**Problem 5.6**

(a) $v = \omega r$, so $\boxed{K = \sigma \omega r.}$ (b) $\mathbf{v} = \omega r \sin\theta\,\hat{\boldsymbol{\phi}} \Rightarrow \boxed{\mathbf{J} = \rho \omega r \sin\theta\,\hat{\boldsymbol{\phi}},}$ where $\rho \equiv Q/(4/3)\pi R^3$.

**Problem 5.8**

(a) Use Eq. 5.35, with $z = R, \theta_2 = -\theta_1 = 45°$, and four sides: $B = \boxed{\dfrac{\sqrt{2}\mu_0 I}{\pi R}}$.

(b) $z = R,\ \theta_2 = -\theta_1 = \dfrac{\pi}{n}$, and $n$ sides: $B = \boxed{\dfrac{n\mu_0 I}{2\pi R}\sin(\pi/n).}$



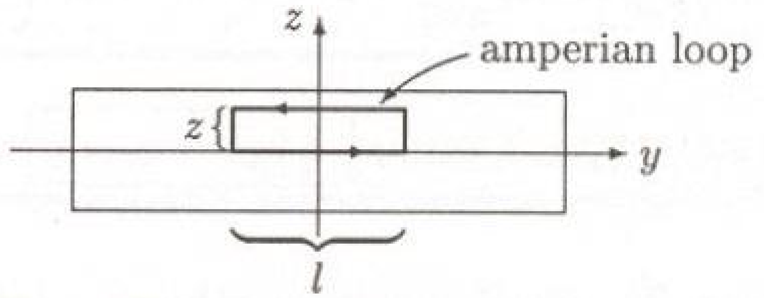
(c) For small $\theta$, $\sin\theta \approx \theta$. So as $n \to \infty, B \to \dfrac{n\mu_0 I}{2\pi R}\left(\dfrac{\pi}{n}\right) = \boxed{\dfrac{\mu_0 I}{2R}}$ (same as Eq. 5.38, with $z = 0$).

**Problem 5.14**

By the right-hand-rule, the field points in the $-\hat{\mathbf{y}}$ direction for $z > 0$, and in the $+\hat{\mathbf{y}}$ direction for $z < 0$. At $z = 0, B = 0$. Use the amperian loop shown:

$\oint \mathbf{B} \cdot d\mathbf{l} = Bl = \mu_0 I_{enc} = \mu_0 l z J \Rightarrow \boxed{\mathbf{B} = -\mu_0 J z\,\hat{\mathbf{y}}}$ $(-a < z < a)$. If $z > a, I_{enc} = \mu_0 l a J$,

so $\boxed{\mathbf{B} = \begin{cases} -\mu_0 J a\,\hat{\mathbf{y}}, & \text{for } z > +a; \\ +\mu_0 J a\,\hat{\mathbf{y}}, & \text{for } z > -a. \end{cases}}$



**Problem 5.19**

(a) $\rho = \dfrac{\text{charge}}{\text{volume}} = \dfrac{\text{charge}}{\text{atom}} \cdot \dfrac{\text{atoms}}{\text{mole}} \cdot \dfrac{\text{moles}}{\text{gram}} \cdot \dfrac{\text{grams}}{\text{volume}} = (e)(N)\left(\dfrac{1}{M}\right)(d)$, where

$$\begin{aligned} e &= \text{charge of electron} &&= 1.6 \times 10^{-19}\,\text{C},\\ N &= \text{Avogadro's number} &&= 6.0 \times 10^{23}\,\text{mole},\\ M &= \text{atomic mass of copper} &&= 64\,\text{gm/mole},\\ d &= \text{density of copper} &&= 9.0\,\text{gm/cm}^3. \end{aligned}$$

$$\rho = (1.6 \times 10^{-19})(6.0 \times 10^{23})\left(\frac{9.0}{64}\right) = \boxed{1.4 \times 10^4\,\text{C/cm}^3.}$$

(b) $J = \dfrac{I}{\pi s^2} = \rho v \Rightarrow v = \dfrac{I}{\pi s^2 \rho} = \dfrac{1}{\pi(2.5 \times 10^{-3})(1.4 \times 10^4)} = \boxed{9.1 \times 10^{-3}\,\text{cm/s},}$ or about 33 cm/hr. This is astonishingly small—literally slower than a snail's pace.

(c) From Eq. 5.37, $f_m = \dfrac{\mu_0}{2\pi}\left(\dfrac{I_1 I_2}{d}\right) = \dfrac{(4\pi \times 10^{-7})}{2\pi} = \boxed{2 \times 10^{-7}\,\text{N/cm}.}$

(d) $E = \frac{1}{2\pi\epsilon_0}\frac{\lambda}{d}$; $f_e = \frac{1}{2\pi\epsilon_0}\left(\frac{\lambda_1\lambda_2}{d}\right) = \frac{1}{v^2}\frac{1}{2\pi\epsilon_0}\left(\frac{I_1 I_2}{d}\right) = \left(\frac{c^2}{v^2}\right)\frac{\mu_0}{2\pi}\left(\frac{I_1 I_2}{d}\right) = \frac{c^2}{v^2}f_m$, where $c \equiv 1/\sqrt{\epsilon_0\mu_0} = 3.00 \times 10^8$ m/s. Here $\frac{f_e}{f_m} = \frac{c^2}{v^2} = \left(\frac{3.0 \times 10^{10}}{9.1 \times 10^{-3}}\right)^2 = \boxed{1.1 \times 10^{25}.}$

$f_e = (1.1 \times 10^{25})(2 \times 10^{-7}) = \boxed{2 \times 10^{18} \text{ N/cm.}}$