Homework 7

Chapter 22

Problem 6. A proton moves with a velocity of $\mathbf{v} = (2\hat{\mathbf{i}} - 4\hat{\mathbf{j}} + \hat{\mathbf{k}})$ m/s in a region in which the magnetic field is $\mathbf{B} = (\hat{\mathbf{i}} + 2\hat{\mathbf{j}} - 3\hat{\mathbf{k}})$ T. What is the magnitude of the magnetic force this charge experiences?

$$\mathbf{F} = q\mathbf{v} \times \mathbf{B} = q\begin{vmatrix} \hat{\mathbf{i}} & \hat{\mathbf{j}} & \hat{\mathbf{k}} \\ 2 & -4 & 1 \\ 1 & 2 & -3 \end{vmatrix} = q[\hat{\mathbf{i}}(12-2) - \hat{\mathbf{j}}(-6-1) + \hat{\mathbf{k}}(4-(-4))] = q(10\hat{\mathbf{i}} + 7\hat{\mathbf{j}} + 8\hat{\mathbf{k}}) \tag{1}$$

$$|\mathbf{F}| = q\sqrt{10^2 + 7^2 + 8^2} = 2.34 \cdot 10^{-18} \text{ N} \tag{2}$$

Problem 8. An electron moves in a circular path perpendicular to a constant magnetic field of magnitude $B = 1.00$ mT. The angular momentum of the electron about the center of the circle is $L = 4.00 \cdot 10^{-25}$ Js. Determine (a) the radius of the circular path and (b) the speed of the electron.

Angular momentum is defined as

$$\mathbf{L} = \mathbf{r} \times \mathbf{p} = m\mathbf{r} \times \mathbf{v} \ , \tag{3}$$

which for circular orbits reduces to

$$L = mrv \ , \tag{4}$$

because $\mathbf{r}$ and $\mathbf{v}$ are perpendicular.
We also have

$$F_c = qvB = m\frac{v^2}{r} \tag{5}$$

$$qBr = mv \ , \tag{6}$$

which combined with the angular momentum formula give two equations with two unknowns.
Solving for the unknowns

$$L = qBr^2 \tag{7}$$

$$r = \sqrt{\frac{L}{qB}} = 0.0500 \text{ m} \tag{8}$$

$$v = \frac{L}{mr} = 8.78 \text{ Mm/s} \ . \tag{9}$$

Problem 16. A wire $l = 2.80$ m in length carries a current of $I = 5.00$ A in a region where a uniform magnetic field has a magnitude of $B = 0.390$ T. Calculate the magnitude of the magnetic force on the wire assuming that the angle between the magnetic field and the current is (a) $\theta_a = 60.0°$, (b) $\theta_b = 90.0°$, and (c) $\theta_c = 120°$.

Using our formula for the force on a wire due to a uniform field we have

$$\mathbf{F} = I\mathbf{l} \times \mathbf{B} \tag{10}$$

$$F = IlB\sin\theta \ , \tag{11}$$

so just pluggging in

$$F_a = IlB\sin\theta_a = 4.73 \text{ N} \tag{12}$$

$$F_b = IlB\sin\theta_b = 5.46 \text{ N} \tag{13}$$

$$F_c = IlB\sin\theta_c = 4.73 \text{ N} \ . \tag{14}$$