Phys 332
Electricity and Magnetism II
Prof. Fulvio Melia
Homework - 1

Physics — Magnetic Energy and Multipoles

1: A cylindrical conductor of radius a carries a uniformly distributed current I. Use Equation 18-21 to determine the total magnetic energy in a length l of the cylinder between $\rho = 0$ and $\rho = R$ where $R > a$.

2: You have an infinite solenoid of radius a carrying a current I. Determine the total magnetic energy in a length l of the solenoid using Equation 18-12. You should compare your answer to the short example between Equations 18-23 and 18-24 in the text. Hint: use $\int\int \vec{B} \cdot \vec{da} = \oint \vec{A} \cdot \vec{ds}$ to find $\vec{A}$.

3: Wangsness 17-24. You solved this on the previous assignment but this time determine L using a technique that requires calculating the magnetic energy. Also, find the magnetic pressure on the inner conductor. Does this pressure tend to expand or contract the conductor? Lastly, if $a = 1$ cm, what current would you need to generate a pressure of 1 atm?

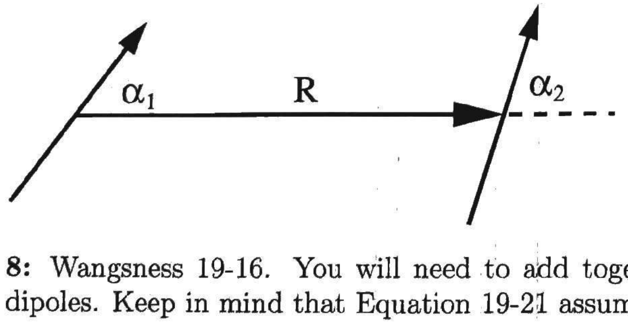
4: Wangsness 19-1. The $\vec{ds}'$ in the integral to calculate $\vec{m}$ will be $\vec{dr}$ where the $\vec{r}$ is the position vector given in the problem. Do you understand why? To determine $\vec{dr}$ you will need to (among other things) take $d\hat{\rho}$. Do you know how to do that?

Do you understand why the question has the restriction $n \geq 2$? Hint: the integral will be different if $n = 1$.

5: Wangsness 19-3. Additionally, a point dipole ($\vec{m} = m\hat{z}$) is located at $z = z_0$ when the cylinder is centered on the origin. You may assume that $z_0 \gg \frac{l}{2}$. Determine the force on that point dipole due to the spinning cylinder. You may use Equation 19-24. Since the cylinder is obviously best handled in cylindrical coordinates, the dipole field is best written in spherical coordinates and the point dipole is on the z axis, expect to use all three coordinate systems!

6: Wangsness 19-7. You may again use Equation 19-24. You may assume that $\vec{B}$ doesn't vary over the surface of the loop.

7: Wangsness 19-11. You may start with Equation 19-56. Does your answer make sense if $\alpha_1 = 0$ and if $\alpha_1 = \frac{\pi}{2}$? Explain.



8: Wangsness 19-16. You will need to add together the vector potential due to the two dipoles. Keep in mind that Equation 19-21 assumes that the dipole is at the origin.