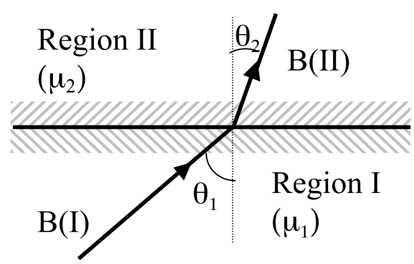
Phys 3310, HW #15, Due in class Wed May 1

Q1. SURVEY: http://tinyurl.com/CU-phys-SP13
You will get full credit on this homework problem for filling out this survey (URL above). We obviously won't grade you in any way on your specific responses - your opinions matter and will help us improve this course in the future. *(When I get the results, they will be anonymized and summarized, so I can give you credit but can't connect answers to names)*

Q2. AND, ANOTHER (DIFFERENT!) SURVEY
http://per.colorado.edu/surveys/pollock_sp13_3310_post.html
All the same comments as for Q1. Thanks for participating.

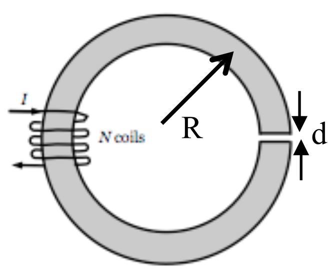
Q3. B INSIDE WIRES.
In a regular household wire, current I flows (uniformly!) down a long straight conducting wire of radius R. Assume the metal is "magnetically linear" with susceptibility χ_m, and find **B** as a function of distance s from the center of the wire (both *inside* and *outside* the wire)
A) What are all the bound currents in this problem? (Check yourself by verifying that the total *bound* current is zero)
B) Consider explicitly two real-world cases, copper wire and aluminum wire. For each case: sketch B(s) versus s, and explicitly discuss the physics inside, at the boundary, and outside which explains all interesting features of the s-dependence of this B field.
- Would it have mattered much if we had treated this problem like a "Chapter 5 problem" and totally neglected the magnetic susceptibility of the wire?

Q4. BOUNDARY CONDITIONS FOR B AND H FIELDS
In class awhile ago, we considered the situation of a static E field spanning a boundary between two different materials (with different dielectric constants, ε). Now, let's do the same thing with static B fields:



A) in the configuration shown, assuming medium one has relative magnetic permeability μ_1, and medium two has permeability μ_2, find the ratio $\tan\theta_2/\tan\theta_1$.
(Find the ratio in terms of μ_1 and μ_2, that should be simplest. Assume there is no free current anywhere in the figure).
B) In the figure as shown, if one of the regions is vacuum, and the other one is paramagnetic, which is which? (I.e. which region is vacuum, region I or region II?)
- How about if one is vacuum, and one is diamagnetic, then which is which? Briefly explain.

Q5. CONTINUITY B AND H FIELDS
A toroidal piece of "soft iron" (iron that is roughly magnetically linear, but has a very large permeability μ characteristic of ferromagnetic materials) has a very thin gap in it, of width "d". A wire carries current I, and is wrapped N times around a section of the toroid. The toroid has a constant cross-sectional area A, and a central radius R (as shown)
Find the B and H fields in the gap.
Given your answer, discuss a practical advantage to building such a thing.



You may assume: that B (and H and M) inside the soft iron are quite uniform, smooth, and continuous all the way around... except of course in the gap. (What is continuous through the little gap region, H or B? Why?)
HINT: Given the assumption that the H field is "running around the torus", what does

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Ampere's law for H (Griffiths eq 6.20) tell you? That's a helpful starting point!
More assumptions: neglect fringe fields, $\mu/\mu_0 >> 1$ for soft iron.
Finally, assume that $\mu/\mu_0 >> (2\,\pi\,R/d)$, in other words that although the gap may be reasonably small, μ/μ_0(iron) is quite huge (typically of order 1000)

Q6. B AND H IN A CAVITY

A) Find **B** and **H** at the center of a hollow spherical cavity carved out of a *large* chunk of uniform, linear, magnetic material (susceptibility χ_m) which had (before you carved the hole!) a total uniform field $\mathbf{B} = B_0\,\hat{\mathbf{z}}$ through its volume. So, this material will be magnetized, and (before the cavity is carved) will have a uniform $\mathbf{H}_0 = (1/\mu_0)B_0\,\hat{\mathbf{z}} - M_0\,\hat{\mathbf{z}}$.
(Important: express your final answers in terms of B_0 and χ_m only!)
B) For a diamagnetic material, how does B in the hole compare with B_0? (Discuss the physics, how does this arise?)
Hint: Think of the problem as the superposition of a large totally uniform magnetized system with a sphere of uniform but opposite magnetization. Griffiths works out an example problem with such a sphere – you may use that result without rederiving it)
This problem could help you to "model" magnetic materials - knowing B in a cavity would tell you how an atom there would magnetize...