MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Physics Department

Physics 8.07: Electromagnetism II November 4, 2012
Prof. Alan Guth

PROBLEM SET 8

DUE DATE: Friday, November 9, 2012. Either hand it in at the lecture, or by 6:00 pm in the 8.07 homework boxes.

READING ASSIGNMENT: Chapter 6 of Griffiths: *Magnetic Fields in Matter.*

CREDIT: This problem set has 115 points of credit.

PROBLEM 1: THE MAGNETIC FIELD OF A SPINNING, UNIFORMLY CHARGED SPHERE *(25 points)*

This problem was held over from Problem Set 7.

Griffiths Problem 5.58 (p. 253). In part (b), you are expected to use Eq. (5.89), from Problem 5.57, without proving it in any way. In part (c), where you are asked to find the approximate vector potential, you are expected to find it in the dipole approximation.

PROBLEM 2: SQUARE CURRENT LOOP ON AXIS: BIOT-SAVART AND THE MAGNETIC DIPOLE APPROXIMATION *(15 points)*

Griffiths Problem 5.37 (p. 246).

PROBLEM 3: CURRENT LOOPS AND NEWTON'S THIRD LAW *(10 points)*

Griffiths Problem 5.49 (p. 250).

There is nothing wrong with the hint that Griffiths gives, but I would give a slightly different hint: recall that

$$\frac{\vec{r} - \vec{r}\,'}{|\vec{r} - \vec{r}\,'|^3} = -\vec{\nabla}_{\vec{r}} \frac{1}{|\vec{r} - \vec{r}\,'|} \ .$$

PROBLEM 4: AN INFINITE SLAB OF CURRENT AND THE FORCE ON A MAGNETIC DIPOLE *(15 points)*

Griffiths Problem 6.5 (p. 260).

PROBLEM 5: A BAR MAGNET IN THE SHAPE OF A RIGHT CIRCULAR CYLINDER *(20 points)*

This problem is based on Griffiths Problem 6.9 (p. 265) and Jackson Problem 5.19 (p. 230).

A bar magnet is in the shape of a right circular cylinder of length L and radius a. The cylinder has a permanent magnetization M_0 uniform throughout its volume and parallel to its axis.

(a) Calculate $\vec{H}$ and $\vec{B}$ at all points on the axis of the cylinder, both inside and outside the magnet. Use a coordinate system in which the z axis is the axis of the cylinder, with the cylinder extending from $z = -\frac{1}{2}L$ to $z = \frac{1}{2}L$.

(b) Sketch in a plot the quantities $|\vec{B}|/\mu_0 M_0$ and $|\vec{H}|/M_0$ as a function of z/a, for $L/a = 5$.

(c) Find the bound current.

(d) The $\vec{B}$ field far away from the magnet is approximately that of a magnetic dipole. What is the dipole moment?

PROBLEM 6: CURRENT TRAVELING ON A LONG STRAIGHT WIRE MADE OF A MATERIAL WITH LINEAR MAGNETIZATION *(15 points)*

Griffiths Problem 6.17 (p. 277).

PROBLEM 7: DONUT-SHAPED MAGNETS ON A VERTICAL ROD *(15 points)*

Griffiths Problem 6.25 (p. 283).

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Fall 2012