Ch 12 homework solutions

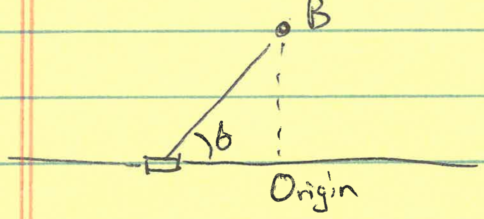
16) a) See figure from Section 12.2 in OpenStax

From 12.7 (and also see equation in homemade problem shee[t] from chapter 12 tutorials):

$$B(x) = \mu_0 I\, 2a \,/\, 4\pi x\sqrt{x^2+a^2} \qquad \text{where } x = 3\cdot10^{-2}\,m, \quad 2a = 5\cdot10^{-4}\,m$$

$$= \boxed{5.56\cdot10^{-7}\ T}$$

b) Figure 12.5 applies here, with the origin now below Point B



$$B(B) = \frac{\mu_0 I}{4\pi R}\left[\frac{x}{\sqrt{x^2+R^2}}\right]_{-4.025\cdot10^{-2}\,m}^{-3.975\cdot10^{-2}\,m}$$

where $R = 3\cdot10^{-2}\,m$ $\boxed{= 1.2\cdot10^{-7}\ T}$

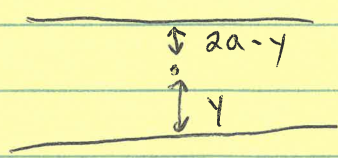
18) The contributions from the short horizontal segments are zero ($\sin 0° = 0$)

The contributions from semi-circles are half that from full circles.

$$\vec{B}_{net} = \vec{B}_{outer-semi} + \vec{B}_{inner-semi} = \boxed{\frac{\mu_0 I}{4b}\odot + \frac{\mu_0 I}{4a}\otimes}$$

21) $B(semi) = B(line) \Rightarrow \dfrac{\mu_0 I}{4R} = \dfrac{\mu_0 I}{2\pi a} \Rightarrow \boxed{a = 2R/\pi}\ (+\hat{j})$

29) $\vec{B}_{net} = \dfrac{\mu_0 I}{2\pi}\left(\dfrac{1}{y} + \dfrac{1}{2a-y}\right)\otimes$



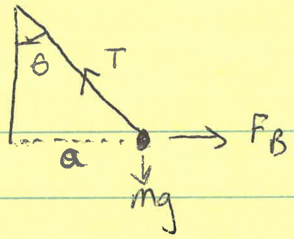
$$\frac{d\vec{B}_{net}}{dy} = \frac{\mu_0 I}{2\pi}\left(-\frac{1}{y^2} + \frac{1}{(2a-y)^2}\right) = 0$$

$$\Rightarrow \boxed{y = a}$$

This is a local minimum (and not maximum) since $\dfrac{d^2B}{dy^2} > 0$ at y=

$B = \dfrac{\mu_0 I}{2\pi 2a} \Rightarrow F = \dfrac{\mu_0 I^2 L}{2\pi 2a}$ $\qquad a = l\sin\theta$

32)



$T\cos\theta = mg\ ,\quad T\sin\theta = \mu_0 I^2 L / 2\pi 2a$

$\Rightarrow \tan\theta = \mu_0 I^2 / 2\pi 2a \frac{m}{L} g$

$\Rightarrow I = \sqrt{4\pi a \frac{m}{L} g \tan\theta / \mu_0} = \sqrt{4\pi l \sin\theta \frac{m}{L} g \tan\theta / \mu_0} = \boxed{40.2\ A}$

36) $B = \mu_0 N I / 2R \Rightarrow N = B2R/\mu_0 I = \boxed{15}$

38) $B(y) = \mu_0 I R^2 / 2(y^2+R^2)^{3/2}$ (12.15) $\qquad B(0) = \mu_0 I / 2R$

$\Rightarrow \dfrac{\mu_0 I R^2}{2(y^2+R^2)^{3/2}} = \dfrac{\mu_0 I}{4R} \Rightarrow (y^2+R^2)^{3/2} = 2R^3 \Rightarrow y = R\sqrt{2^{2/3}-1} = \boxed{0.7}$

42)
a) $\mu_0 I(2A) = 2.51\cdot10^{-6}$ T·m
b) $\mu_0 I(9A) = 1.13\cdot10^{-5}$ T·m
c) 0
d) $\mu_0 I(2A) = 2.51\cdot10^{-6}$ T·m
e) $\mu_0 I(-5A) = -6.28\cdot10^{-6}$ T·m

46)
a) $\oint \vec{B}\cdot\vec{dl} = \mu_0 I_{enc} = 0$
b) $I_{encl} = I\dfrac{\pi 4^2 - \pi 3^2}{\pi 5^2 - \pi 3^2} = 0.4375 I$

$B\cdot 2\pi r = \mu_0\, 0.4375 I \Rightarrow B = \boxed{1.09\cdot10^{-4}\ T}$ clockwise

c) $B\cdot 2\pi r = \mu_0 I \Rightarrow B = \boxed{1.7\cdot10^{-4}\ T}$

52) Equation 12.27: $B = \dfrac{\mu_0 I N}{2L}(\sin\theta_2 - \sin\theta_1)$ $\qquad N=500 \quad I=4.0A \quad L=0.40m$

a) $\theta_2 = 85.7108°$ $\quad \theta_1 = -85.7108°$ $\Rightarrow B = \boxed{6.27\cdot10^{-3}T}$
b) $\theta_2 = 81.4692°$ $\quad \theta_1 = -87.1376°$ $\Rightarrow B = \boxed{6.24\cdot10^{-3}T}$
c) $\theta_2 = 73.3008°$ $\quad \theta_1 = -87.5460$ $\Rightarrow B = \boxed{6.15\cdot10^{-3}T}$