Due Apr. 16, Thursday

Problem 1 (10 points) Consider the setup considered in Example 8.3, but now assume that the space between the inner conductor and the outer conductor is filled completely with a dielectric material with permittivity ε. Assume that the material is not magnetic ($\mu = \mu_0$). [You need to use the results from homework problem 1.5.]

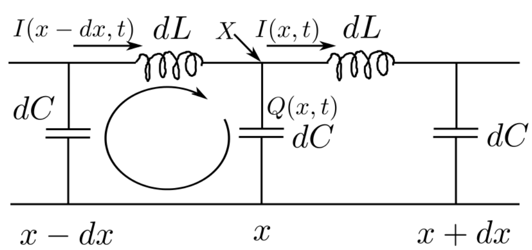
(a) Calculate the power transported down the wire in terms of the voltage V and the current I.

(b) Find the momentum of the field over the length l of this coaxial cable in terms of I, V, c, etc. Note that $(\varepsilon\mu_0)^{-1/2}$ is a speed scale—it is the speed of light *in the dielectric*. You may express this as c/n where n is the so-called index of refraction.

(c) Find the capacitance per unit length ($\mathcal{C}$) and the inductance per unit length ($\mathcal{L}$) of this coaxial cable.

(d) According to the telegraph equation (see the next problem), the current propagates at the speed given by $\sqrt{1/(\mathcal{L}\mathcal{C})}$ down the line. Find this speed and compare it with the speed of light.

Problem 2 (10 points) Consider a lossless transmission line, a small arbitrary segment of which can be modeled as shown in the diagram below. Here, the coordinate x is used to denote the position along the transmission line. Each (infinitesimally) small segment of the line has inductance $dL = \mathcal{L}\,dx$ and capacitance $dC = \mathcal{C}\,dx$, where $\mathcal{L}$ is the inductance per unit length and $\mathcal{C}$ is the capacitance per unit length.



By considering the Kirchoff law for the circuit loop indicated in the above diagram and the current conservation at junction point X, and by combining the two resulting equations, show that the current $I(x,t)$ satisfies the wave equation

$$\frac{\partial^2 I}{\partial t^2} = v^2 \frac{\partial^2 I}{\partial x^2}$$

where the speed of the current propagation is given by

$$v = \frac{1}{\sqrt{\mathcal{LC}}}.$$

Problem 3 (10 points) Problem 8.17 (a wishful classical model of electron).

Problem 4 (10 points) Probelm 8.8 (field angular momentum)

Problem 5 (10 points) Problem 9.2 (standing wave)

Problem 6 (10 points) Problem 9.5 (mechanical wave)

Problem 7 (10 points) Problem 9.33 (Fourier integral)

Someone said "If a nation values anything more than freedom, it will lose its freedom, and the irony of it is that if it is comfort or money that it values more, it will lose that too." We might also say, I think, "If a student values anything more than sweat and true knowledge, the student will lose knowledge, and the irony of it is that if it is easy solution or easy grade that the student values more, the student will lose that too."
