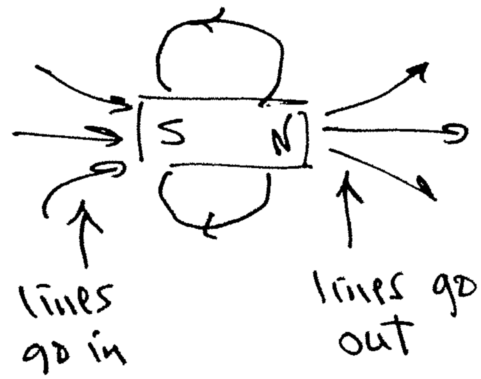
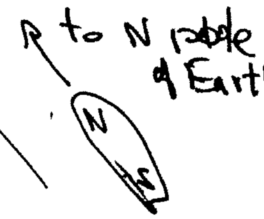


Lines of B point out of the N end of a magnet

$\boxed{\text{B lines go \underline{in} the \underline{S} pole, go out the \underline{N} pole}}$

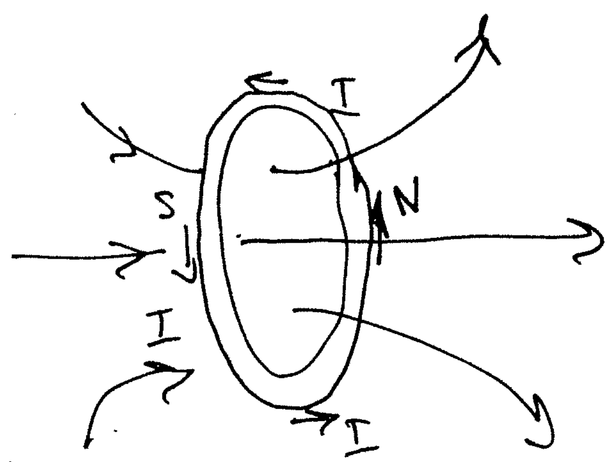
A compass N pole points toward the Earths "N" pole

This makes Earth geographic N pole a South magnetic pole (Fig 32.1, p. 998)



Direction of B field

single current loop



Wrap fingers of right hand around the current. $\vec{B}$ in the direction of your thumb.

Solenoid (it's like lots of loops in series, one after another

WRAP RH FINGERS AROUND I
$\vec{B}$ IS ALONG THUMB

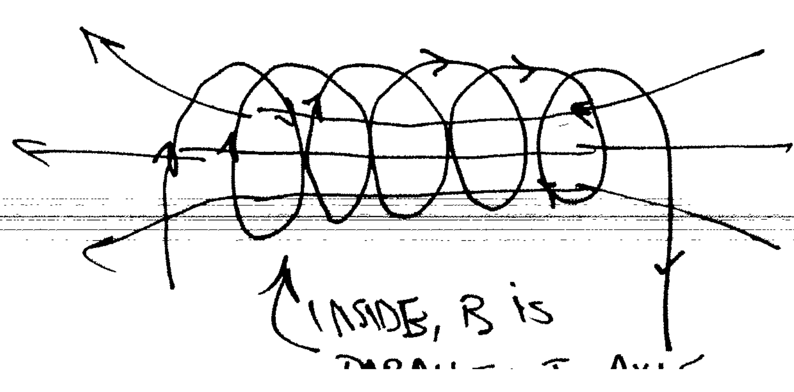
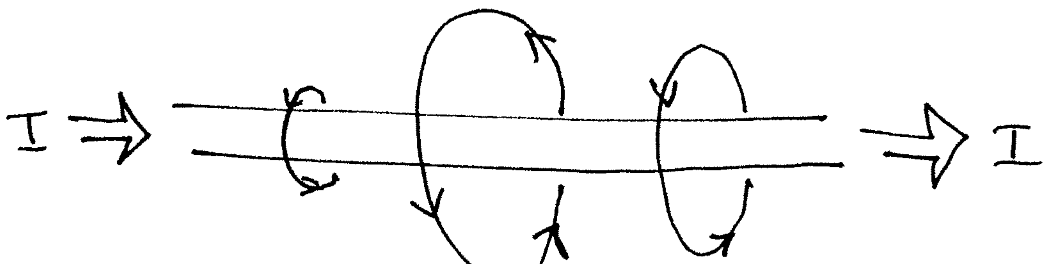


Fig 32.29 p. 1015

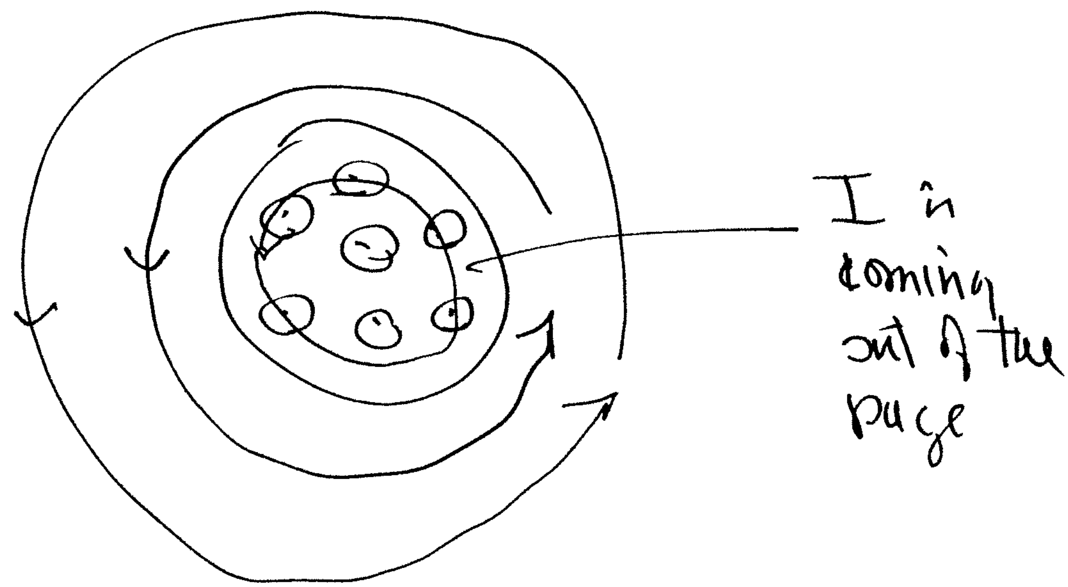
$\vec{B}$ of a long straight wire (OUTSIDE THE WIRE)



p. 1032
p. 1000

Place Thumb of RH along I. Fingers wrap in the direction of B

$\vec{B}$ INSIDE A LONG STRAIGHT WIRE



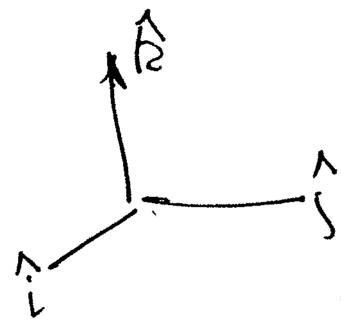
p. 1014

lines of B are CCW outside the wire and also inside the wire

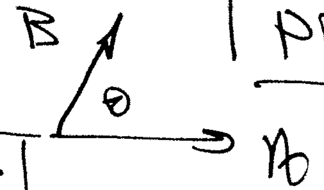
Dot and cross product

$\vec{A} = \hat{i}\, A_x + \hat{j}\, A_y + \hat{k}\, A_z$

vector, unit vector, scalar component



DOT PRODUCT



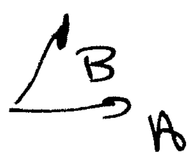
$$\boxed{\vec{A}\cdot\vec{B} = A\underbrace{B\cos\theta}_{\text{projection of } \vec{B} \text{ on } \vec{A}}}$$

$\hat{i}\cdot\hat{i} = 1 \quad \hat{i}\cdot\hat{j} = 0 \quad \hat{j}\cdot\hat{j} = 1 \quad \hat{j}\cdot\hat{k} = 0$ etc.

$(\hat{i} A_x + \hat{j} A_y + \hat{k} A_z)\cdot(\hat{i} B_x + \hat{j} B_y + \hat{k} B_z) = \vec{A}\cdot\vec{B}$

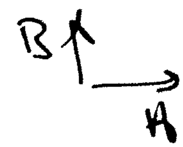
9 terms but 6 are zero, ∴

$$\boxed{A_x B_x + A_y B_y + A_z B_z = \vec{A}\cdot\vec{B}}$$



$A\cdot B > 0$

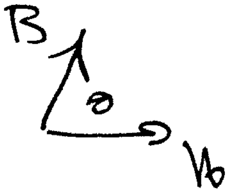
$A\cdot B < 0$



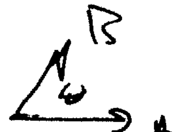
$A\cdot B = 0$

DOT PRODUCT TURNS 2 VECTORS INTO A SCALAR

Cross product $\vec{A}\times\vec{B}=\vec{C}$ turns 2 vectors into another vector

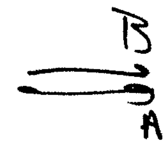


curl fingers of RH from A to B → thumb points in direction of $\vec{C}$



C is out of page

C is into page



C is zero

$$|\vec{C}| = C = AB\sin\theta$$

Mnemonic: $\begin{array}{ccc} & i & \\ k & & j \end{array}$

$i\times i=0$
$j\times j=0$
$k\times k=0$

$$\left.\begin{array}{l} i\times j=k \\ j\times k=i \\ k\times i=j \end{array}\right\}$$ CW on the mnemonic

$j\times i=-k$
$i\times k=-j$
$\hat{k}\times\hat{j}=-\hat{i}$

CCW on the mnemon

Determinant

$$\begin{array}{ccc} i & j & k \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{array}$$

Down to right is $+$

$$\begin{array}{ccc} i & j & k \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{array}$$

$\hat{i}\,A_yB_z+\hat{j}\,A_zB_x+\hat{k}\,A_xB_y$

Down + left is $-$

$$\begin{array}{ccc} i & j & k \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{array}$$

$-\hat{i}\,B_yA_z$
$-\hat{j}\,A_xB_z$
$-\hat{k}\,A_yB_x$

$$\vec{A}\times\vec{B} = \hat{i}\,(A_yB_z-A_zB_y) + \hat{j}\,(A_zB_x-A_xB_z) + \hat{k}\,(A_xB_y-A_yB_x)$$

B due to current in a wire

$$d\vec{B}_p = \frac{\mu_0}{4\pi} I \, \frac{\vec{dl}\times\vec{r}}{r^3}$$

p.1004 Eq 32.6

$\vec{dl}$ goes along the wire

$\vec{r}$ goes from $\vec{dl}$ to p, where ~~where~~ you are calculating the B field

Simplest example: $\vec{B}$ at center of ⊙ loop

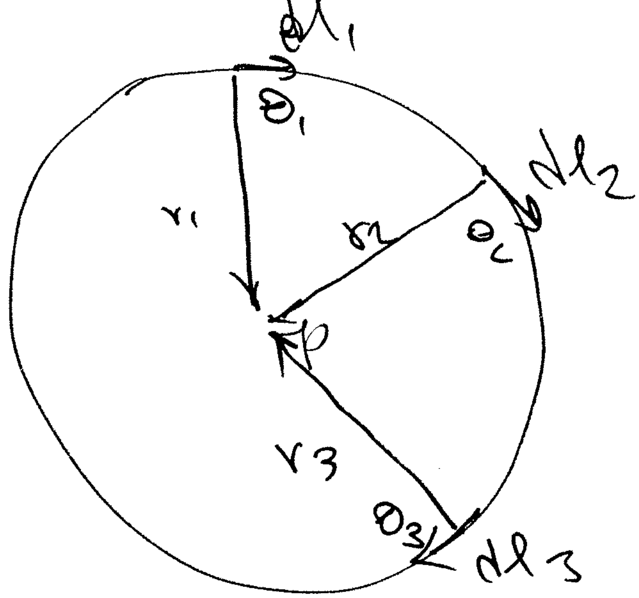
$\vec{dl}_1 \times \vec{r}_1$ (IN)

$\vec{dl}_2 \times \vec{r}_2$ (IN)

$\vec{dl}_3 \times \vec{r}_3$ (IN)

$\theta_1 = 90^\circ$

$\theta_2 = \theta_3 = 90^\circ$



$\cancel{B_p \left(\frac{\mu_0 I}{2r}\right)}$

$B_p = \frac{\mu_0 I}{2r}$

(bottom of page)

$$B_p = \frac{\mu_0 I}{4\pi}\left(\frac{\vec{dl}_1\times\vec{r}_1}{r_1^3} + \frac{\vec{dl}_2\times\vec{r}_2}{r_2^3} + \ldots\right) = \frac{\mu_0 I}{4\pi}\int \frac{\vec{dl}\times\vec{r}}{r^3}$$

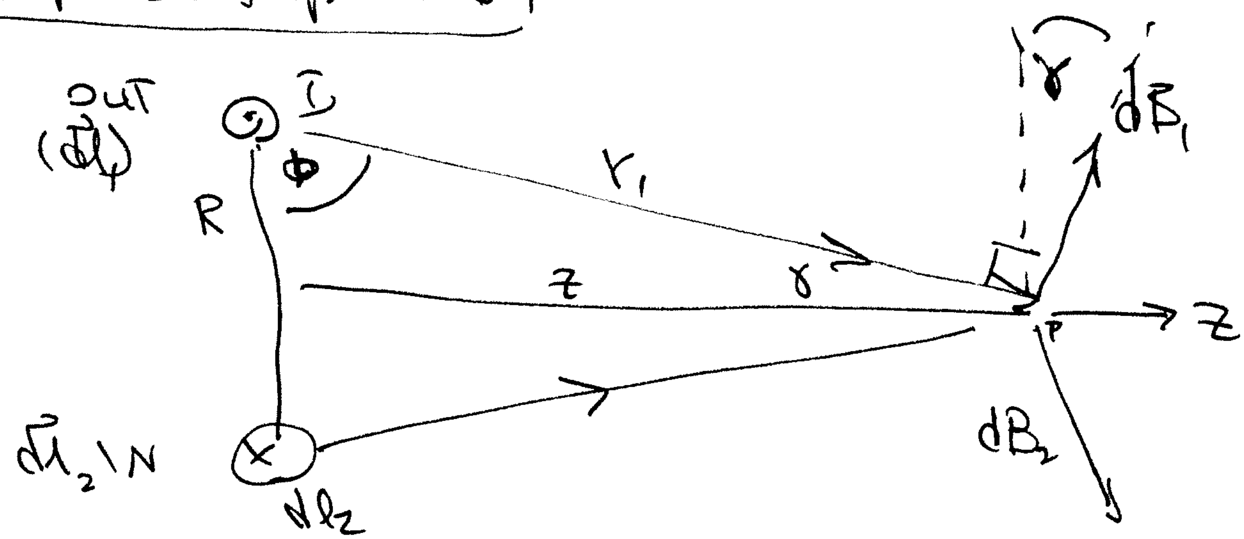
$$B_p = (\text{INTO PAGE})\frac{\mu_0 I}{4\pi}\int \frac{dl\, r}{r^3}\sin 90^\circ$$

$$= (\text{IN})\frac{\mu_0 I}{4\pi}\frac{1}{r^3}\int_{\text{loop}} dl = (\text{IN})\frac{\mu_0 I\,(2\pi r)}{4\pi r^3}$$

$$\boxed{\vec{B}_p = (\text{IN})\,\mu_0 I/2r}$$

$\vec{B}$ on axis of a loop w/ current I

$\boxed{\text{Example 32.5 p. 1006}}$



$\vec{dl}_1 \times \vec{r}_1$: $\sin\theta_1 = 90°$ since $\vec{dl}_1$ points out of page

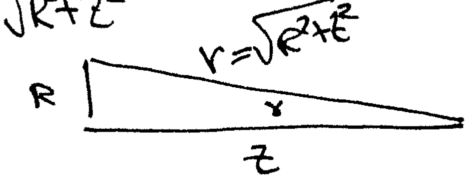
$\vec{dl}_2 \times \vec{r}_2$: $\sin\theta_2 = 90°$ since $\vec{dl}_2$ points into the page

$d\vec{B}_1$ & $d\vec{B}_2$ add together in the z-direction

We'll get the z-component of $d\vec{B}_1$ and integrate dl around the loop

$$dB_{1z} = dB_1 \cancel{\sin\phi} \sin\gamma \; ; \quad \sin\gamma = \frac{R}{\sqrt{R^2+z^2}} = \frac{R}{r}$$

$$\vec{B}_p = \hat{k}\,\frac{\mu_0 I}{4\pi}\sin\gamma \int \frac{dl \cdot r \sin 90°}{r^3} \qquad r = \sqrt{R^2+z^2}$$



$$B_p = \hat{k}\,\frac{\mu_0 I}{4\pi r^2}\,\frac{R}{r}\underbrace{\int dl}_{2\pi R}$$

$\boxed{\text{p. 1007}}$

$$\boxed{B_{\text{axis of loop}} = \hat{k}\,\frac{\mu_0 R^2 I}{2r^3} = \hat{k}\,\frac{\mu_0 R^2 I}{2(R^2+z^2)^{3/2}}}$$

When $z = 0$, we get B at center of loop:

$$B_{center} = \frac{\mu_0 I}{2R}$$