**EMA** An infinitely long, thin, massless, and non-conducting cylindrical shell of radius $R$ has a uniform surface charge density $\sigma$. The cylinder rotates around its axis at angular velocity $\omega$.

a) Initially assume that $\omega$ is constant. Find the electric field $\mathbf{E}$ and the magnetic field $\mathbf{B}$ at all points inside and outside the cylinder.

*For all remaining parts of this problem the angular velocity increases steadily, so $\omega = \alpha t$ where $\alpha$ is a constant.*

b) Find the electric field $\mathbf{E}$ at all points inside and outside the cylinder.

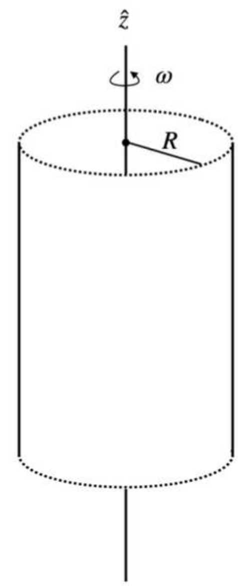
c) Compute the Poynting vector $\mathbf{S} = \mathbf{E} \times \mathbf{H}$ just outside and just inside the cylinder. Use the Poynting vector to find the direction and rate of the energy flow per unit cylinder length.

d) Find the time rate of change of the energy density

$$U \equiv \frac{1}{2}\mathbf{B} \cdot \mathbf{H} + \frac{1}{2}\mathbf{E} \cdot \mathbf{D}$$

both inside and outside the cylinder.

e) Is your answer to part (d) consistent with your result in part (c)? If not explain why it is not.




f) Because the energy stored in the fields is increasing, external work is being done on the cylinder. What is the torque $\tau$ per unit length that must be applied to do the work? Show that $\tau$ is time independent.