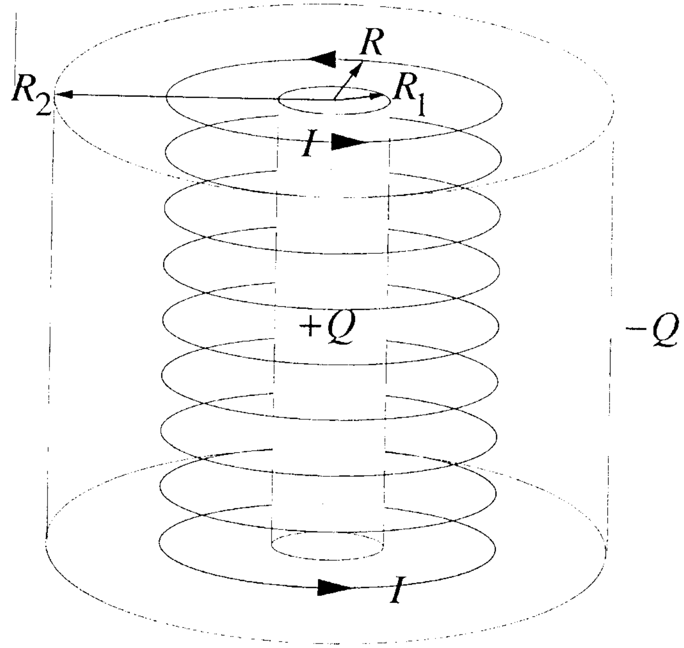

Two long thin cylindrical shells have radii R_1 and R_2 with $R_1 < R_2$. The inner shell carries on its surface a uniformly distributed bound charge $+Q$ per unit length, and the outer shell carries on its surface a uniformly distributed bound charge of $-Q$ per unit length. These charges give rise to an electric field $\mathbf{E}$ in the region between the shells. A long solenoid of radius R with $R_1 < R < R_2$ is also coaxial with the cylindrical shells. Initially the solenoid carries a counter-clockwise current I which generates a magnetic field $\mathbf{B} = \mu_0 \mathbf{H}$, where μ_0 is the permeability of free space.

(SI units are used throughout this problem.)

a) Compute the $\mathbf{E}$ and $\mathbf{B}$ fields everywhere in space. Ignore end effects.

b) Compute the volume integral

$$\mathbf{L} = \frac{1}{c^2} \int \mathbf{r} \times (\mathbf{E} \times \mathbf{H})\, dV$$

for a unit length of the assembly in terms of I, Q, R, R_1 and R_2. Here $\mathbf{r}$ is a position vector whose origin may conveniently be taken to lie on the axis of the assembly, $c = 1/\sqrt{\mu_0 \epsilon_0}$ is the speed of light, and ϵ_0 is the dielectric constant of the vacuum.

The current in the solenoid is now switched off, giving rise to a transient **E** field.

c) Compute the time integral of the torque per-unit-length that the transient **E** field produces on the charge on the *inner* cylindrical shell.

d) Compute the time integral of the torque per-unit-length that the transient **E** field produces on the charge on the *outer* cylindrical shell.

e) Explain the relation, if any, between your computations in parts c) and d) and your results in part b).