Physics 4B
Fall 2017

$$\boxed{\begin{aligned} \text{average} &= 8.0 \\ \sigma &= 1.5 \end{aligned}}$$

Name: Answer Key

Lab (circle one): 8:00 am 11:15 am 2:45 pm

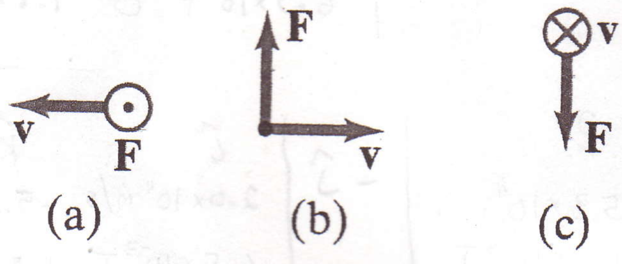
Quiz #7: Magnetic Fields

Problem 1 (3 points)
Determine the direction of the magnetic field **B** for each case in the figure below, where **F** represents the force on a *negatively charged* particle moving with velocity **v**.

a) upwards $(+\hat{j})$

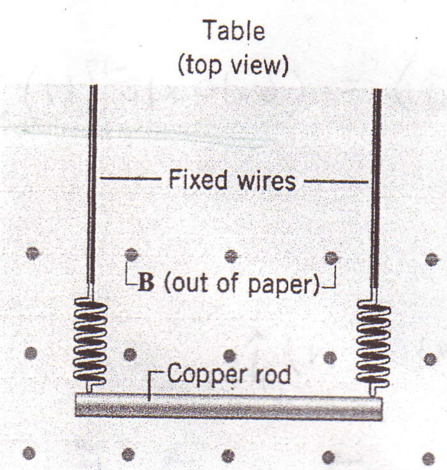
b) out of page $(\odot)$

c) leftwards $(-\hat{i})$



Problem 2 (3 points)
A copper rod of length 0.85 m is lying on a frictionless table (see the figure below). Each end of the rod is attached to a fixed wire by an unstretched spring that has a spring constant of k = 75 N/m. A magnetic field with a strength of 0.16 T is oriented perpendicular to the surface of the table. **(a)** What must be the direction of the (conventional) current in the copper rod that causes the springs to stretch? **(b)** If the current is 12.0 A, by how much does each spring stretch?

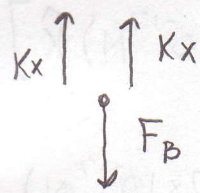
(Hint: the magnitude of the force exerted by a stretched spring is given by F = kx)



(a) current is $\boxed{\text{to the right}}$

to stretch the spring, the magnetic force on the rod must point downward

(b)



$\Sigma F_y = ma_y = 0$

$Kx + Kx - F_B = 0$

$2Kx = F_B \longrightarrow 2Kx = iLB\sin\theta \quad \theta = 90°$

$2Kx = iLB \longrightarrow x = \dfrac{iLB}{2K}$

$$x = \frac{(12.0\,A)(0.85\,m)(0.16\,T)}{2(75\,N/m)} \longrightarrow \boxed{x = 0.011\,m = 11\,mm}$$

Problem 3 (4 points)

An electron traveling with a velocity of $\vec{v} = (2.0\times10^4\,\text{m/s})\hat{i} - (5.3\times10^4\,\text{m/s})\hat{k}$ enters a region of space that contains both an electric and a magnetic field. The net force on the electron from both fields is $\vec{F} = (1.5\times10^{-16}\,\text{N})\hat{j} - (5.7\times10^{-17}\,\text{N})\hat{k}$. If the magnetic field is $\vec{B} = (6.5\times10^{-3}T)\hat{i} + (1.8\times10^{-3}\text{T})\hat{k}$, what is the electric field in unit vector notation?

$$\vec{F}_B = q(\vec{v}\times\vec{B}) \qquad \vec{v}\times\vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2.0\times10^4\,\text{m/s} & 0 & -5.3\times10^4\,\text{m/s} \\ 6.5\times10^{-3}\,\text{T} & 0 & 1.8\times10^{-3}\,\text{T} \end{vmatrix}$$

$$\vec{v}\times\vec{B} = \hat{i}\underbrace{\begin{vmatrix} 0 & -5.3\times10^4\,\text{m/s} \\ 0 & 1.8\times10^{-3}\,\text{T} \end{vmatrix}}_{=0} - \hat{j}\begin{vmatrix} 2.0\times10^4\,\text{m/s} & -5.3\times10^4\,\text{m/s} \\ 6.5\times10^{-3}\,\text{T} & 1.8\times10^{-3}\,\text{T} \end{vmatrix} + \hat{k}\underbrace{\begin{vmatrix} 2.0\times10^4\,\text{m/s} & 0 \\ 6.5\times10^{-3}\,\text{T} & 0 \end{vmatrix}}_{=0}$$

$$\vec{v}\times\vec{B} = -\hat{j}\left[(2.0\times10^4\,\text{m/s})(1.8\times10^{-3}\,\text{T}) - (-5.3\times10^4\,\text{m/s})(6.5\times10^{-3}\,\text{T})\right]$$

$$\vec{v}\times\vec{B} = (380.5\,\text{Tm/s})(-\hat{j})$$

$$\vec{F}_B = q(\vec{v}\times\vec{B}) = (-1.602\times10^{-19}\,\text{C})(380.5\,\text{Tm/s})(-\hat{j}) = (6.10\times10^{-17}\,\text{N})\hat{j}$$

$$\vec{F}_{net} = \vec{F}_B + \vec{F}_E \rightarrow \vec{F}_E = \vec{F}_{net} - \vec{F}_B$$

$$\vec{F}_E = \left[(1.5\times10^{-16}\,\text{N})\hat{j} - (5.7\times10^{-17}\,\text{N})\hat{k}\right] - (6.10\times10^{-17}\,\text{N})\hat{j}$$

$$\vec{F}_E = (8.90\times10^{-17}\,\text{N})\hat{j} - (5.7\times10^{-17}\,\text{N})\hat{k} \qquad \vec{F}_E = q\vec{E} \rightarrow \vec{E} = \vec{F}_E/q$$

$$\vec{E} = \frac{(8.90\times10^{-17}\,\text{N})\hat{j} - (5.7\times10^{-17}\,\text{N})\hat{k}}{-1.602\times10^{-19}\,\text{C}} = (-556\,\text{N/C})\hat{j} + (356\,\text{N/C})\hat{k}$$

$$\boxed{\vec{E} = (-5.6\times10^2\,\text{N/C})\hat{j} + (3.6\times10^2\,\text{N/C})\hat{k}}$$