Solutions to MT-03 (FALL 2014, PHYS-205B)

MT-03, prob 1

$$\frac{1}{2}mv^2 = qV \Rightarrow V = \sqrt{\frac{2qV}{m}} = \sqrt{\frac{2\times 1.6\times 10^{-19}\times 350}{9.1\times 10^{-31}}} = 1.11\times 10^{7}\ \frac{m}{s}$$

$$qvB = \frac{mv^2}{R} \Rightarrow R = \frac{mv}{qB} = \frac{9.1\times 10^{-31}\times 1.11\times 10^{7}}{1.6\times 10^{-19}\times 0.2} = 3.16\times 10^{-4}\ m$$

MT-03, prob 2

Case: No rolling

$$F = IdB$$

$$FL = \frac{1}{2}mv^2$$

$$\Rightarrow v = \sqrt{\frac{2IdBL}{m}}$$

Case: with rolling

$$F = IdB$$

$$FL = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 \qquad I = \frac{1}{2}MR^2$$

$$= \frac{3}{4}mv^2$$

$$\Rightarrow v = \sqrt{\frac{4}{3}\frac{IdBL}{m}}$$

MT-03, prob 3

$$L = 2\pi R \Rightarrow R = \frac{L}{2\pi} = \frac{4.80\times 10^{-2}\ m}{2\pi} = 7.64\times 10^{-3}\ m$$

$$A = \pi R^2$$

$$\tau = IAB = 4.40\times\left(\pi\times\left[7.64\times 10^{-3}\right]^2\right)\times 1.50$$

$$= 1.21\times 10^{-3}\ N\text{-}m$$

MT-03, prob 4

$$B = \frac{\mu_0 I}{2\pi r} = \frac{4\pi \times 10^{-7} \times 4.75}{2\pi \times 35.5 \times 10^{-2}}$$

$$= 2.68 \times 10^{-6} \text{ T}$$

MT-03, prob 5

$$B_P = \frac{1}{2} B_{\infty\text{-wire}} + \frac{1}{2} B_{\infty\text{-wire}} + \frac{1}{2} B_{\text{loop}}$$

$$= \frac{\mu_0 I}{4\pi a} + \frac{\mu_0 I}{4\pi a} + \frac{\mu_0 I}{4a}$$

$$= \frac{\mu_0 I}{2\pi a} + \frac{\mu_0 I}{4a}$$

$$= \frac{\mu_0 I}{4\pi a}(2 + \pi)$$

Direction : Out of page.

MT-03, prob 6

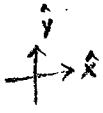
$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{in}$$

$$B\, 2\pi r = \mu_0 (I_1 - I_2)$$

$$B = \frac{\mu_0 (I_1 - I_2)}{2\pi\, 3d}$$

$$= \frac{4\pi \times 10^{-7} \times (1.18 - 3.04)}{2\pi \times 3 \times 1 \times 10^{-3}}$$

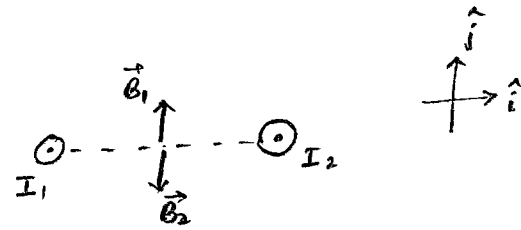
$$= 1.24 \times 10^{-4} \text{ T}$$



Direction : $-\hat{y}$

or clockwise about the wire.

MT-03, prob 7



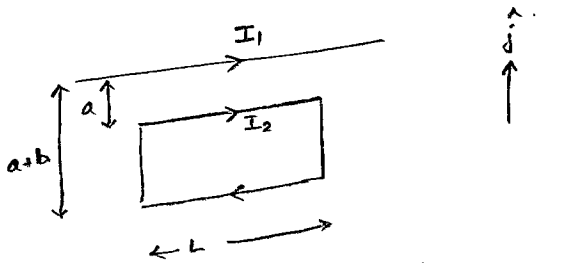
$$\vec{B}_{tot} = \vec{B}_1 + \vec{B}_2$$

$$= \frac{\mu_0 I_1}{2\pi \frac{d}{2}} \hat{j} - \frac{\mu_0 I_2}{2\pi \frac{d}{2}} \hat{j}$$

$$= \frac{\mu_0 (I_1 - I_2)}{\pi d} \hat{j}$$

$$= \frac{4\pi \times 10^{-7} \times (2.50 - 5.25)}{\pi \times 23 \times 10^{-2}} \hat{j} = -4.78 \times 10^{-6}\ T\ \hat{j}$$

MT-03, prob 8



$$\vec{F} = \frac{\mu_0 I_1 I_2 L}{2\pi a} \hat{j} - \frac{\mu_0 I_1 I_2 L}{2\pi (a+b)} \hat{j}$$

$$= \frac{\mu_0 I_1 I_2 L}{2\pi} \left[\frac{1}{a} - \frac{1}{a+b} \right] \hat{j}$$

$$= \frac{4\pi \times 10^{-7} \times 30 \times 20 \times 48 \times 10^{-2}}{2\pi} \left[\frac{1}{1.0 \times 10^{-2}} - \frac{1}{9.0 \times 10^{-2}} \right] \hat{j} = 5.12 \times 10^{-3}\ N\ \hat{j}$$

(attractive)

MT-03, prob 9

$$B = \mu_0 I n \quad \Rightarrow \quad \frac{mv}{qR} = \mu_0 I n \quad \Rightarrow \quad I = \frac{9.1 \times 10^{-31} \times 0.0452 \times 2.99 \times 10^8}{1.6 \times 10^{-19} \times 3.20\ \text{cm} \times \frac{145}{\text{cm}} \times 4\pi \times 10^{-7}}$$

$$= 0.132\ A$$

$$\frac{mv^2}{R} = qvB$$

MT-03, prob 10

$$4L = 2\pi R$$

$$\frac{R}{L} = \frac{2}{\pi}$$

$$\phi_{circle} = B \pi R^2 \quad \Rightarrow \quad \frac{\phi_{circle}}{\phi_{square}} = \pi \left(\frac{R}{L}\right)^2 = \frac{4}{\pi}$$

$$\phi_{square} = B L^2$$

$$\phi_{circle} = \frac{4}{\pi} \times 3.9 \times 10^{-3}\ Wb$$

$$= 4.97 \times 10^{-3}\ Wb$$