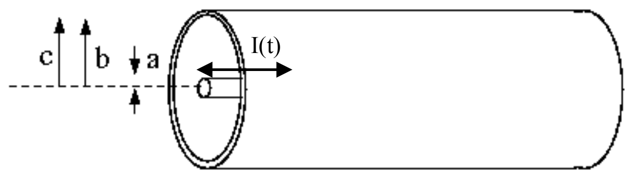
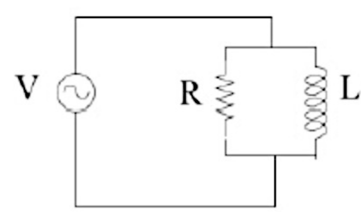
NOTE: First midterm exam is Thursday Oct 2, 7:30-9:30 PM. See our website for exam details – it will NOT be held in our classroom, it will be in HUMN 150.

1.) Review of Ampere's & Faraday's law: Consider a standard coax cable as an "infinite" length wire of radius a surrounded by a thin conducting cylinder, coaxial with the wire, with inner radius b and outer radius c.



Assume it's a "thin wire and thin shell", i.e. $a \ll b$ and $c-b \ll b$ as show in the figure. (We will be neglecting fields INSIDE solid metal regions, just focusing on the "coax region" ($a<s<b\approx c$)
Assume $I(t) = I_0 \cos \omega t$ flows down the central wire and a corresponding current $-I(t)$ returns in the opposite direction on the outer cylinder.
- Find the B field $\mathbf{B}(s,t)$ in the "coax region" ($a<s<b$) where s is the usual radial coordinate and the current on the wire is I_0 in the $+z$ direction at $t = 0$. (*Nothing tricky here, it should be a familiar old problem. You pretty much already did it last week, but see hints below.*)
-Then, find the induced electric field $\mathbf{E}(s,t)$ in the "coax region" ($a<s<b$)
(Hint: For the B field, think Ampere! Assume we are "quasi-static": the currents are identical in magnitude at each moment, and changes in current are slow, so you can still safely use Ampere's law in the usual way to find the B field.
For the E field, think Faraday! I found it much easier to work directly from the differential form and just "eyeball" a solution. I did need to look at the front flyleaf to remember curl(E) in cylindrical coordinates, though!)
Other comments: I assume that the magnitude of $\mathbf{E} \to 0$ *as* $s\to\infty$. *I claim this implies* $\mathbf{E}=0$ *all the way in to the coax, can you argue why more rigorously? This may turn out to be a useful "boundary condition" for E inside…)*

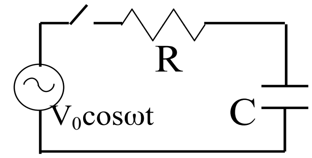
2.) In the circuit shown in the figure, the power supply provides an EMF of $V = V_0 \cos(\omega t)$.



(a) Find the current through the power supply as a function of time after all the transients have died away. Use the method of "phasors"!

(b) How does your answer behave in the limits $\omega \to 0$ and $\omega \to \infty$? Make sense of these limits, given the characteristics of an inductor.

3.) More AC circuits: If you drive the RC circuit shown with an AC source $V = V_0 \cos(\omega t)$, closing the switch at t=0, I claim the resulting current is:



$$I(t) = \frac{V_0}{\sqrt{R^2 + 1/C^2\omega^2}}\cos(\omega t + \varphi) + \frac{V_0}{R}\frac{1}{1+R^2C^2\omega^2}e^{-t/RC}, \text{ with } \varphi = \tan^{-1}(1/RC\omega)$$

You do <u>not</u> have to derive that formula! (though you're welcome to, I think it's good practice) Instead, I have some questions about interpreting this result. *(In all these questions, where I say "response", I generally mean "the amplitude of current")*

i) What is the time constant for this circuit? (Can you just "spot it"? No calculation needed!) Briefly, how do you interpret it physically, what is it telling you? How would you make it *longer*?

ii) How do you read off from that formula the "long time" response? (Again, no calculation needed, can you just "spot it"?) Describe this long term response in words, what is physically happening?

iii) After a long time, is the current "leading" or "lagging" the source voltage? (Again, no calculation needed, can you just "see" the answer from the formula?)

iv) Which leads to a stronger response of this circuit after a long time: low or high driver frequency? (Briefly, does this make physical sense to you, given this circuit?)

EXTRA CREDIT: (You can choose either one of these two options! But for this week, no doubling up of EC if you do both…)

i) **Earn an old problem back!** Review your graded homeworks and the posted solutions up to now. Choose a problem on which you did not get full credit (**Please** clearly state which set, *and* which problem, you have decided to focus on.) State what was incorrect about the solution you had given on the first pass. (This means you should find a problem you got WRONG, rather than one you simply *punted!)*. This is more than simply redoing an old problem with a solution set in front of you – we want you to explain what you have learned. Express your reasoning at the time, then explain the correct solution. We don't want you to simply copy/reproduce a solution that is in front of you - we want you to understand it, own it for yourself)

OR

ii) Invent a plausible exam question, and post it on Piazza. Then, look at other people's questions, pick one that hasn't been responded to by too many people, and try it/respond. Give them some constructive feedback (online!) – do you think their problem is too easy for a test, too hard, off topic? (For this extra credit, you must *both* invent and respond to someone else's piazza question)