Physics 506 **Winter 2006**

Practice Midterm

The midterm will be a 120 minute open book, open notes exam. Do all three problems.

1. A resonant cavity is in the shape of a rectangular box with sides of lengths a, b and c.
   a) Assuming infinite conductivity for the walls, determine the modes of the cavity and their respective resonant frequencies.
   b) Calculate Q for each of the modes in part *a*), assuming the walls have large but finite conductivity σ.

2. A current $I = \Re I_0 e^{-i\omega t}$ is flowing in a circular antenna with radius a centered on the origin and lying in the x-y plane.
   a) Compute the exact multipole radiation coefficients $a_E(l,m)$ and $a_M(l,m)$.
   b) What is the dominant radiation mode (electric dipole, magnetic dipole, electric quadrupole, etc.) in the limit $ka \ll 1$? Compute the total radiated power for this mode (in the limit $ka \ll 1$).

3. *a*) Using the Born approximation, compute the unpolarized differential cross section for the scattering of electromagnetic radiation off of a uniform dielectric sphere of relative dielectric constant $\epsilon_r \approx 1$.
   b) Show that in the limit $ka \ll 1$ the differential cross section reduces to the small sphere result
   $$\frac{d\sigma}{d\Omega} = \tfrac{1}{18} k^4 a^6 |1 - \epsilon_r|^2 (1 + \cos^2\theta)$$
   c) Show that for $ka \gg 1$ the differential cross section is highly peaked in the forward direction.