Electrodynamics(H2) (SC1.102a)

IIIT-H, Semester Winter 25, Assignment 2

Submission deadline: 4th May 2025 (strict deadline)

---

1. In the ground state of hydrogen atom the charge density of the electron cloud is given as

$$\rho(r) = \frac{q}{\pi a^3} e^{-2r/a} \,,$$

where q is the charge of an electron, and a is the (so called Bohr) radius. Find the atomic polarizability of hydrogen atom. *Hint: Calculate the electric filed E_e due to the electron cloud at some distance r from the center. Once external electric field E is applied the nucleus will shift from $r = 0$ to $r = d$. At $r = d$, E_e cancels the external field E.*

2. Show that the energy of a dipole $\vec{p}$, kept in an electric field is $\vec{E}$ is $U = -\vec{p}.\vec{E}$. *Hint: Torque acting on the dipole is $\vec{N} = \vec{p} \times \vec{E}$. Energy is the work to rotate the dipole to align with the field.*

3. In class we have shown that for an electromagnetic wave (EM) in free space ($\rho = 0, \vec{J} = 0$) traveling along the z axis, the $\vec{E}$ and $\vec{B}$ and $\hat{z}$ are perpendicular to each other. Repeat the exercise assuming that the wave is traveling along $\vec{r} = \hat{x}x + \hat{y}y + \hat{z}z$. Show that $\vec{E}$ and $\vec{B}$ and $\vec{r}$ are perpendicular to each other. *Hint: Follow Griffiths's book.*

4. EM waves inside a conductor.

   (a) Obtain the electromagnetic wave equations for $\vec{E}$ and $\vec{B}$ in a conducting media with free charge density ρ and current density $\vec{J}$. Take the conductivity as σ.

   (b) Assuming plane wave solutions, show that both $\vec{E}$ and $\vec{B}$ are attenuated inside the conductor.