MAGNETIC FIELDS: DIGIT View: 3, 4*, 8* , 36*, 74* (TRY 80*), 80*, 14*, 23, 28* (TRY 64), 30*(TRY 71,72), 34*, 37, 38*, 76(a)* only, 42, 45*, 46*, 47*, 49.*

Due: 11:59pm on Monday, April 21, 2014

4-21-14

To understand how points are awarded, read the Grading Policy for this assignment.

Notes

A message from your instructor...

IN ADDITION TO DETAILED LINKS BELOW, THIS LECTURE NOTES PAGE IS ALSO CRITICAL FOR CH. 28 SUCCESS AT THIS MOMENT: http://www.nvaphysics.com/4BSP14/4B_3_24_14.pdf . IN ALL PROBLEMS BELOW, HINTS ASSUME THE CURRENT OR CHARGE MOTION DIRECTION GIVEN BY A SOMETIMES RANDOMIZED PRESENTATION. THUS, YOUR DIRECTIONS MAY BE DIFFERENT AND YOU MAY HAVE TO "REVERSE ENGINEER" MY HINTS TO MATCH YOU SPECIFIC VERSION.

A message from your instructor...

HINT: FOR USEFUL SOLUTION METHODS SEE LECTURE NOTES: http://www.nvaphysics.com/4BSP14 /4B_4_9_14.pdf

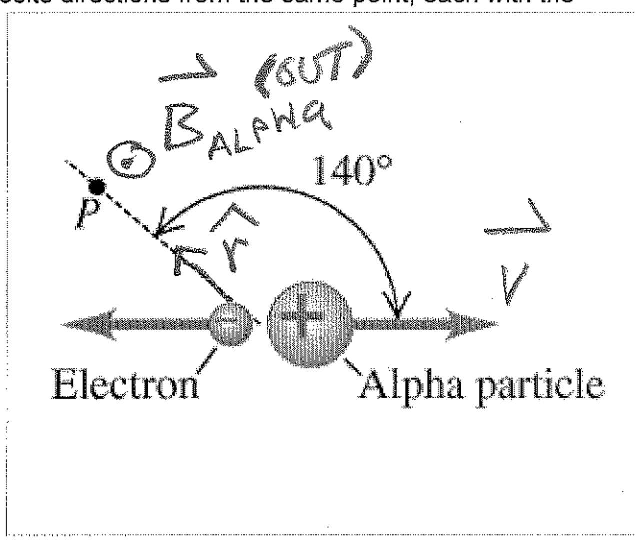
Exercise 28.4

An alpha particle (charge $+2e$) and an electron move in opposite directions from the same point, each with the speed of $2.60\times10^5 \mathrm{m/s}$ (the figure).

Use $\vec{B} = \dfrac{\mu_0 q \vec{v}\times\hat{r}}{4\pi r^2}$

see example →

from alpha at P:



$$|\vec{B}_{ALPHA}| = \frac{\mu_0 q V \sin 140}{4\pi(1.80\times10^{-9})^2} (T) \text{ where}$$

$V = 2.60\times10^{5} \frac{m}{s}$, $q = 2e$.

Part F

This question will be shown after you complete previous question(s).

Instructors: View all hidden parts

Part G

Find the magnitude of the magnetic field this electon produces at the point D.

ANSWER:

B = T

Part H

This question will be shown after you complete previous question(s).

Instructors: View all hidden parts

A message from your instructor...

HINT: FOR USEFUL SOLUTION METHODS SEE LECTURE NOTES: http://www.nvaphysics.com/4BSP14/4B_4_9_14.pdf

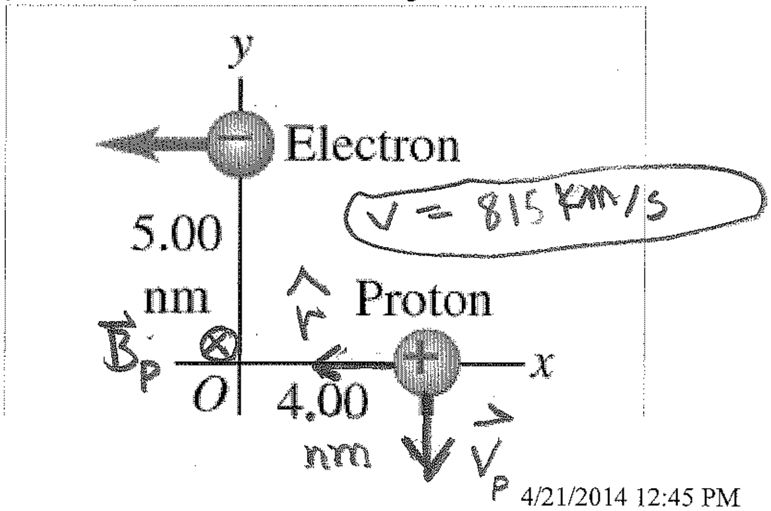
Exercise 28.8

An electron and a proton are each moving at $815 \mathrm{km/s}$ in perpendicular paths as shown in the figure . At the instant they are at the positions shown in the figure.

USE $\vec{B} = \frac{\mu_0 q \vec{v} \times \hat{r}}{4\pi r^2}$

FOR PROTON: $\vec{B}_p$ IN ⊗

$|\vec{B}| = \frac{\mu_0 e v \sin 90}{4\pi (4.00\times10^{-9})^2}$ (T)



α =	° counterclockwise from the $+x-$ axis

A message from your instructor...

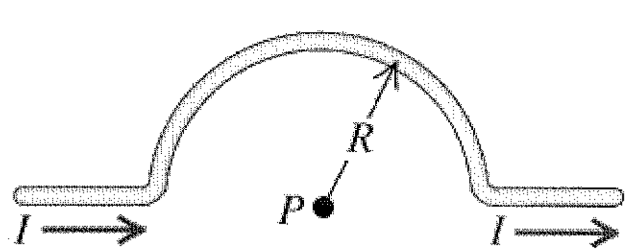
HINT: USE SUPERPOSITION AND COMMON SENSE FROM WHAT WE KNOW IN LECTURE:http://www.nvaphysics.com/4BSP14/4B_4_9_14.pdf . EACH MAGNETIC FIELD DUE TO THE TWO STRAIGHT LINE SEGMENTS ON EITHER SIDE OF THE EVALUATION POINT IS **ZERO**. SEE EXAMPLE 28.2 TO CONFIRM THIS. NOW LET'S LOOK AT THE FIELD DUE TO THE CURVED HALF CIRCLE. YOU NEED TO DO AN INTEGRATION OF FORMULA 28.6 TO GET THIS FIELD. INTEGRATE THE FOLLOWING: dB = (uo/[4*pi])*I*dLsin 90/[R*R]= (uo/[4*pi])*I*dL/[R*R]. Note the 90 degree angle between the unit vector directed toward center and vector-dL. Integrating dL over a half - circumference pi*R we get: B = (uo/[4*pi])*I*pi*R/[R*R]= (uo/4)*I/R. IT IS NOW UP TO YOU TO FIND THE CORRECT DIRECTION, IN OR OUT OF THE PAGE, USING THE RIGHT HAND RULE FOR CROSS PRODUCTS IN FORMULA 28.6.

Exercise 28.36

Part A

Calculate the magnitude of the magnetic field at point P due to the current in the semicircular section of wire shown in the figure . (*Hint:* Does the current in the long, straight section of the wire produce any field at P?)

Express your answer in terms of the variables I, R and appropriate constants.



use $d\vec{B} = \frac{\mu_0}{4\pi} \cdot \frac{I d\vec{l} \times \hat{r}}{r^2}$

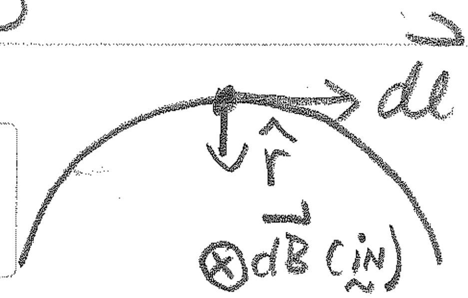
FOR STRAIGHT segments:

$|d\vec{B}| \propto I dl \sin 0 = I dl \sin 180 = 0$

ANSWER:

For curved segment:

$|d\vec{B}| = \frac{\mu_0}{4\pi} \cdot \frac{I\, dl \sin 90}{R^2}$



$\Rightarrow B = \int dB = \frac{\mu_0}{4\pi} \cdot \frac{I \cdot \pi R}{R^2}$

$= \boxed{\frac{\mu_0 I}{4R}}$

Part B

Find the direction of the magnetic field at point P.

Part B

Find the direction of the net magnetic field that the current in the wires produces at point *P*.

ANSWER:

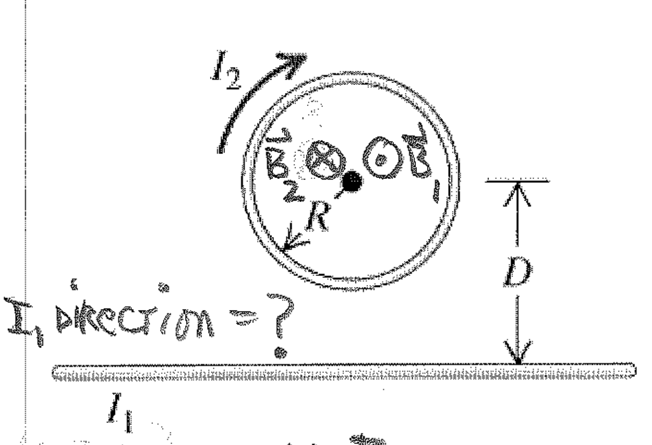
- out of the page
- into the page

A message from your instructor...

HINT: THIS PROBLEM USES THE FIELD FROM BOTH AN (i) INFINITELY LONG STRAIGHT WIRE AND ALSO A (ii) WIRE LOOP DISCUSSED IN LECTURE NOTES, PAGES 1 AND 2: http://www.nvaphysics.com/4BSP14 /4B_3_24_14.pdf. *LOOP --- FROM THAT PAGE, WE KNOW THE FIELD FROM THE (ii) WIRE LOOP POINTS **IN** THE PAGE: IF YOU WRAP YOUR RIGHT FINGERS IN LOOP CURRENT'S DIRECTION (CLOCKWISE), YOUR RIGHT THUMB POINTS **INTO** (IN) THE PAGE ALONG AXIS THROUGH CENTER FROM THE RIGHT-HAND-RULE FOR LOOPS. BY THE WAY, THE MAGNITUDE OF LOOP FIELD ON AXIS (AT CENTER) IS GIVEN BY FORMULA 28.15 AFTER SETTING x = 0. *LONG WIRE --- NOW, WE KNOW IF THE TOTAL FIELD IS ZERO, THEN THE FIELD FROM LONG STRAIGHT WIRE MUST BE **OUT**. THUS WE KNOW FROM PAGE 1 OF ABOVE NOTES, THE CURRENT IN LONG, STRAIGHT WIRE IS HORIZONTALLY *RIGHTWARD*: IF YOU POINT YOUR RIGHT THUMB IN THE RIGHTWARD DIRECTION OF LONG WIRE CURRENT, YOUR RIGHT FINGERS GO *OUT* ABOVE THE LONG WIRE (WHERE THE LOOP IS LOCATED) AND *IN* BELOW THE LONG WIRE FROM THE RIGHT-HAND-RULE FOR LONG, STRAIGHT WIRES. THE FORMULA FOR THE FIELD MAGNITUDE IS GIVEN ON PAGE ONE OF ABOVE NOTES. THE TWO FIELDS ADD AS VECTORS TO ZERO, ONE POINTING *OUT* AND THE OTHER *IN*; CHOOSE THE LONG WIRE CURRENT TO CREATE THE TOTAL ZERO FIELD CONDITION AT LOOP CENTER.

Problem 28.80

A circular loop has radius R and carries current I_2 in a clockwise direction (the figure). The center of the loop is a distance D above a long, straight wire.



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

$$|\vec{B}_{net}| = |B_1 - B_2|$$

$$B_1 = \frac{\mu_0 I_1}{2\pi D}, \quad B_2 = \frac{\mu_0 I_2 R^2}{2R^3} = \frac{\mu_0 I_2}{2R}$$

B = T

Part F

What is its direction?

ANSWER:

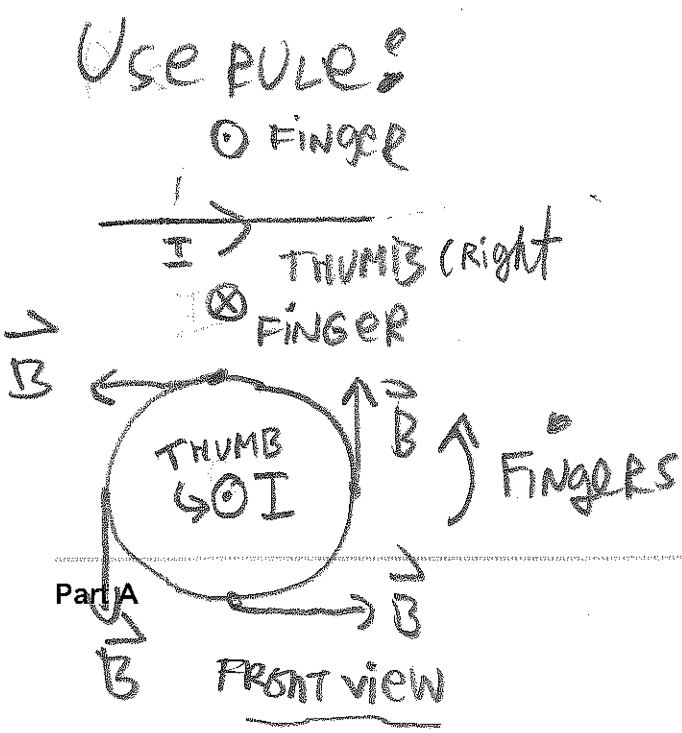
° from +x to +z axis.

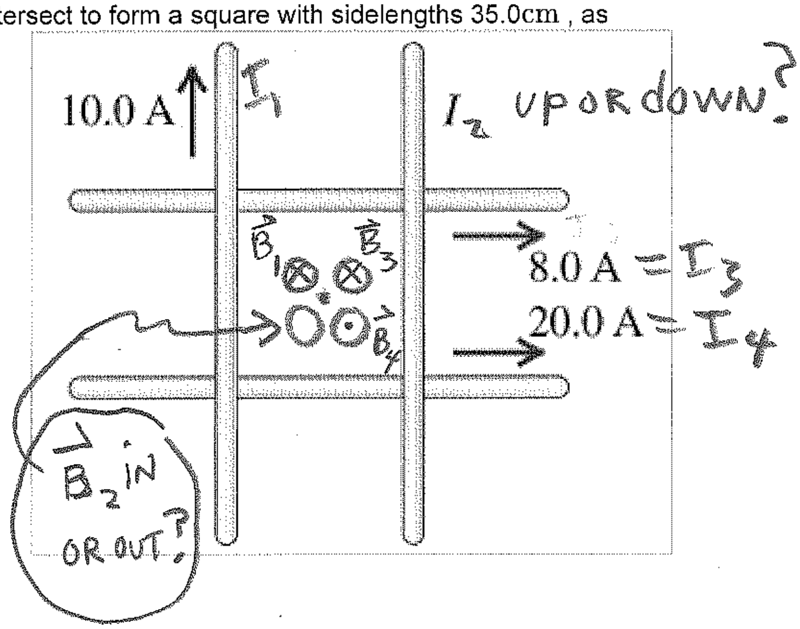
A message from your instructor...

THIS IS CLASSIC APPLICATION OF SUPERPOSITION, ADDING 4 FIELDS TO ZERO, USING FORMULA FOR LONG WIRE --- THE FIELDS FROM EACH LONG STRAIGHT WIRE MUST BE SCIENTIFICALLY JACKED USING THE RIGHT HAND RULE . WE KNOW FROM PAGE 1 OF NOTES , http://www.nvaphysics.com/4BSP14/4B_3_24_14.pdf, THE CURRENT IN A LONG, STRAIGHT WIRE IS IN THE DIRECTION OF YOUR RIGHT THUMB. IF YOU POINT YOUR RIGHT THUMB IN THE DIRECTION OF LONG WIRE'S CURRENT, YOUR RIGHT FINGERS GO IN A DIRECTION TANGENT TO THE LOOP DEFINING THE CLOSED MAGNETIC FIELD LINE SURROUNDING THE WIRE---FROM THE RIGHT-HAND-RULE FOR LONG, STRAIGHT WIRES. THE FORMULA FOR THE FIELD MAGNITUDE IS GIVEN ON PAGE ONE OF ABOVE NOTES.

Exercise 28.28

Four very long, current-carrying wires in the same plane intersect to form a square with sidelengths 35.0cm , as shown in the figure .





Part A

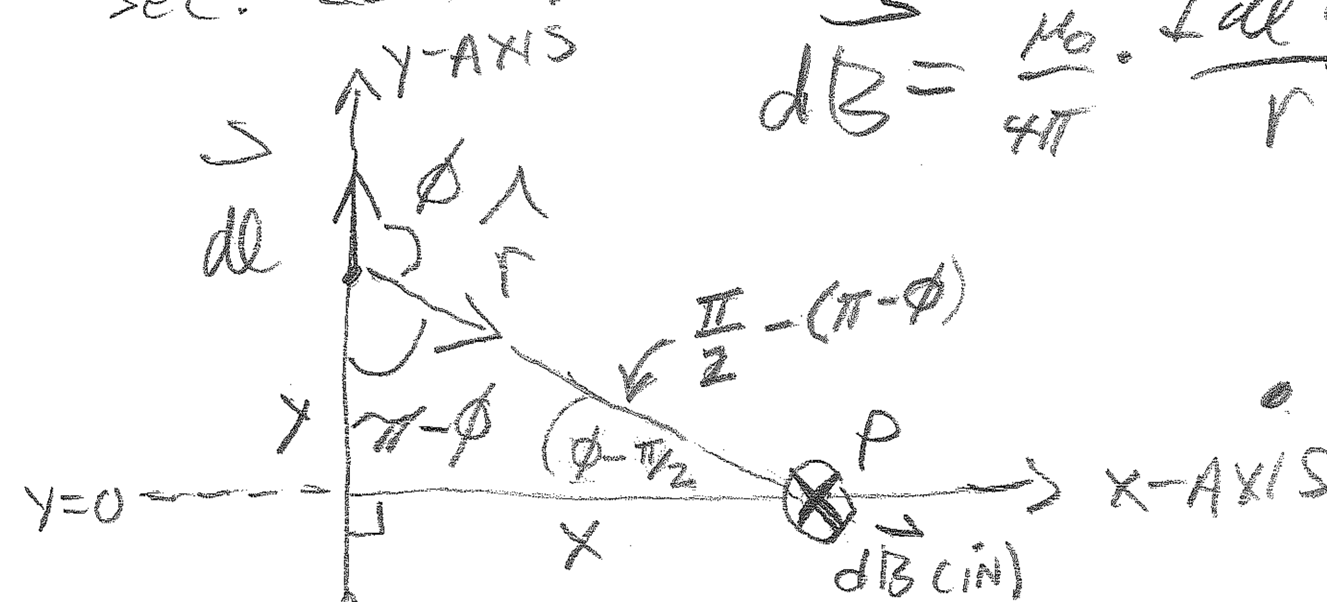
4-21-14

4B Detailed CH 28 problem-driven presentation.

New concepts

sec. 28.5

$$d\vec{B} = \frac{\mu_0}{4\pi}\cdot\frac{I\,d\vec{l}\times\hat{r}}{r^2}$$



Use way:

$$|d\vec{B}| = \frac{\mu_0}{4\pi}\,\frac{I\,dy\cdot\sin\phi}{r^2}$$

$$\frac{y}{x} = \tan\left(\phi-\frac{\pi}{2}\right) = \frac{\sin\left(\phi-\frac{\pi}{2}\right)}{\cos\left(\phi-\frac{\pi}{2}\right)} = \frac{-\cos\phi}{\sin\phi}$$

$\sin\left(\phi-\frac{\pi}{2}\right) = \sin\phi\cos\frac{\pi}{2} - \cos\phi\cdot\sin\frac{\pi}{2}$

$\cos\left(\phi-\frac{\pi}{2}\right) = \cos\phi\cdot\cos\frac{\pi}{2} + \sin\phi\cdot\sin\frac{\pi}{2}$

$\Rightarrow$

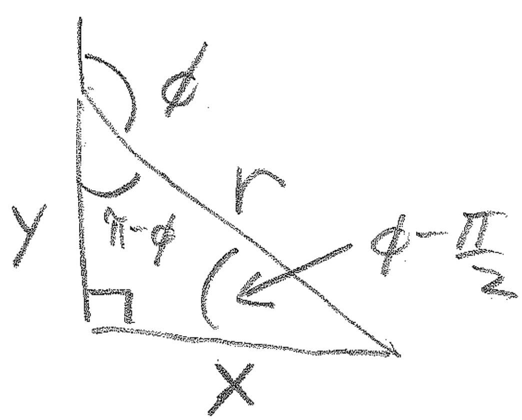
$$\frac{y}{x} = -\cot\phi = -\frac{1}{\tan\phi}$$

$$y = -x\cdot\cot\phi$$

$$dy = x\csc^2\phi\, d\phi, \quad \text{since } \frac{d\cot\phi}{d\phi} = -\csc^2\phi.$$

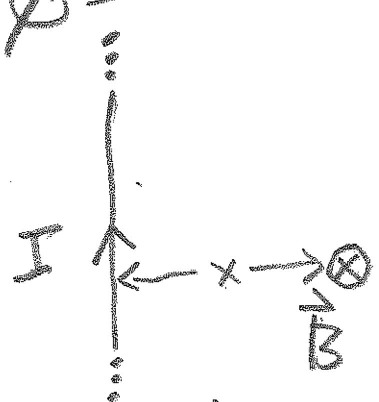
$$dB = \frac{\mu_0}{4\pi}\cdot\frac{I\cdot x\cdot\csc^2\phi\, d\phi\cdot\sin\phi}{x^2\csc^2\phi}$$

$$x = r\cdot\cos\left(\phi-\frac{\pi}{2}\right) = r\cdot\sin\phi$$



$$\Rightarrow r = \frac{x}{\sin\phi}$$

$$r = x\cdot\csc\phi$$

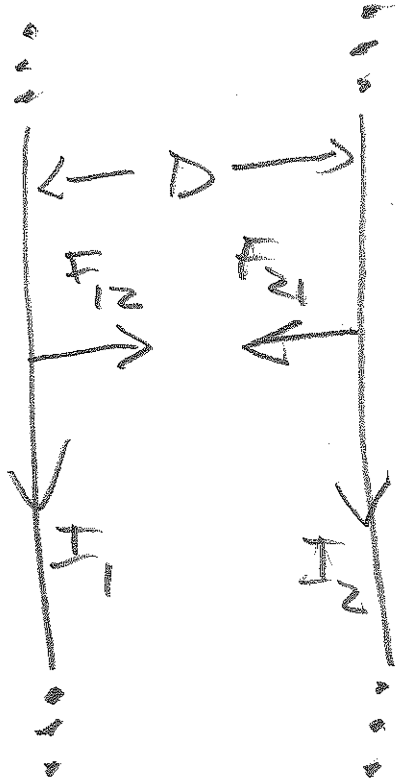


$$dB = \frac{\mu_0}{4\pi}\cdot\frac{I\sin\phi\, d\phi}{x}$$

$$B = \int_0^{\pi}\frac{\mu_0}{4\pi x}\cdot I\cdot\sin\phi\, d\phi = \frac{\mu_0 I}{4\pi x}\cdot(2) = \frac{\mu_0 I}{2\pi x} = |\vec{B}|$$

sec 28-4 : covered in 3-24-14

NOTES : see EXAMPLE PAGE 3.

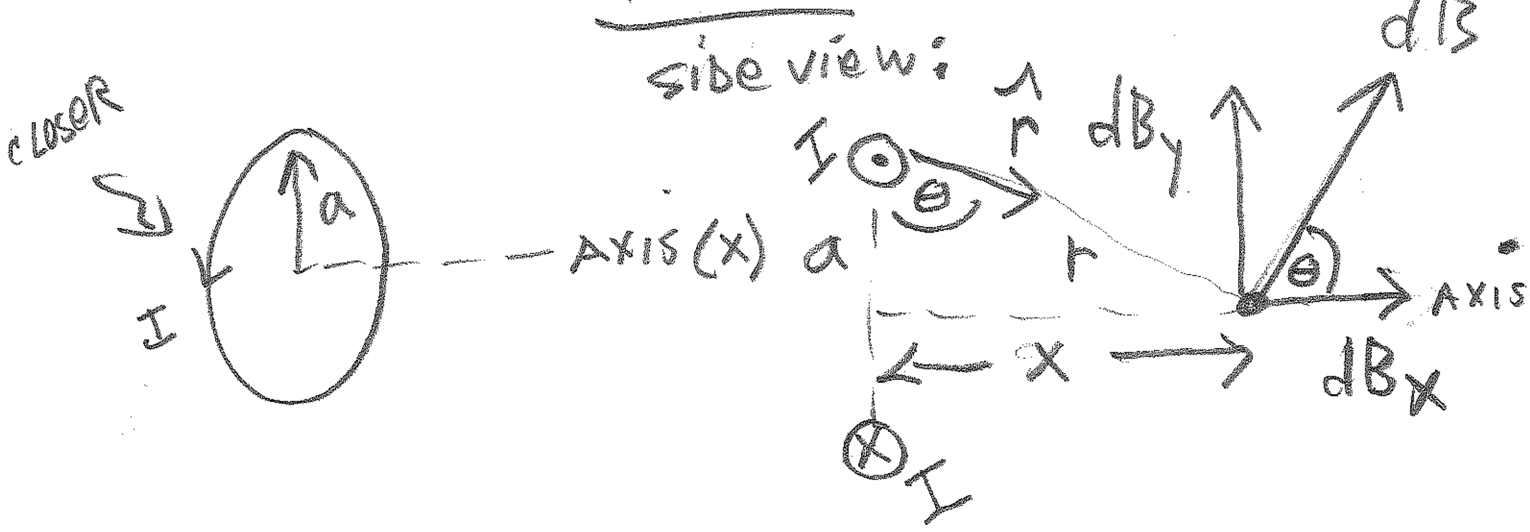


$$F_{12} = \frac{\mu_0 I_1 \cdot I_2 \cdot L}{2\pi \cdot D} = F_{21}$$

L = Length (MUTUAL)

sec 28.5 : see 3-24-14 NOTES

THIS APPLIES FORMULA 28.6



$$dB = \left| \frac{\mu_0 I}{4\pi} \cdot \frac{\vec{dl} \times r}{r^2} \right|$$

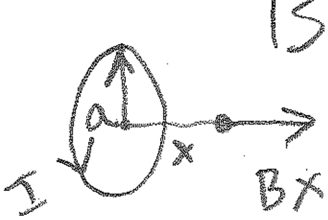
$$dB = \frac{\mu_0 I}{4\pi} \cdot \frac{dl \cdot \sin 90^\circ}{(x^2+a^2)}$$

$$dB_x = dB \cdot \cos\theta$$

$$dB_x = \frac{\mu_0 I}{4\pi} \cdot \frac{dl}{(x^2+a^2)} \cdot \frac{a}{(x^2+a^2)^{1/2}}$$

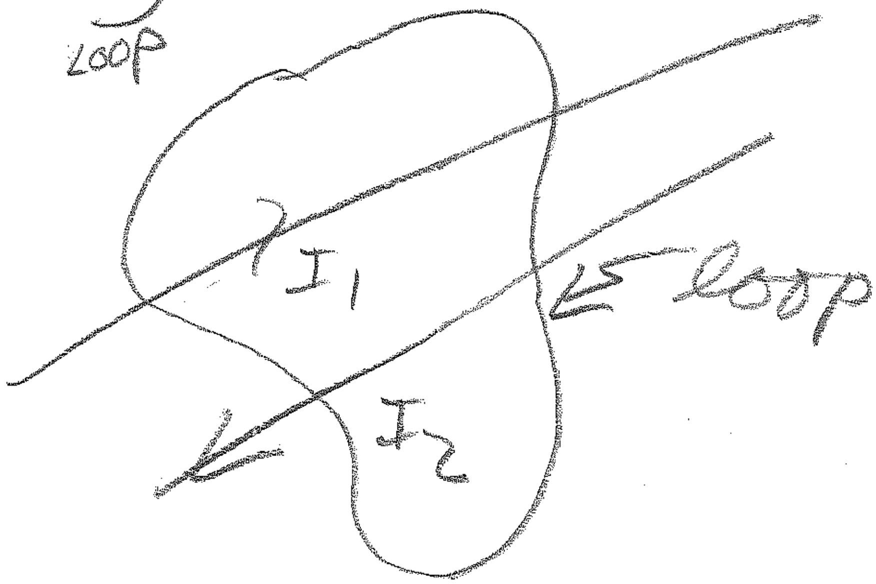
$$dB_x = \frac{\mu_0 I a}{4\pi (x^2+a^2)^{3/2}} \cdot dl$$

$$B_x = \frac{\mu_0 \cdot I \cdot a \cdot 2\pi \cdot a}{4\pi (x^2+a^2)^{3/2}} = \boxed{\frac{\mu_0 I a^2}{2(x^2+a^2)^{3/2}}}$$

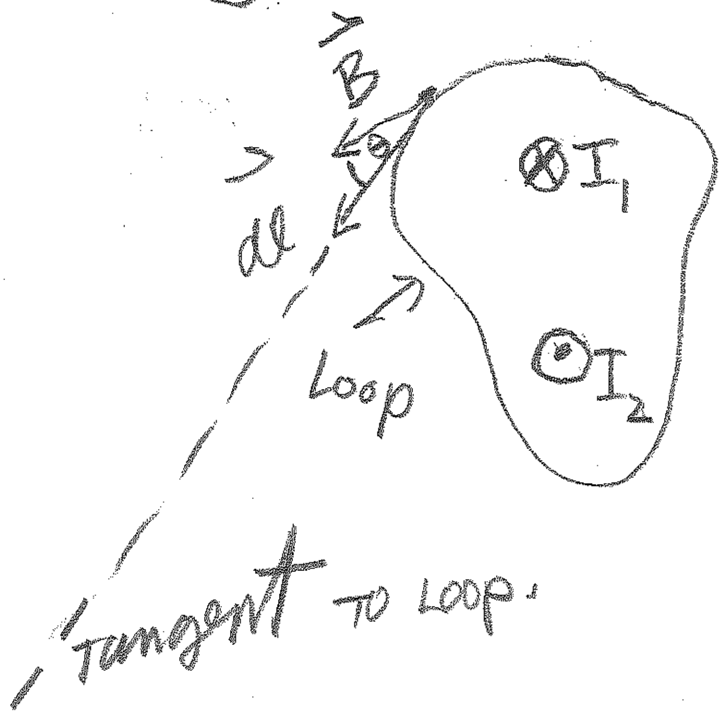


Ampère's Law
Sec. 28.6

$$\oint_{\text{loop}} \vec{B}\cdot\vec{dl} = \mu_0 I_{encl}$$



$$\oint \vec{B}\cdot\vec{dl} = \mu_0 (I_2 - I_1)$$



Note:

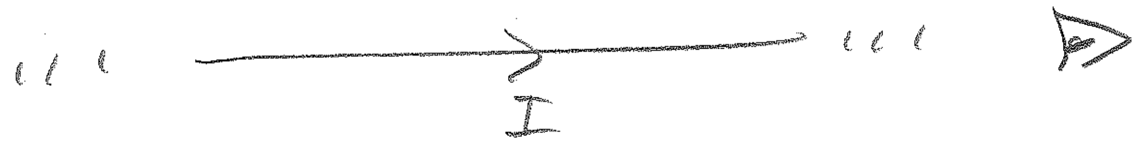
$\vec{B}\cdot\vec{dl}$

$= B\,dl\cos\theta$

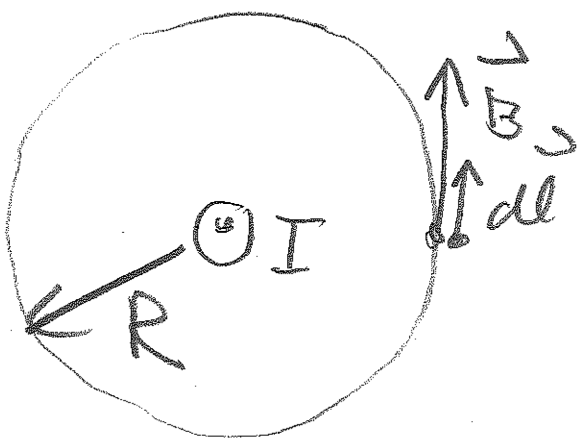
sec 28.6

QUICK FIX of

SEC 28.3 computation
(LONG WIRE)



FRONT VIEW: CHOOSE LOOP = CIRCLE, RADIUS R



$$\oint \vec{B} \cdot \vec{dl} = \oint B\, dl \cos 0 = \oint B\, dl$$

closed loop

$$= B \oint dl = B \cdot (2\pi R)$$

$$B(2\pi R) = \mu_0 I_{encl} = \mu_0 I$$

$$B = \frac{\mu_0 I}{2\pi R}$$ like sec 28.3