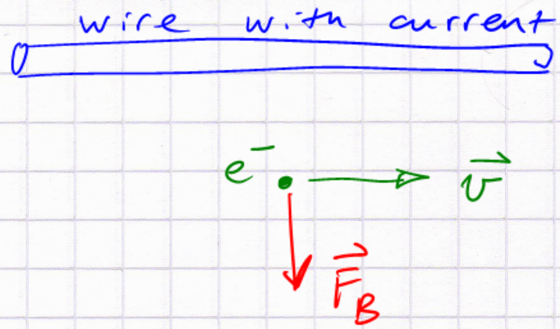
Week 17 20.4



what is the current direction in the wire?

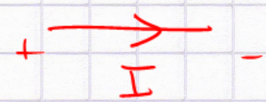
Solution.

The magnetic force: $\vec{F}_M = q\,\vec{v} \times \vec{B}$ section 20.3

e^-: $q = -e$ reverses the direction!

If I_{wire} was left-to-right: $\vec{B}$ at the e^- location would be into the page. $\vec{v} \times \vec{B}$ then points towards the wire. $q = -e$ reverses, and thus $\vec{F}_M$ would be in the plane, away from the wire. This is the situation shown.

Thus, the current flows $L \to R$

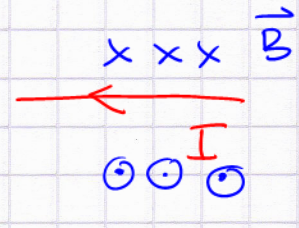


20.6

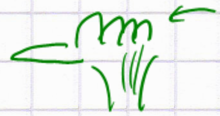
Direction of $\vec{B}$ at A ?

Solution.

Biot-Savart, qualitative :



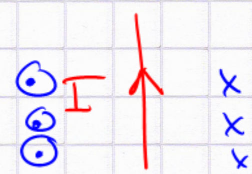
use RH



← fingers curl

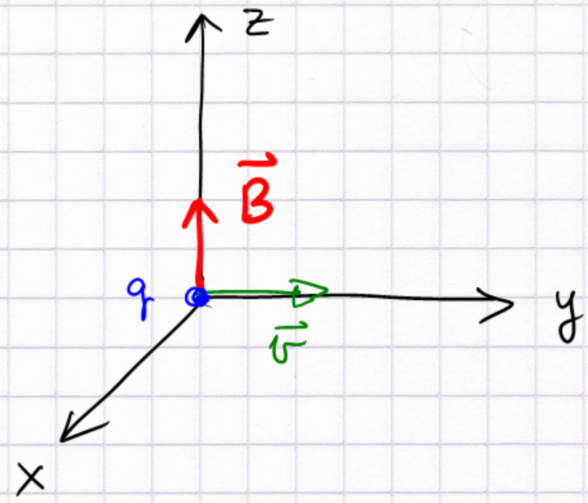
into page above

We have to add two contributions at A, from two straight segments, horizontal + vertical. Horizontal is shown (into the page at A. The vertical:



Thus, the two contributions add, $\vec{B}_{tot}$ is into the page at A

20.10



$\vec{v} \sim \hat{j}$ $\qquad$ $\vec{B} \sim \hat{k}$

$\vec{F}_M \sim \hat{\imath}$

$\swarrow \vec{F}_M$ $\qquad$ is $q > 0$ or $q < 0$?

Solution.

By the RH rule $\qquad$ $\vec{v} \times \vec{B}$ is $\sim \hat{\imath}$

Thus, $q > 0$

20.13 Proton, $v = 300\ m/s$ moves through a region with $B = 2.5\ T$ (Tesla)

$F_M = 6.4 \times 10^{-17}\ N$ (magnitude)

What angle does $\vec{v}$ make with $\vec{B}$?

Solution

$$\vec{F}_M = q\,\vec{v} \times \vec{B} \qquad q = +e = 1.60 \times 10^{-19}\ C$$

$$F_M = |\vec{F}_M| = |q|\,|\vec{v}|\,|\vec{B}|\,\sin\vartheta$$

$$\sin\vartheta = \frac{F_M}{|q v B|} = \frac{6.4 \times 10^{-17}}{1.6 \times 10^{-19} \cdot 300 \cdot 2.5}$$

NB: $\frac{10^{-17} \cdot 10^{19}}{10^2} = 1 \quad \therefore \quad = \frac{6.4}{1.6 \cdot 3.0 \cdot 2.5}$

$$\vartheta = \sin^{-1}\left(\frac{4.0}{7.5}\right)$$

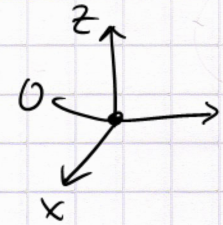
$$= 0.56\ \text{rad}$$

$$= 32^\circ$$

20.16

proton is at O (x, y, z)

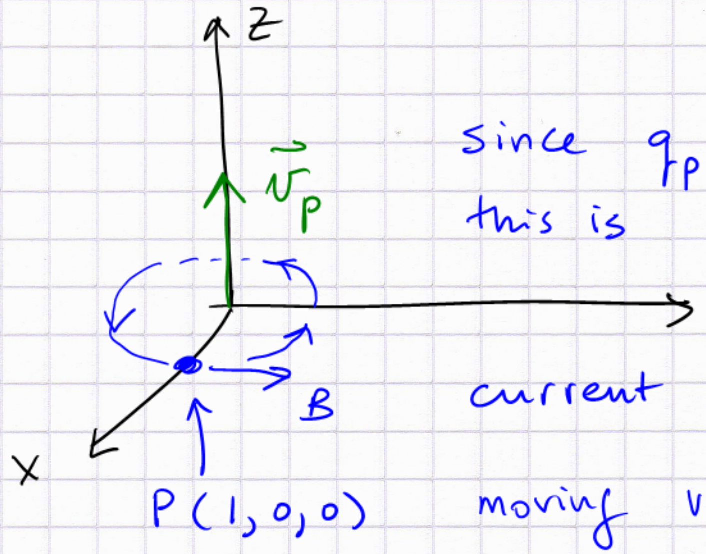
$\vec{v} \sim \hat{k}$



$\vec{B}$ field direction <u>due</u> to the moving proton at P (1, 0, 0) ?

x = 1 m on the x-axis.

Solution

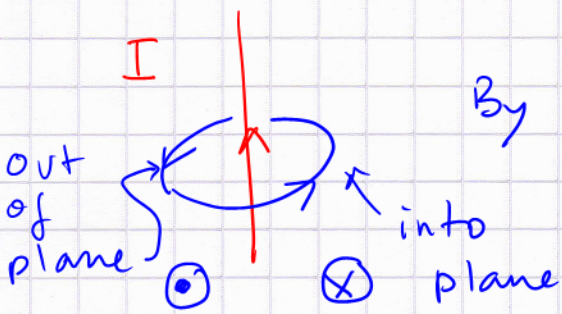


since $q_p = +e$

this is like a

current I

moving vertically up



By RH rule

But we want the field "above" the plane

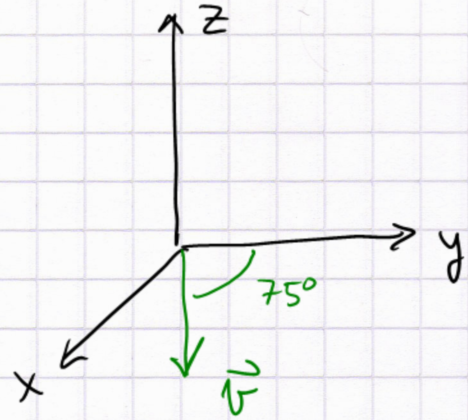
$$\boxed{\text{Thus, } \vec{B} \sim \hat{j} \text{ at } P(1, 0, 0)}$$

20.20 Particle with $q < 0$

$\vec{v}$ in the x-y plane

$75°$ with y-axis

$\vec{B} \sim \hat{\imath}$



Direction of $\vec{F}_M$ on particle?

Solution.

$\vec{F}_M = q \, \vec{v} \times \vec{B}$

since $q < 0$ we seek the direction opposite to $\vec{v} \times \vec{B}$

Since $\vec{B} = B \hat{\imath}$

$\vec{v} \times \vec{B}$ points down by the RH rule

($\vec{v}$ = thumb, $\vec{B}$ = index finger)

first   second

$\vec{v} \times \vec{B} \sim -\hat{k}$

$q < 0 \quad \therefore \quad \vec{F}_M \sim +\hat{k}$, or $\vec{F}_M = F_M \hat{k}$