Indian Institute of Technology Gandhinagar

PH101: Physics

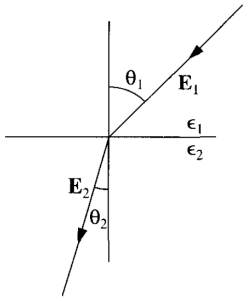
Assignment-4 Due on January 31, 2017

Note:

1. Write your **name**, **roll number** and **section** clearly on the answer sheet on the top-right corner. Also put down assignment number and submission date.
2. Deadlines for assignment submission will be followed strictly.
3. Show all the necessary steps clearly and concisely. Avoid scratch work on the main answer sheet and box the final answer.

Problems

1. Show that the energy of an ideal dipole **p** in an electric field **E** is given by $U = -\mathbf{p}\cdot\mathbf{E}$. Hence show that the interaction energy of two dipoles separated by a displacement **r** is $U = \frac{1}{4\pi\varepsilon_0}\frac{1}{r^3}\left[\mathbf{p}_1\cdot\mathbf{p}_2 - 3(\mathbf{p}_1\cdot\hat{\mathbf{r}})(\mathbf{p}_2\cdot\hat{\mathbf{r}})\right]$
2. A solid sphere of radius *a* and dielectric constant ε_r has a uniform volume charge density of ρ_0. (a) At the center of the sphere, show that $V = \frac{\rho_0 a^2}{6\varepsilon_0\varepsilon_r}(2\varepsilon_r + 1)$. (b) Find the potential at the surface of the sphere.
3. At the interface between two linear dielectrics, the electric field lines bend as shown below. Show that $\frac{\tan\theta_2}{\tan\theta_1} = \frac{\varepsilon_2}{\varepsilon_1}$, assuming there is no free charges at the boundary.



4. An infinitely long solid conductor of radius *a* is placed along the z-axis. If the conductor carries current I in the z-direction, show that $\boldsymbol{B} = \frac{I\rho}{2\pi a^2}\boldsymbol{a}_\phi$ within the conductor. Also find the corresponding current density.
5. A current distribution gives rise to the magnetic vector potential $\vec{A} = x^2 y\hat{i} + y^2 x\hat{j} - 4xyz\hat{k}$ Wb/m. Calculate (a) B at (-1, 2, 5) and (b) The flux through the surface defined by $z = 1$, $0 \le x \le 1$ and $-1 \le y \le 4$.
6. Calculate the force between two parallel circular coaxial coils of nearly the same size (radius R_1 and R_2) and carrying current I_1 and I_2 respectively, kept separated by a small distance in free space. For what distance between the coils is this force a maximum?