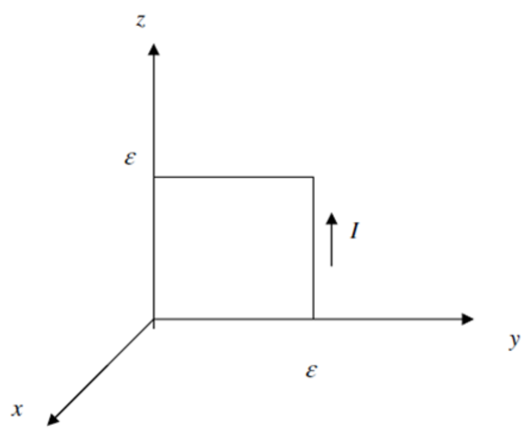
PHYS 3033/3053 Assignment 7

Due: 18 Nov 2015 at begin of lecture at 3:00 pm

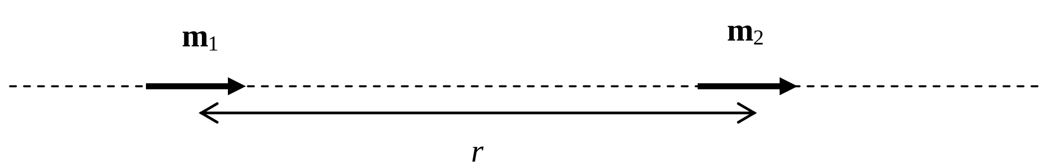
Problem 1.

Consider an infinitesimal square of side ε. Choose the coordinate system such that the square is in the first quadrant on the *yz* plane, with one corner at the origin and sides parallel to the axes. The square carries a current *I*. Calculate $\mathbf{F} = I\int d\mathbf{l}\times\mathbf{B}$ along each of the four sides. Expand $\mathbf{B}$ in a Taylor series. For example, on the right hand side, $\mathbf{B} = \mathbf{B}(0,\varepsilon,z) \cong \mathbf{B}(0,0,z) + \varepsilon \left.\frac{\partial \mathbf{B}}{\partial y}\right|_{(0,0,z)}$. Show that the magnetic force on the square is given as $\mathbf{F} = \nabla(\mathbf{m}\cdot\mathbf{B})$.



Problem 2.

Use $\mathbf{F} = \nabla(\mathbf{m}\cdot\mathbf{B})$ to find the force between two ideal magnetic dipoles, $\mathbf{m}_1$ and $\mathbf{m}_2$, pointing at the same direction along the line joining them, as shown in the figure below. The separation of the two dipoles is *r*.



Problem 3.

Calculate the torque exerted on the square loop (side length *b*) due to the circular loop (radius *a*) as shown in the figure below.

Both loops carry the same current I and the distance between the centers of the two loops is r. Assume that r is much larger than a and b.

(a) Find the torques acting on one loop due to the other.

(b) If the square loop is free to rotate, what will its equilibrium orientation be?

Problem 4.

A long circular cylinder of radius R carries a magnetization $\mathbf{M} = ks^2\hat{\boldsymbol{\phi}}$, where k is a constant. Find the magnetic field due to **M**, for points inside and outside the cylinder.