Week 12 Worksheet
Electrodynamics

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Exercise 1. An infinite solenoid with a number of wire loops per unit length n is hooked up to an alternating current $I = I_0 \sin(\omega t)$. Find the electric field inside the solenoid if the radius of the solenoid is $a \ll c/\omega$.
Hint: The divergence in cylindrical coordinates is

$$\nabla \cdot \mathbf{v} = \frac{1}{s}\partial_s(s v_s) + \frac{1}{s}\partial_\varphi v_\varphi + \partial_z v_z.$$

Exercise 2. A toroidal coil has N tightly wound turns of wire with current $I(t) = kt$, where k is a constant. The torus has outer radius a (in the equatorial plane), and it has a circular cross section of radius $b \ll a$. Find the following fields, ignoring any components of the current which are perpendicular to the circular cross sections.

a) The magnetic field inside and outside the solenoid.

b) The electric field at a distance $r \gg a$ from the coil. Your answer can be of the form of the lowest multipole moment (e.g. monopole moment, dipole moment, etc.).
Hints: Maxwell's equations for Faraday fields are identical to those for *magnetostatics*, with $\mathbf{E}$ and $-\partial_t \mathbf{B}$ playing the role of $\mathbf{B}$ and $\mu_0 \mathbf{J}$, respectively.