

# CLASSICAL ELECTRODYNAMICS II

## Homework Set 1

September 18, 2015

1. Consider transverse electromagnetic waves in free space of the form:

$$\begin{aligned}\mathbf{E} &= \mathbf{E}_0(x, y) e^{i(kz - \omega t)}, \\ \mathbf{B} &= \mathbf{B}_0(x, y) e^{i(kz - \omega t)}.\end{aligned}$$

Find the relation between  $k$  and  $\omega$ , as well as the relation between  $\mathbf{E}_0$  and  $\mathbf{B}_0$ . Also show that  $\mathbf{E}_0$  and  $\mathbf{B}_0$  satisfy the equations for electrostatics and magnetostatics in free space; *i.e.*, show that  $\mathbf{E}_0$  and  $\mathbf{B}_0$  have no divergence and no curl.

2. Consider a medium where the macroscopic fields satisfy the constitutive relations,  $\mathbf{D} = \epsilon_0 \mathbf{E} + \mathbf{P}$  and  $\mathbf{B} = \mu_0(\mathbf{H} + \mathbf{M})$ , with  $\mathbf{P}$  the polarization and  $\mathbf{M}$  the magnetization. Determine  $\rho_b$  (the density of bound charges) and  $\mathbf{J}_b$  (the corresponding current density) in terms of  $\mathbf{P}$  and  $\mathbf{M}$  such that  $\rho_b$  and  $\mathbf{J}_b$  satisfy the charge continuity equation and the fields satisfy Maxwell's equations.
3. Consider Maxwell's equations when no dielectric or magnetic materials are present. (The equations should be expressed only in terms of the fields  $\mathbf{E}$  and  $\mathbf{B}$  and the sources  $\rho$  and  $\mathbf{J}$ .)
  - (a) Determine the behavior of the sources and fields under the operation of charge conjugation (the act in which the signs of all the source charges are reversed:  $q \rightarrow q' = -q$ ).
  - (b) Determine the behavior of the sources and fields under the operation of complete spatial inversion ( $\mathbf{r} \rightarrow \mathbf{r}' = -\mathbf{r}$ ).
  - (c) Determine the behavior of the sources and fields under the operation of time reversal ( $t \rightarrow t' = -t$ ).