

Electrodynamics (PHY 514) : 2006

Assignment 6 :

This problem set is due **Thursday February 16**, at the end of the lecture. Feel free to discuss the problems with others in the class, but you must write your own solutions. Simply writing the answer without showing a derivation will obtain zero credit.

1. Consider a localized charge distribution $\rho(\mathbf{r})$. This charge distribution gives rise to a potential $\phi(\mathbf{r})$. In class we derived the multipole expansion of $\phi(\mathbf{r})$ up to and including the contribution from the quadrupole moment of the distribution. Consider the scenario in which the photon has a very small mass μ . Derive the multipole expansion of $\phi(\mathbf{r})$ up to and including the contribution from the quadrupole moment. Discuss the physical origin of any new terms that might appear in the expansion.
2. Consider an axially symmetric molecule with vanishing charge and electric dipole moment, but non-zero quadrupole moment. The molecule is aligned along the z-axis. A point charge, $+q$ is located at (r_0, θ_0, ϕ_0) .
 - (a) What is the torque on the molecule in terms of Q_{zz} ?
 - (b) The force on the molecule can be written as

$$\mathbf{F} = F_r \hat{\mathbf{e}}_r + F_z \hat{\mathbf{e}}_z ,$$

where $\hat{\mathbf{e}}_r$ and $\hat{\mathbf{e}}_z$ are the unit vectors in the radial and z-directions. What are the coefficients F_r and F_z in terms of Q_{zz} ?

3. A dielectric sphere of radius a and dielectric constant ϵ , is located at the origin. A charge $+q$ is located a distance d from the origin, with $d > a$. Give a series expansion for the force on the sphere?
4. Consider a grounded conducting shell of radius a . The inside of the shell is uniformly coated with a dielectric, of dielectric constant ϵ , into a radius b (i.e. the layer is $a - b$ thick). A charge $+q$ is placed a distance c from the center of the sphere, with $a > b > c$.

- (a) Find the potential everywhere inside the shell.
- (b) What is the force on the charge?