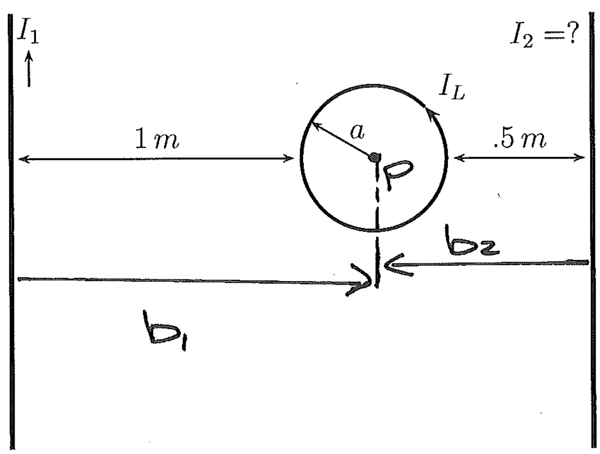
PHYSICS 161 TEST 6

(a) Two infinitely-long, parallel wires and a circular loop of radius $a = 0.35\,m$ are all in the same plane and arranged as shown. The first wire has current $I_1 = 5\,A$ flowing through it as shown. The current loop has current $I_L = 0.8\,A$ flowing through it in the counter-clockwise sense. If the net magnetic field (from the two wires and the current loop) at the center of the loop is $\vec{B}_{Net} = 3 \times 10^{-7}\,T, \otimes$, how much and in what direction is the current, I_2, flowing through the second wire? *(5pts)*



$\downarrow I_2$

By RHR,

$$\vec{B}_1 = \frac{\mu_0 I_1}{2\pi b_1}, \otimes$$

$$\vec{B}_L = \frac{\mu_0 I_L}{2a}, \odot$$

$$b_1 = 1m + a = 1m + .35m = 1.35m \Rightarrow B_1 = \frac{\mu_0}{2\pi}\frac{I_1}{b_1} = \frac{(2\times10^{-7}\,T\cdot m/A)(5A)}{1.35m}$$

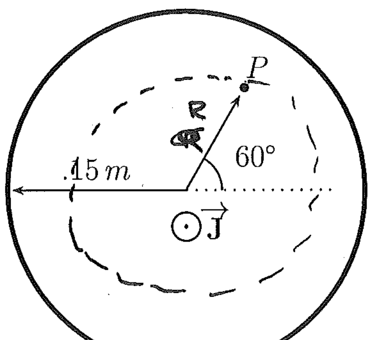
$$\Rightarrow B_1 = 7.4074\times10^{-7}\,T, \quad B_L = \frac{(4\pi\times10^{-7}\,T\cdot m/A)(0.8A)}{2(.35m)} = 1.436\times10^{-6}\,T = 14.36\times10^{-7}\,T$$

$\vec{B}_{NET} = \vec{B}_1 + \vec{B}_L + \vec{B}_2$ Let $\otimes$ be positive $\Rightarrow 3\times10^{-7}T = 7.4074\times10^{-7}T - 14.36\times10^{-7}T + B_2$

$$\Rightarrow B_2 = 9.9526\times10^{-7}\,T \Rightarrow \vec{B}_2 = 9.9526\times10^{-7}\,T, \otimes \Rightarrow \boxed{I_2 = \downarrow}$$

$$B_2 = \frac{\mu_0 I_2}{2\pi b_2} \quad b_2 = .5m + .35m = .85m \Rightarrow I_2 = \frac{B_2 b_2}{(\mu_0/2\pi)} = \frac{(9.9526\times10^{-7}T)(.85m)}{2\times10^{-7}T} \Rightarrow \boxed{I_2 = 4.23A}$$

(b) The 0.15-m-radius wire, whose cross-section is shown below, has a total current of 6 A flowing through it. Assuming the current density $\vec{J}$ in the wire is constant and points out of the page, use Ampere's Law to find the magnitude and direction of the magnetic field at the point P which is 0.10 m from the center of the wire. *(5pts)*



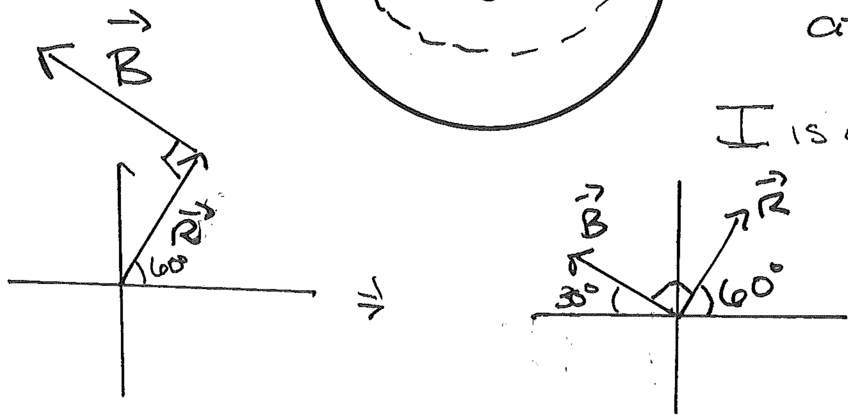
By symmetry

$\int \vec{B}\cdot d\vec{\ell} = B(2\pi R)$

at R = .1m

I is out of page

RHR ⇒



$\vec{B}$ at 30°

OR 150° standard Angle

Ampere's Law: $\oint \vec{B}\cdot d\vec{\ell} = \mu_0 I_{encl} \Rightarrow B(2\pi R) = \mu_0 I_{encl}$

$I_{encl} = \int \vec{J}\cdot d\vec{A} = \int_0^R J(2\pi r)\,dr$. Constant $J \Rightarrow I_{encl} = J(\pi R^2)$

$J = \frac{I_{total}}{A_{total}} = \frac{6A}{\pi(.15m)^2} \Rightarrow I_{encl} = \frac{6A}{\pi(.15m)^2}\pi(.1m)^2 = 2.666...\,A$

$\therefore B = \frac{\mu_0 I_{encl}}{2\pi R} = \frac{\mu_0}{2\pi}\frac{I_{encl}}{R} = \frac{(2\times10^{-7}\,T\cdot m/A)(2.666A)}{.1m} \Rightarrow \boxed{B = 5.33\times10^{-6}T}$