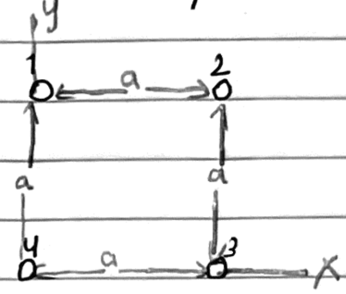
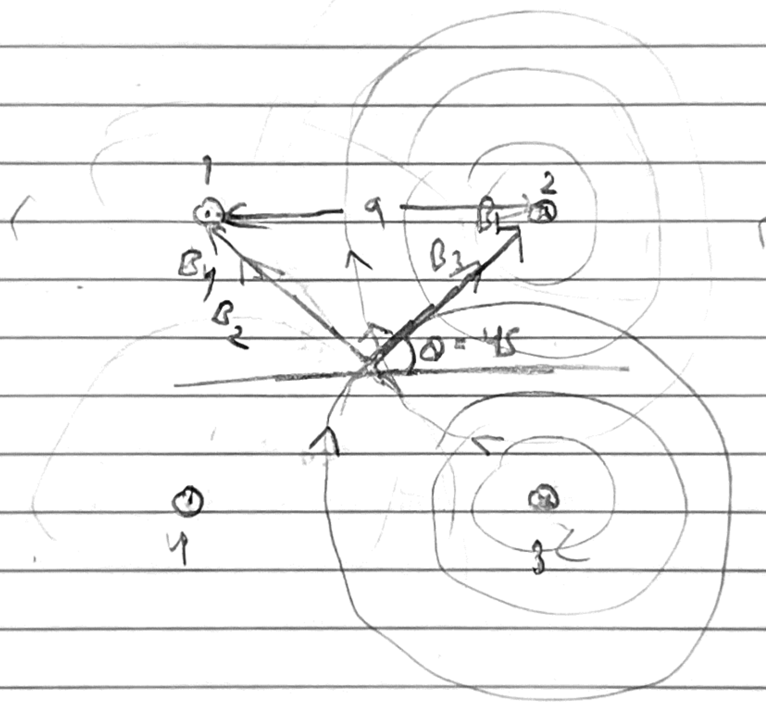
سارمجار

Principles of physics (10th eddition)
phy 132
CH 29: Magnetic fields Due currents
Problems: 5, 6, 21, 25, 34, 35, 53, 58

P5: In Fig 29-26, four long straight wires are perpendicular to this page and their cross sections form a squre of edge length $a = 40\,cm$. The currents are out of the page in wires 1 and wires 4 and into the page in wires 2 and 3 and each wire carries 12A. In unit-vector notation what is the net magnetic field at the squar's center?



Sol:



نحدد اتجاه B باستخدام
قاعدة اليد اليمنى

$$B = \frac{\mu_0 i}{2\pi R}$$

$B_1 = B_2 = B_3 = B_4$ since $i_1 = i_2 = i_3 = i_4 = i$

$R_1 = R_2 = R_3 = R_4 = \frac{1}{2}\sqrt{a^2 + a^2} = \frac{\sqrt{2}}{2} a$

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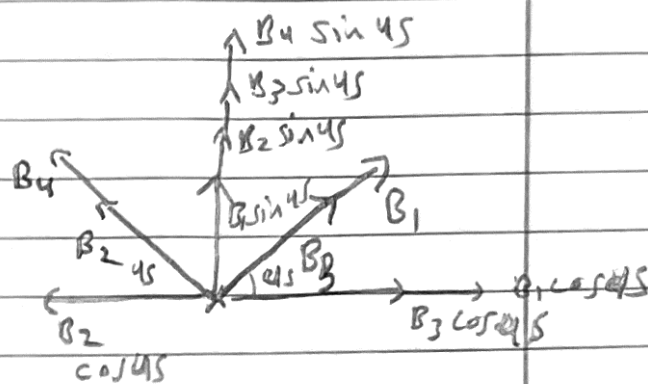
$$B = \frac{\mu_0 \cdot i}{2\pi R} = \frac{(4\cancel{\pi} \times 10^{-7})(12)}{\cancel{2\pi}\left(a\frac{\sqrt{2}}{\cancel{2}}\right)}$$

$$= \frac{48 \times 10^{-7}}{a\sqrt{2}}$$

$$= \frac{48 \times 10^{-7}}{(0.4 \times \sqrt{2})}$$

$$= 8.845 \times 10^{-6}\ T$$



$$\Sigma B_x = B_1 \cos 45 + B_3 \cos 45 - B_2 \cos 45 - B_4 \cos 45$$
$$= 0$$

$$\Sigma B_y = B_1 \sin 45 + B_2 \sin 45 + B_3 \sin 45 + B_4 \sin 45$$

but $B_1 = B_2 = B_3 = B_4 = B$

$$\Sigma B_y = 4B \sin 45$$
$$= 4 \times 8.845 \times 10^{-6} \times \sin 45$$
$$= 2.4 \times 10^{-5}\ T\ \hat{j}$$
$$= 24 \times 10^{-6}\ T\ \hat{j}$$
$$= (24\ \mu T)(\hat{j})$$

$$B_{net} = \sqrt{\Sigma B_x^2 + \Sigma B_y^2} = \sqrt{0 + \Sigma B_y^2} = (24\ \mu T)\ \hat{j}$$

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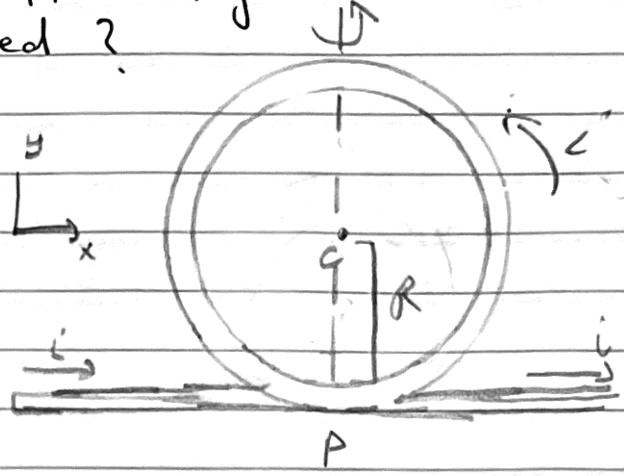
P_6: In Fig 29-27, part of a long insulated wire carrying current $i = 5.78\,mA$ is bent into a circular section of radius $R = 1.54\,cm$. In unit-vector notation, what is the magnetic field at the center of curvature C if the circular section (a) lies in the plane of the page as shown and (b) is perpendicular to the plane of the page after being rotated 90° counterclockwise as indicated?



Sol:

a) $\vec{B}$ due to long wire $= \dfrac{\mu_0 i}{2\pi r} = \dfrac{\mu_0 i}{2\pi R}$

$\vec{B}$ due circular Loop $= \dfrac{\mu_0 i}{2R}$

$$\vec{B}_{net} = \frac{\mu_0 i}{2\pi R}\,\hat{k} + \frac{\mu_0 i}{2R}\,\hat{k}$$

$$= \frac{\mu_0 i}{2R}\left(\frac{1}{\pi} + 1\right)\hat{k}$$

$$= \frac{4\pi \times 10^{-7} \times 5.78 \times 10^{-3}}{2 \times 1.54 \times 10^{-2}}\left(\frac{1}{3.14} + 1\right)\hat{k}$$

$$\vec{B}_{net} = 3.107 \times 10^{-7}\ T\ \hat{k}$$

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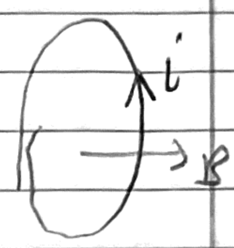
b) circular loop 90° counterclockwise

$$\vec{B}_{net} = \vec{B}_{loop} + \vec{B}_{wire}$$

$$= \frac{\mu_0 i}{2R}\,\hat{i} + \frac{\mu_0 i}{2\pi R}\,\hat{k}$$

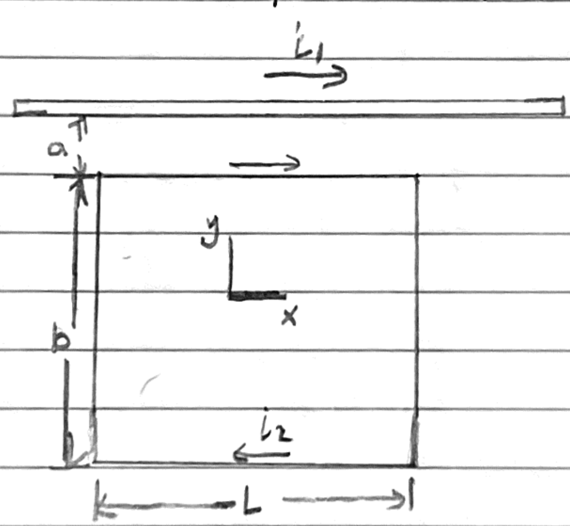
$$= \frac{4\pi\times10^{-7}\times5.78\times10^{-3}}{2\times1.54\times10^{-2}}\,\hat{i} + \frac{4\pi\times10^{-7}\times5.78\times10^{-3}}{2\pi\times1.54\times10^{-2}}\,\hat{k}$$



$$= 2.35\times10^{-7}\,T\,\hat{i} + 7.51\times10^{-8}\,T\,\hat{k}$$

$$= (23.5\,\hat{i} + 7.51\,\hat{k})\times10^{-8}\,T$$

P21: In Fig 29-36, a long straight wire carries a current $i_1 = 30.0\,A$ and a rectangular loop carries current $i_2 = 20.0\,A$. Take the dimensions to be $a = 1.00\,cm$, $b = 8.00\,cm$ and $L = 20.0\,cm$. In unit-vector notation What is the net force on the loop due to i_1?



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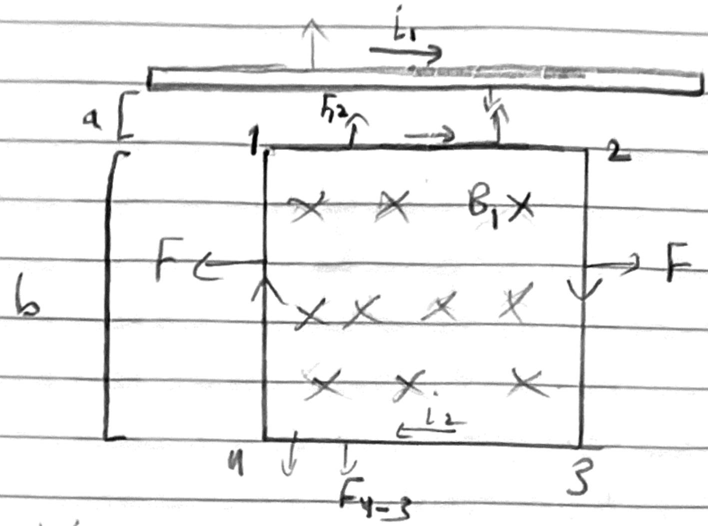
$i_1 = 30\,A$, $i_2 = 20\,A$

$a = 1\,cm = 0.01\,m$, $b = 8\,cm = 0.08\,m$

$L = 20\,cm = 0.20\,m$



* الاسلاك التي يسري فيها تيار بنفس الاتجاه يحدث بينها تجاذب
* الاسلاك التي يسري فيها تيار متعاكس في الاتجاه يحدث بينها تنافر

* The force between two parallel conductor carrying current is given by

$$F = \frac{\mu_0 L\, i_1 i_2}{2\pi d}$$

* The direction of magnetic field due to i_1 (B_1) is in to the page

* باستخدام قاعدة اليد اليمنى

$$\vec{F}_{2-3} + \vec{F}_{4-1} = 0$$

$$\int_a^{a+b} \frac{\mu_0 i_1 i_2}{2\pi y}\,dy - \int_a^{a+b} \frac{\mu_0 i_1 i_2}{2\pi y} = 0$$

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$$\vec{F}_{1-2} = \frac{\mu_0 i_1 i_2 L}{2\pi a} \hat{j}$$

$$\vec{F}_{3-4} = \frac{\mu_0 i_1 i_2 L}{2\pi(a+b)} (-\hat{j})$$

$$\vec{F}_{net} = \vec{F}_{1-2} + \vec{F}_{3-4}$$

$$= \left(\frac{\mu_0 i_1 i_2 L}{2\pi a} - \frac{\mu_0 i_1 i_2 L}{2\pi(a+b)}\right) \hat{j}$$

$$= \left[\frac{\mu_0 i_1 i_2 L}{2\pi} \left(\frac{1}{a} - \frac{1}{a+b}\right)\right] \hat{j}$$

$$= \left[\frac{\cancel{4}^{2}\cancel{\pi} \times 10^{-7} \times 30 \times 20 \times 0.2}{\cancel{2\pi}} \left(\frac{1}{0.01} - \frac{1}{0.01+0.08}\right)\right] \hat{j}$$

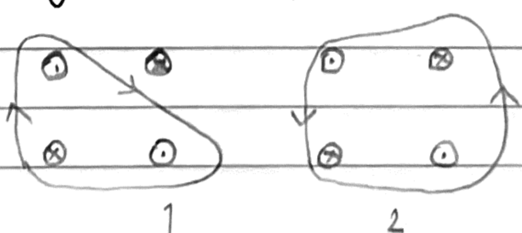
$$= \left[2.4 \times 10^{-5} \left(100 - \frac{1}{0.09}\right)\right] \hat{j}$$

$$= \left[2.4 \times 10^{-5} \left(100 - \frac{100}{9}\right)\right] \hat{j}$$

$$= 2.13 \times 10^{-3}\ N\ (\hat{j})$$

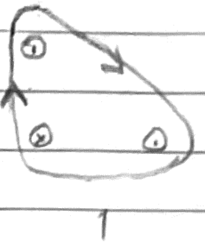
$$= 2.13\ mN\ (\hat{j})$$

P25: Each of the eight conductors in Fig 29-40 carries 5.0 A of current into or out of the page. Two paths are indicated for the line integral $\oint \vec{B} \cdot d\vec{s}$. What is the value of the integral for (a) path 1 and (b) path 2 ?



1 2

سارة دبابنة



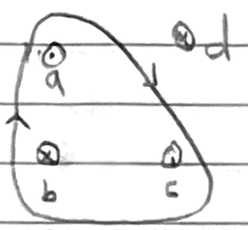
a) using Ampere's law

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 i$$

, where is the line integral is around closed-loop called (Amperian loop)

* The current i in the eq is the net current encircled by the loop.

* $\oint \vec{B} \cdot d\vec{s}$ for path 1



Since the path traversed in the clockwise direction, a current into the page is positive and a current out of the page is negative

$\Rightarrow$ $i_{enc} = -\cancel{i_a} + \cancel{i_b} - \cancel{i_c}$, note: i_d is out of the Amperian loop

$\Rightarrow$ $i_{enc} = -5\,A$

so use Ampere's law

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 i = \mu_0 (-5) = 4\pi \times 10^{-7} \times -5$$

$\Rightarrow$ $\oint \vec{B} \cdot d\vec{s} = -6.28 \times 10^{-6}$ T.m

$= -6.28\ \mu$T.m

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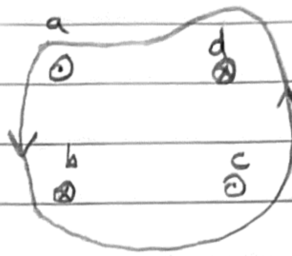
?? b) since the path is traversed in counterclockwise direction, a current into the page is negative, a current out of the page is positive.



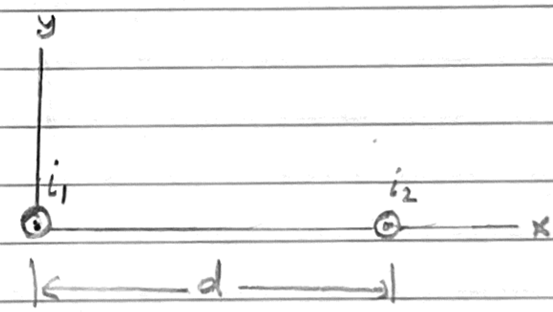
$i_{enc} = i_a - i_b + i_c - i_d = 0$

$\Rightarrow \oint B \cdot ds = \mu_0 i$

$= \mu_0 (0)$

$\oint B \cdot ds = 0$

P34: In Fig. 29-45, two long straight wires at separation $d = 30.0$ cm carry currents $i_1 = 3.61$ mA and $i_2 = 4.00 i_1$ out of the page (a) Where on the x axis is the net magnetic field equal to zero? (b) If the two currents are doubled, is the zero-field point shifted toward wire 1 shifted toward wire 2 or unchanged?

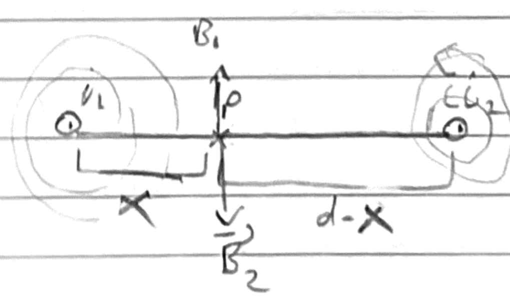


Sol: $i_1 = i = 3.61$ mA

$i_2 = 4 i$

both wire carry current in the same direction

$\Rightarrow$ the magnetic field cacel in the region between them



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$B_1 = \frac{\mu_0 i_1}{2\pi x} \, (\hat{j})$, $B_2 = \frac{\mu_0 i_2}{2\pi (d-x)} \, (-\hat{j})$

$B_{net} = 0$

$\Rightarrow \frac{\cancel{\mu_0} i_1}{\cancel{2\pi} x} = \frac{\cancel{\mu_0} i_2}{\cancel{2\pi}(d-x)}$

$\frac{i_1}{x} = \frac{i_2}{(d-x)}$

$\frac{\cancel{i_1}}{x} = \frac{4\cancel{i_1}}{d-x}$

$d-x = 4x$
$d = 5x$

$\Rightarrow x = \frac{d}{5} = \frac{30\,cm}{5} = 6\,cm$

so the net magnetic field is zero at 6 cm from wire 1

b) If the current is doubled the zero point field is unchanged

$i_1 = i \Rightarrow i_1' = 2i$
$i_2 = 4 i_1 = 4i \Rightarrow i_2' = 8i$

$\frac{i_1'}{x} = \frac{i_2'}{d-x}$

$\frac{2i}{x} = \frac{8i}{d-x} \Rightarrow$

$\frac{i}{x} = \frac{4i}{d-x}$

$4x = d-x \Rightarrow 5x = d$

$x = \frac{d}{5} = 6\,cm$

ساعدني

P35: The current density $\vec{J}$ inside along, solid, cylindrical wire of radius $a = 4.5$ mm is in the direction of the central axis and its magnitude varies linearly with radial distance r from the axis according to $J = \frac{J_o r}{a}$ where

$J_o = 420$ A/m². Find the magnitude of the magnetic field at (a) $r=0$ (b) $r=a/2$ (c) $r=a$

sol: $i_{enc} = \int J \, dA$

$$= \int \frac{J_o r}{a} (2\pi r)\, dr$$

$$= \frac{2J_o\pi}{a} \int_0^r r^2 dr$$

$$= \frac{J_o 2\pi}{a} \frac{r^3}{3}$$

$$\oint \vec{B} \cdot d\vec{s} = \mu_o i_{enc}$$

$$B\,(\cancel{2\pi r}) = \mu_o J_o \frac{(\cancel{2\pi r})(r^2)}{3a}$$

$$B = \frac{\mu_o J_o r^2}{3a}$$

a) $r=0 \Rightarrow B(r=0) = 0$

b) $r = a/2 \Rightarrow B = \frac{\mu_o J_o (a/2)^2}{3a} = \frac{\mu_o J_o a^2}{(3a)\, 4} = \frac{\mu_o J_o a}{12}$

$$\Rightarrow B = \frac{4\pi \times 10^{-7} \times 420 \times 4.5 \times 10^{-3}}{12} = 1.9782 \times 10^{-7}$$

$\simeq 0.20 \times 10^{-6}$ T

$\simeq 0.20\ \mu$T

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(c) $r = a$

$$B = \frac{\mu_0 J_0 r^2}{3a}$$

$$B(r=a) = \frac{\mu_0 J_0 a^2}{3a}$$

$$B = \frac{\mu_0 J_0 a^{\cancel{2}}}{3\cancel{a}}$$

$$B = \frac{\mu_0 J_0 a}{3}$$

$$B = \frac{4\pi \times 10^{-7} \times 420 \times 4.5 \times 10^{-3}}{3}$$

$$B = 7.9128 \times 10^{-7}\ T$$

$$B = 0.79 \times 10^{-6}\ T$$

$$B = 0.79\ \mu T$$

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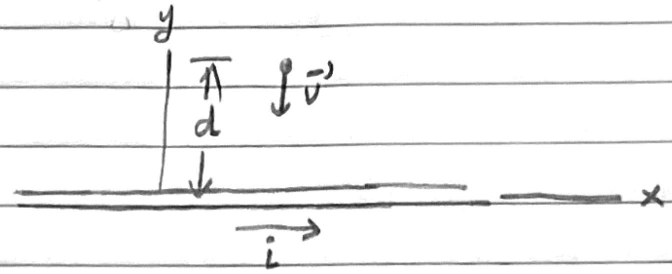
P53: Figure 29-58 Shows a snapshot of a proton moving at velocity $\vec{v} = (-380\ m/s)\hat{j}$ toward a long straight wire with current $i = 470\ mA$. At the instant shown, the proton's distance from the wire is $d = 2.89\ cm$. In unit-vector notation What is the magnetic force on the proton due to the current



sol: $V = -380\ m/s\ \hat{j}$

$i = 470\ mA = 470 \times 10^{-3}\ A$

$d = 2.89\ cm = 2.89 \times 10^{-2}\ m$

$$B = \frac{\mu_0 i}{2\pi r}$$

يتعرض P لمجال مغناطيسي مصدره السلك والذي سيؤثر عليه بقوة مغناطيسية $F = q\vec{V} \times \vec{B}$

$$= \frac{4\pi \times 10^{-7} \times 470 \times 10^{-3}}{2 \times 3.14 \times 2.89 \times 10^{-2}}$$

$$= 3.25 \times 10^{-6}\ T\ \hat{k}$$

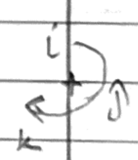
باستخدام قاعدة اليد اليمين المجال B خارج الصفحة $\hat{k}$

$$F = q\vec{V} \times \vec{B}$$

$$= (1.6 \times 10^{-19})(-380\ \hat{j}) \times (3.25 \times 10^{-6}\ \hat{k})$$

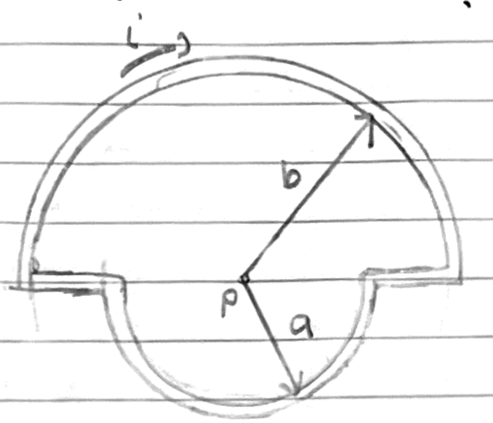
$$= -1.977 \times 10^{-22}\ N\ (\hat{i})$$

$$= 1.977 \times 10^{-22}\ N\ (-\hat{i})$$



سؤال ٥

P58: In Fig 29-62, current $i = 56.2$ mA is set up in a loop having two radial lengths and two semicircles of radii $a = 5.72$ cm and $b = 8.75$ cm with a common center P. What are the (a) magnitude and (b) direction (into or out of the page) of the magnetic field at P and the (c) magnitude and (d) direction of the loop's magnetic dipole moment?



Sol: $B = \frac{\mu_0 i \phi}{4\pi r}$ the magnetic field for a semicircle

$a = 5.72$ cm $\qquad b = 8.75$ cm

a) $B_1 = \frac{\mu_0 i \phi}{4\pi r} = \frac{\mu_0 i \pi}{4\pi a} = \frac{\mu_0 i}{4a}$

$B_2 = \frac{\mu_0 i \phi}{4\pi r} = \frac{\mu_0 i \pi}{4\pi b} = \frac{\mu_0 i}{4b}$

$$\vec{B} = \vec{B_1} + \vec{B_2} = \frac{\mu_0 i}{4a} + \frac{\mu_0 i}{4b}$$

$$\vec{B} = \frac{\mu_0 i}{4}\left(\frac{1}{a} + \frac{1}{b}\right)$$

$$\vec{B} = \frac{4\pi \times 10^{-7} \times 56.2 \times 10^{-3}}{4}\left(\frac{1}{0.0572} + \frac{1}{0.0875}\right)$$

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$\vec{B} = 1.76 \times 10^{-8} \times (28.91)$

$= 5.088 \times 10^{-7}\ T$

b) in to the page

c) dipole moment $\mu = iA$

Area $(A) = A_1 + A_2$

$= \frac{1}{2}\pi r_1^2 + \frac{1}{2}\pi r_2^2$

$= \frac{1}{2}\pi a^2 + \frac{1}{2}\pi b^2$

$= \frac{1}{2}\pi (a^2 + b^2)$

$= \frac{3.14}{2}\left((0.0572)^2 + (0.0875)^2\right)$

$= 0.0176\ m^2$

$\mu = iA$

$= (56.2 \times 10^{-3})(0.0176)$

$= 9.64 \times 10^{-4}\ Am^2$