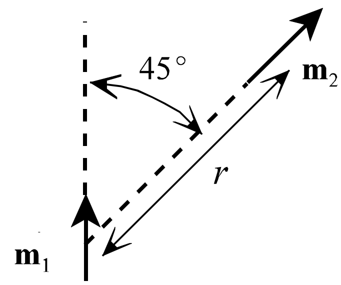
Phys 321 – E & M II – Test 1 – Sept. 27, 1999

1. (20 pts) Two magnetic dipoles, $\vec{m}_1$ and $\vec{m}_2$, are oriented as shown. The angle between their directions is $45°$ and they are a distance r apart.

   a) Calculate the torque on $\vec{m}_2$ due to $\vec{m}_1$.

   b) Calculate the force on $\vec{m}_2$ due to $\vec{m}_1$.



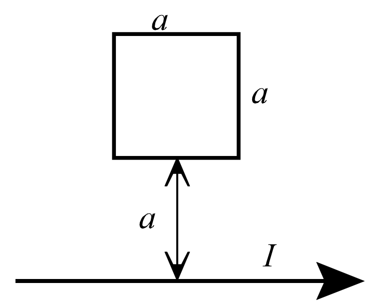
Recall: $\vec{B} = \dfrac{\mu_0}{4\pi r^3}\left[3(\vec{m}\cdot\hat{r})\hat{r} - \vec{m}\right]$

2. (20 pts) Find the self-inductance per unit length of a long solenoid, of length ℓ and radius R, carrying n turns per unit length.

3. (20 pts) A square loop of wire of side a lies a distance a from a long straight wire, which carries a current I.

   a) Find the magnetic flux through the loop.

   b) If the current in the wire varies as $I(t) = I_0 e^{-\alpha t}$, where I_0 and α are constants, determine the emf induced in the loop.



3. (20 pts) Consider *charging up* an inductor L, by connecting it and a resistor R to a battery of fixed voltage V_0 at time $t = 0$. The current is described by $I(t) = I_0(1 - e^{-t/\tau})$

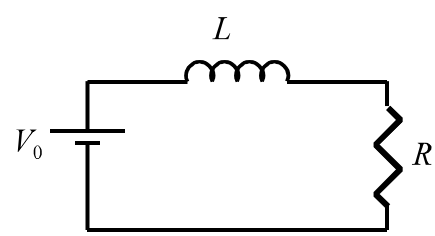
   a) Determine expressions for I_0 and τ.

Let $L = 0.2$ H, $R = 40\ \Omega$, and $V_0 = 20$ volts.

   b) Evaluate I_0 and τ.

   c) After a long time what is the power dissipated in the resistor as heat?

   d) What is the final energy stored in the inductor?



Recall: $\displaystyle\int_0^\infty x^n e^{-ax} dx = \frac{n!}{a^{n+1}}$

5. (20 pts) An "infinitely" long hollow cylinder, inner radius a and outer radius b, carries a "frozen-in" magnetization

$$\vec{M} = M_0 \frac{a^2}{s^2}\hat{\phi} \qquad a \le s \le b$$

where M_0 is a constant, s is the distance from the center of the cylinder, and $\hat{\phi}$ is the usual azimuthal unit vector.

   a) Determine all the bound currents.

   b) Use the bound currents to determine the magnetic field in all three regions: $s < a$; $a < s < b$; $s > b$.