Homework 8

Physics 112A

Problem 5.12 Use the result of Ex. 5.6 to calculate the magnetic field at the center of a uniformly charged spherical shell, of radius R and total charge Q, spinning at constant angular velocity ω

$$B(z) = \frac{\mu_0 I}{4\pi}\frac{cos\theta}{r^2}2\pi R = \frac{\mu_0 I}{2}\frac{R^2}{(R^2+z^2)^{\frac{3}{2}}}$$

θ is from the center of the sphere instead of from the ring, so $cos\theta \to sin\theta$.

$$\begin{aligned}
R &\to Rsin\theta \\
dI &= KRd\theta \\
&= \sigma v R d\theta \\
&= \frac{Q}{4\pi R^2} Rsin\theta\omega R d\theta \\
&= \frac{Q\omega}{4\pi} sin\theta d\theta \\
dB &= \frac{2\pi\mu_0}{4\pi}\frac{Rsin^2\theta}{R^2}dI \\
&= \frac{\mu_0}{2R}sin^2\theta\frac{Q\omega}{4\pi}sin\theta d\theta \\
&= \frac{Q\omega\mu_0}{8\pi R}\int_0^\pi sin^3\theta d\theta \\
&= \frac{Q\omega\mu_0}{8\pi R}[\frac{1}{3}cos^3\theta - cos\theta]_0^\pi \\
&= \boxed{\frac{Q\omega\mu_0}{6\pi R}}
\end{aligned}$$

Problem 5.13 Suppose you have two infinite straight-line charges λ, a distance d apart, moving along at a constant speed v. How great would v have to be in order for the magnetic attraction to balance the electrical repulsion ? Work out the actual number. Is this a reasonable sort of speed ?

Biot-Savart:

$$B(r) = \frac{\mu_0 I}{4\pi}\int \frac{dlx\hat{r}}{r^2}$$

$$F_C = F_L$$
$$\frac{Q}{4\pi\epsilon_0 d^2} = \int (Id\vec{l}x\vec{B})$$