( B\alpha \omega \)

\[
B\alpha \omega = \text{Ampl} \Rightarrow \omega = \frac{\text{Ampl}}{BA} \Rightarrow \psi = \frac{2\pi \text{Ampl}}{2\pi \omega BA} = \frac{12.0 \, \psi}{2\pi \left(2.0 \times 10^{-2} \, T \right) \left(0.02 \, m^2 \right)} = \frac{4.8 \times 10^3 \, s^{-1}}{120} = 40
\]
(a) \( B = \mu_0 n I \cdot \frac{dB}{dt} = \mu_0 n \frac{dI}{dt} = \left( 4\pi \times 10^{-7} \right) (300) 50 = 1.9 \times 10^{-2} \text{ T/s} \)

(b) In every turn of the coil, \( \varepsilon = -\frac{d\Phi}{dt} = -\frac{d}{dt} (BA) \); therefore, for every 120 turns, \( \varepsilon = -120 \frac{d}{dt} (BA) = -120 (A) \frac{dB}{dt} = -120 [\pi (0.03)^2] \frac{dB}{dt} = -6.45 \times 10^{-3} \text{ V} \)

32-13

Force on the rod = \( I \int d\varepsilon \cdot B = B_0 I e \), since \( B \) is perpendicular to \( e \), and constant, and \( I = \frac{\varepsilon}{R} \), and by Faraday's law \( \varepsilon = -\frac{d\Phi}{dt} = -(\text{Area}) \frac{dB}{dt} = -\mu_0 \varepsilon \frac{dB}{dt} \); therefore,

\[
I = \frac{\varepsilon}{R} = -\frac{\mu_0 \varepsilon}{R} \frac{dB}{dt}
\]

Therefore,

acceleration \( a = F/m \)

\[
a = -\frac{B_0 I e}{m} = \frac{B_0 e}{m} \left( -\mu_0 \varepsilon \frac{dB}{dt} \right) = -\frac{B_0 e^2 \mu_0}{mR} \frac{dB}{dt}
\]

(Minus sign indicates that force is in direction shown.)