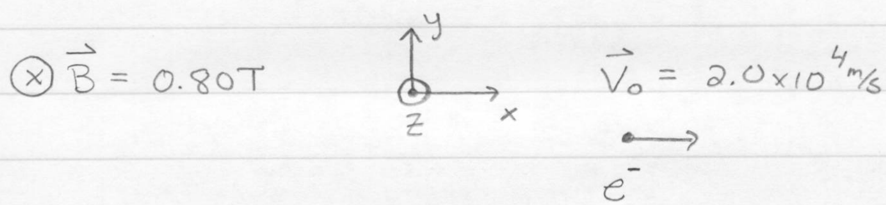
Physics 2b Quiz 6 Solutions #1 p.1



An electron is traveling in a region of mixed $\vec{E}$ and $\vec{B}$ fields without deflection. What is $\vec{E}$?

The right hand rule tells you that $\vec{V}_0 \times \vec{B}$ is up, but the particle is an e^- so its charge is negative and the force $\vec{F}_B = (-e)\,\vec{V}_0 \times \vec{B}$ is <u>down</u>.

In order for there to be no deflection, $\vec{E}$ must be directed along the y-axis. Again, the charge is negative so $\vec{E}$ must point <u>down</u> so that $\vec{F}_E = (-e)\vec{E}$ will point <u>up</u>.

To find the magnitude, just set $qE = qvB$ (because the velocity is $\perp \vec{B} \Rightarrow \sin\theta = 1$) and solve for E.

$$E = vB$$
$$= (2.0\times10^4\ \text{m/s})(0.80\text{T})$$
$$= 16{,}000\ \text{V/m}$$

Final answer: $\boxed{16\text{kV/m}\ (-\hat{j})}$

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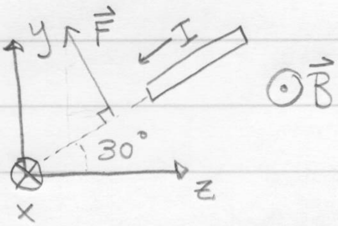

Wire in a magnetic field: $I = 3.5A$, $B = 0.5T$, $\ell = 1.2m$

What is the force on the wire?
The fast way to do this problem is to use the right hand rule to see that the force is "up and to the left" (as indicated on my drawing). That will tell you that the y-component should be positive and the z-component should be negative. That narrows the choices down to 2. Now notice that because $30° < 45°$ the y-component should be larger.
Done! $\boxed{1.8N\hat{j} - 1.1N\hat{k}}$

If you don't trust yourself that much, you can compute the force explicitly using the determinant:

$$\vec{F}_B = \vec{I}\ell \times \vec{B} = \ell \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ I_x & I_y & I_z \\ B_x & B_y & B_z \end{vmatrix} = (1.2m) \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 0 & -3.5\sin 30° A & -3.5\cos 30° A \\ -0.5T & 0 & 0 \end{vmatrix}$$

$$= (1.2m) \begin{pmatrix} \hat{i}(0-0) \\ -\hat{j}(0-(1.52TA)) \\ +\hat{k}(0-(0.88TA)) \end{pmatrix} = 1.82N\hat{j} - 1.05N\hat{k}$$

closest: $\boxed{1.8N\hat{j} - 1.1N\hat{k}}$

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α-particles ($q = +2e$) in a cyclotron w/ $r = 0.40\,m$

$B = 0.50\,T$ ($m = 6.68\times10^{-27}\,kg$)

What is the period?

$$T_{cyclotron} = \frac{2\pi m}{qB} = \frac{2\pi(6.68\times10^{-27}\,kg)}{(2\times1.6\times10^{-19}\,C)(0.5\,T)} = \boxed{0.26\times10^{-6}\,s}$$

You do not need to use the radius to solve this problem, but if you want to: $T = \frac{2\pi r}{v}$, $r = \frac{mv}{qB} \Rightarrow v = \frac{qBr}{m}$

$$\Rightarrow T = \frac{2\pi r}{(qBr/m)} = \frac{2\pi m}{qB}$$, which is the same as above.

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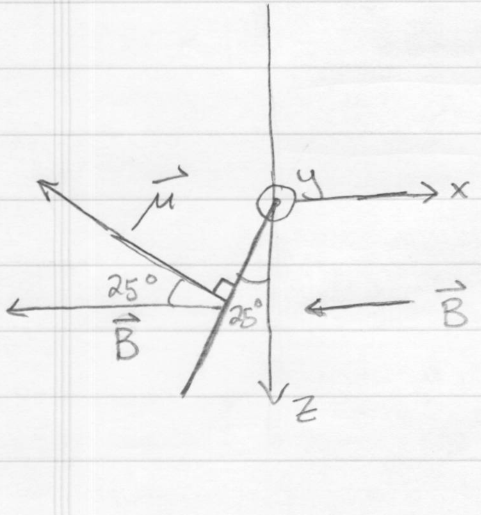

Current loop in a magnetic field,

$I = 2.0\,A$, $l = 0.4\,m$, $w = 0.3\,m$

$B = 1.2\,T$, $\theta = 25°$

What is the magnitude of the torque?

$$|\vec{\tau}| = |\vec{\mu}\times\vec{B}| = \mu B\sin\theta = IAB\sin\theta$$

$$= (2.0A)(0.3m\times0.4m)(1.2T)\sin(25°)$$

$$= \boxed{0.12\,Nm}$$

The difficulty here was finding θ. My "top down" drawing may (or may not) help convince you that θ = 25°. The easiest way for me to see this is by imagining rotating the current loop by 25° ccw. Then $\vec{\mu}$ and $\vec{B}$ would be parallel.