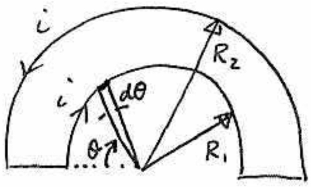
Ch 27. # 4, 5, 17, 19, 25, 44, 50,

# 4




$$dB(R_1) = \frac{\mu_0 i}{4\pi} \frac{d\vec{s}\times\vec{r}}{r^3} \quad \otimes$$

$$= \frac{\mu_0 i}{4\pi} \frac{ds}{R_1^2}$$

$$= \frac{\mu_0 i}{4\pi} \frac{R_1 d\theta}{R_1^2} = \underline{\frac{\mu_0 i}{4\pi R_1} d\theta}$$

$$dB(R_2) = \frac{\mu_0 i}{4\pi} \frac{d\vec{s}\times\vec{r}}{r^3} = \underline{\frac{\mu_0 i}{4\pi R_2} d\theta} \quad \odot$$

$$dB(R_1+R_2) = \frac{\mu_0 i}{4\pi R_1} - \frac{\mu_0 i}{4\pi R_2} d\theta$$

Because $|dB(R_1)| > |dB(R_2)|$ & opposite directions

$$= \frac{\mu_0 i}{4\pi} \left( \frac{1}{R_1} - \frac{1}{R_2} \right) d\theta$$

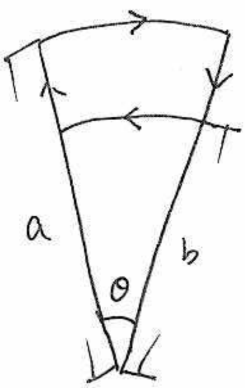
$$\therefore \; B(R_1+R_2) = \int dB = \int_0^{\pi} \frac{\mu_0 i}{4\pi} \left( \frac{1}{R_1} - \frac{1}{R_2} \right) d\theta$$

$$= \frac{\mu_0 i}{4} \left( \frac{1}{R_1} - \frac{1}{R_2} \right) \otimes$$

$$= \frac{4\pi\times10^{-7} \cdot 0.281}{4} \left( \frac{1}{0.0315} - \frac{1}{0.0780} \right)$$

$$= \underline{\underline{1.67072122 1\times10^{-6}\,T \otimes}}$$

# 5




Very similar to # 4

$R_1 \to b$

$R_2 \to a$

limits $(0 \to \pi) \to (0 \to \theta)$

$$\therefore \; B(a+b) = \int_0^{\theta} \frac{\mu_0 i}{4\pi} \left( \frac{1}{b} - \frac{1}{a} \right) d\theta$$

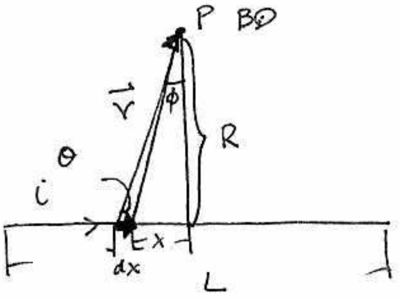
$$= \frac{\mu_0 i}{4\pi} \left( \frac{1}{b} - \frac{1}{a} \right) \theta \quad \odot$$

Do not forget to use "Radians".

$$= \frac{4\pi\times10^{-7} \cdot 0.411}{4\pi} \left( \frac{1}{0.107} - \frac{1}{0.135} \right) \cdot \left( 74^\circ \cdot \frac{\pi}{180} \right)$$

$$= \underline{\underline{1.028943183\times10^{-7}\,T \odot}}$$

#17




$$dB = \frac{\mu_0 i}{4\pi} \frac{d\vec{x} \times \vec{r}}{r^3}$$

$$= \frac{\mu_0 i}{4\pi} \frac{dx \cdot r}{r^3} \sin\theta \qquad r = (x^2 + R^2)^{1/2}$$

$$= \frac{\mu_0 i}{4\pi} \frac{R\,dx}{(x^2+R^2)^{3/2}} \qquad \sin\theta = \frac{R}{r} = \frac{R}{(x^2+R^2)^{1/2}}$$

Let $\tan\phi = \frac{x}{R}$

$x = R\tan\phi$

$dx = R\sec^2\phi\, d\phi$

$$= \frac{\mu_0 i}{4\pi} \frac{R(R\sec^2\phi\, d\phi)}{(R^2\tan^2\phi + R^2)^{3/2}}$$

$$= \frac{\mu_0 i}{4\pi} \frac{R^2}{R^3} \frac{\sec^2\phi}{\sec^3\phi} d\phi$$

$$= \frac{\mu_0 i}{4\pi R} \cdot \cos\phi\, d\phi$$

$$\therefore \quad B = \int dB = \int \frac{\mu_0 i}{4\pi R} \cos\phi\, d\phi$$

$$= \frac{\mu_0 i}{4\pi R} \sin\phi \Big|$$

$$= \frac{\mu_0 i}{4\pi R} \frac{x}{(x^2+R^2)^{1/2}}\Bigg|_{-\frac{1}{2}L}^{+\frac{1}{2}L} = 2\frac{\mu_0 i}{4\pi R} \frac{x}{(x^2+R^2)^{1/2}}\Bigg|_{0}^{\frac{1}{2}L}$$

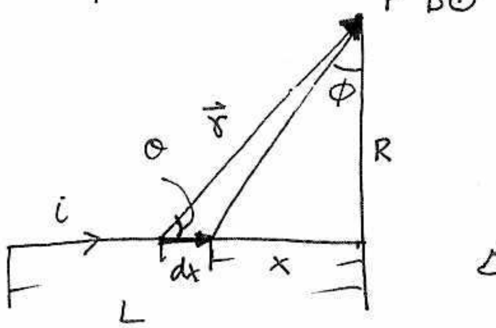
$$= 2\frac{\mu_0 i}{4\pi R}\left[\frac{\frac{1}{2}L}{((\frac{1}{2}L)^2+R^2)^{1/2}} - 0\right]$$

$$= \frac{\mu_0 i}{4\pi R} \frac{L}{(\frac{1}{4}L^2+R^2)^{1/2}} = \frac{\mu_0 i}{2\pi R} \frac{L}{(L^2+4R^2)^{1/2}}$$

$$= \frac{4\pi\times10^{-7} \cdot (58.2\times10^{-3})}{2\pi\,(0.131)} \cdot \frac{(0.18)}{((0.18)^2 + 4(0.131)^2)^{1/2}}$$

$$= \underline{\underline{5.031516772\times10^{-8}\ \mathrm{T} \quad \odot}}$$

\# 19




The set up is exactly the same as # 17. I will skip dB part since it is shown in # 17. The only difference between these problems is the limits.

$$B = \int dB = \int \frac{\mu_0 i}{4\pi R} \cos\phi \, d\phi$$

$$= \frac{\mu_0 i}{4\pi R} \sin\phi \Big| = \frac{\mu_0 i}{4\pi R} \frac{x}{(x^2+R^2)^{1/2}} \Big|_{-L}^{0}$$

$$= 0 - \frac{\mu_0 i}{4\pi R} \frac{-L}{(L^2+R^2)^{1/2}}$$

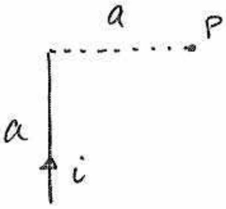
$$= \frac{\mu_0 i}{4\pi R} \frac{L}{(L^2+R^2)^{1/2}}$$

$$= \frac{4\pi \times 10^{-7} \cdot (0.693)}{4\pi\ (0.251)} \cdot \frac{(0.136)}{\left((0.136)^2 + (0.251)^2\right)^{1/2}}$$

$$= \underline{\underline{1.315308451 \times 10^{-7}\ \mathrm{T}\ \odot}}$$

\# 25

If you can do # 17 & 19, this problem is just a combination of these. You should be able to start from the very beginning (dB part – but that is shown in # 17). I will modify # 19.

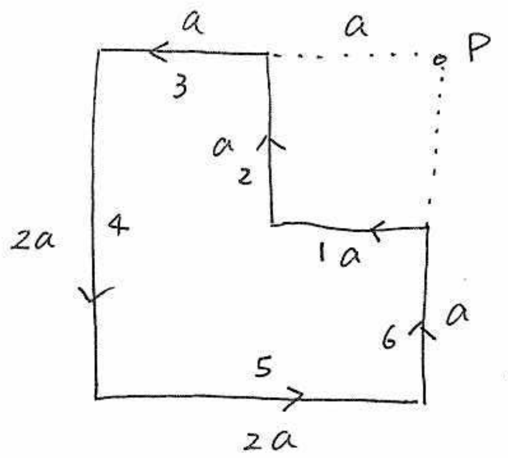



$$B = \frac{\mu_0 i}{4\pi R} \frac{L}{(L^2+R^2)^{1/2}} \quad \begin{cases} L = a \\ R = a \end{cases}$$

$$= \frac{\mu_0 i}{4\pi a} \frac{a}{(a^2+a^2)^{1/2}}$$

$$= \frac{\mu_0 i}{4\pi} \frac{1}{(2a^2)^{1/2}}$$

$$= \frac{\mu_0 i}{4\pi} \frac{1}{\sqrt{2}\,a} \cdot \frac{\sqrt{2}}{\sqrt{2}} = \underline{\underline{\frac{\sqrt{2}\,\mu_0 i}{8\pi a}}}$$




$$B_1 = B_2 = \frac{\sqrt{2}\,\mu_0 i}{8\pi a} \quad (\text{down at } P)$$

$$B_3 = B_6 = 0$$

$$B_4 = B_5 = \frac{\sqrt{2}\,\mu_0 i}{8\pi\,(2a)} \quad (\text{up})$$

$$\therefore \sum B_i = \frac{\sqrt{2}\,\mu_0 i}{8\pi a} \times 2 - \frac{\sqrt{2}\,\mu_0 i}{8\pi\,(2a)} \times 2$$

$$= \frac{\sqrt{2}\,\mu_0 i}{8\pi a} \quad (\text{down})$$

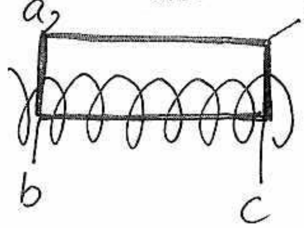
$$= \frac{\sqrt{2} \cdot 4\pi \times 10^{-7} \cdot (13)}{8\pi\,(0.047)}$$

$$= \underline{\underline{1.95582726\overline{7} \times 10^{-5}\ \text{T}\ \otimes}}$$

As you can see, these problems are very similar. the point is that the application of the B-S law is very limited. Make sure you can solve these questions w/o any problem — practice!

#44

Solenoid




Ampere's Law

$$\oint B \cdot dS = \mu_o i$$

$$= \int_a^b B \cdot dS + \int_b^c B \cdot dS + \int_c^d B \cdot dS + \int_d^a B \cdot dS$$

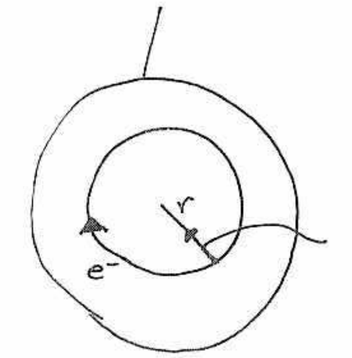
$$= 0 + \int_b^c B \cdot dS + 0 + 0$$

$$= B \cdot \overline{bC} = \mu_o i_{inside}$$

$$B \cdot \overline{bc} = \mu_o i \, n \, \overline{bc} \qquad n: \text{\# turns/unit length}$$

$$\therefore \quad B = \mu_o i n \quad \text{———} \quad (1)$$

Solenoid




$$F_{centri} = F_B$$

$$m_e \frac{V^2}{r} = eV \times B \quad \text{———} \quad (2)$$

(2) ← (1)

$$m_e \frac{V^2}{r} = eV(\mu_o i n)$$

$$i = \frac{m_e V}{\mu_o e n r}$$

$$= 2.71856537 \times 10^{-1} \text{ Amp}$$

$V = 0.046\ c \quad (c = 3.0 \times 10^8 \text{ m/sec})$

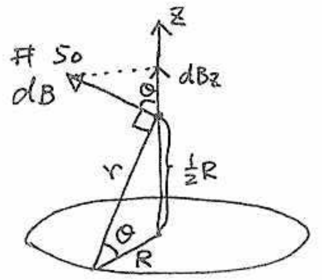
$e = 1.6 \times 10^{-19}\ C$

$n = 10000$ Turns/m

$r = 2.3$ cm $= 0.023$ m

$m_e = 9.11 \times 10^{-31}$ kg

#50




calculate $dB_z$ by one loop. $B_{Total}$ is Twice as much.

$$dB = \frac{\mu_o i}{4\pi} \frac{d\vec{s} \times r}{r^3} \qquad r^2 = (\tfrac{1}{2}R)^2 + R^2$$

$$= \frac{\mu_o i}{4\pi} \frac{dS}{r^2} \qquad = \tfrac{5}{4} R^2$$

$$= \frac{\mu_o i}{4\pi} \frac{dS}{\frac{5}{4} R^2} = \frac{\mu_o i}{5\pi} \frac{dS}{R^2}$$

$$dB_\perp = dB \cos\theta$$

$$= \frac{\mu_o i}{5\pi R^2} \cdot dS \cdot \frac{R}{r} = \frac{\mu_o i}{5\pi R^2} \cdot dS \cdot \frac{R}{\sqrt{\frac{5}{4}}\, R} = \frac{2\mu_o i}{5\sqrt{5}\,\pi R^2} \cdot dS$$

$$B_{single\ loop} = \oint dB_\perp = \frac{2\mu_o i}{5\sqrt{5}\,\pi R^2} \cdot 2\pi R = \frac{4\mu_o i}{5\sqrt{5}\, R}$$

$$B_{n\ loops} = \frac{4n\mu_o i}{5\sqrt{5}\, R}$$

$$B_{Total} = B_{n\ loops} \times 2 = \frac{8n\mu_o i}{5\sqrt{5}\, R} = \frac{8 \cdot 200 \cdot 4\pi \times 10^{-7} \cdot 12.2 \times 10^{-3}}{5\sqrt{5} \cdot 0.25} = 8.77596054 7 \times 10^{-6}\ T$$