Physics 370 **Homework 11** **Due Wednesday, April 25, 2018**

Reading: Griffiths pages 251-255 and 266-291.

<u>Problem 1</u> A small square wire loop has side a and has its center at the origin. Use the dipole approxiation to find the magnetic field $\vec{B}$ at the point $(x, y, z) = (0, d, 0)$ if:
(a) the square is in the xy plane and carries current I clockwise as viewed by an observer on the positive z axis
(b) the square is in the xz plane and carries current I clockwise as viewed by an observer on the positive y axis.

<u>Problem 2</u> Consider a very thin flat circular annular disk of inner radius a and outer radius b, in the xy plane with its center at the origin and with total charge Q, uniformly distributed. The disk rotates about the z axis slowly, with angular velocity ω.
(a) Take a circular part of the disk with infinitesimal thickness dr along the direction measured away from the center, and consider it as a circular current loop. What is the current dI flowing in that circular loop? What is the magnetic moment $d\vec{m}$ of that loop?
(b) What is the magnetic moment of the whole disk?
(c) What is the magnetic field $\vec{B}$ far from the origin?

<u>Problem 3</u> A spherical shell of radius a has its origin at the center. It carries a total charge Q uniformly distributed on its surface, and rotates around the z axis with angular velocity ω.
(a) What is the magnetic field $\vec{B}$ far from the origin? [Hint: you may make use of the results of Example 5.11 of the book.]
(b) What is the magnetic moment of the sphere? [Hint: find this by comparing the vector potential for large r to that of a pure magnetic dipole.]
(c) What is the total force on a point charge q that is at the point $(x, y, z) = (0, 0, d)$ moving with speed v in the $\hat{y}$ direction? Assume $d \gg a$.

<u>Problem 4</u> A region containing some unknown exotic material, which may or may not have free or bound currents in it, has a magnetic field

$$\vec{B} = \frac{\mu_0 m_0}{4\pi r^3}\left[C_1 \sin\theta \sin\phi\, \hat{r} + C_2 \cos\theta \sin\phi\, \hat{\theta} + \cos\phi\, \hat{\phi}\right],$$

where C_1 and C_2 are certain integers.
(a) What are the integers C_1 and C_2?
(b) If I had given you the same expression above but said it was $\vec{H}$ instead of $\vec{B}$, you would not be able to answer part (a). Explain in 15 words or less.