Homework12

Problem 1 Tangent field lines

Assume that the uniform field $\vec{E}_0$ that causes the electric field in Lec. 20-2 (Fig. 1a) is produced by large capacitor plates very far away. Consider the special set of field lines that are tangent to the sphere (as shown in Fig. 1b). These lines hit each of the distant capacitor plates in a circle of radius r. What is r in terms of the radius R and relative dielectric constant ϵ_r of the sphere? Hint: Consider a well-chosen Gaussian surface that has the horizontal great circle of the sphere as part of its boundary.

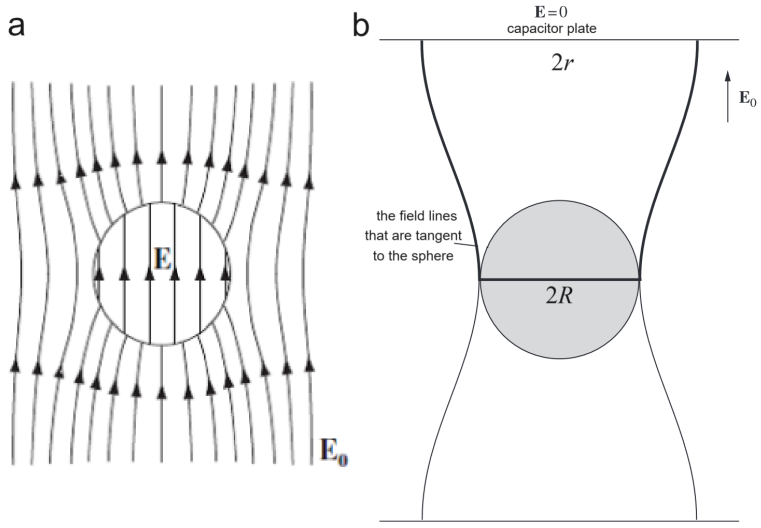

Fig. 1

Problem 2 Q for a leaky capacitor

Consider an oscillating electric field, $E_0 \cos \omega t$, inside a dielectric medium that is not a perfect insulator. The medium has dielectric constant ϵ and conductivity σ . This could be the electric field in some leaky capacitor that is part of a resonant circuit, or it could be the electric field at a particular location in an electromagnetic wave. Show that the Q (quality) factor $Q = \omega \cdot \frac{\text{energy stored}}{\text{average power dissipated}}$, (Lec. 18-2 is the special case of Q for **LCR circuit** at **resonance frequency**), is $\omega\epsilon/\sigma$ for this system, and evaluate it for seawater (the conductivity is 4 $(\Omega\ \mathrm{m})^{-1}$, and the relative dielectric constant is 80 at 10^9 Hz). You will need to use the result from Lec. 20-3. What does your result suggest about the propagation of waves through seawater?