CLASSICAL ELECTRODYNAMICS II

Homework Set 1

January 24, 2020

1. Consider a medium where the macroscopic fields satisfy the constitutive relations, $\mathbf{D} = \epsilon_0\mathbf{E} + \mathbf{P}$ and $\mathbf{H} = \mathbf{B}/\mu_0 - \mathbf{M}$, with $\mathbf{P}$ the polarization and $\mathbf{M}$ the magnetization. Determine ρ_b (the density of bound charges) and $\mathbf{J}_b$ (the corresponding current density) in terms of $\mathbf{P}$ and $\mathbf{M}$ such that ρ_b and $\mathbf{J}_b$ satisfy the charge continuity equation and the fields satisfy Maxwell's equations.

2. A sphere of radius a carries a uniform surface charge density σ. The sphere is rotated about a diameter with constant angular velocity ω.

   (a) Calculate the current density $\mathbf{J}(\mathbf{r})$ for the rotating sphere. Take the origin to lie at the center of the sphere and assume that the axis of rotation is along $\hat{z}$.

   (b) Calculate the vector potential $\mathbf{A}(\mathbf{r})$ both inside the sphere and outside the sphere.

   (c) Use the form of the vector potential outside of the sphere to determine the magnetic dipole moment $\mathbf{m}$ of the current distribution.