Ph.D. Qualify Exam: **Classical Electrodynamics** February 24, 2013

1. (20%) Write down the appropriate equations and explain the physical meanings of the following terms except (e), for which please indicate the most useful situations:
(a) Lorentz force law for a point charge in presence of electric and magnetic fields.
(b) Maxwell's equations.
(c) Poynting's vector and Poyting's theorem.
(d) Group velocity and phase velocity.
(e) Coulomb gauge and Lorentz gauge.

2. (20%) (a) Describe in words and qualitatively draw the field lines pictures of the electric field and magnetic field of a point charge moving with constant velocity. (b) Make a qualitative drawing of the emitted radiation power profile from a accelerating point charge when its velocity is (i) zero; (ii) parallel to acceleration; (iii) perpendicular to acceleration.

3. (20%) The potentials of two thin concentric shells, of inner radius *a* and outer radius *b*, are given by $V_a(\theta,\phi)=0$ and $V_b(\theta,\phi)$ respectively. Assume that there are no charges elsewhere. Find the potential at $r < a$, $a < r < b$, and $r > b$ for (a) $V_b(\theta,\phi)=V_0$, where V_0 is a constant; (b) $V_b(\theta,\phi)=V_0\cos\theta$.

4. (20%) A long cylinder of radius *R*, made of linear isotropic material of magnetic susceptibility χ_m, is placed in a uniform external magnetic field $\vec{B}_0$ with the field direction along the axis of the cylinder. Find: (a) the magnetization of the cylinder; (b) the magnetic field inside the cylinder; (c) the magnetic field outside. (Note that you can use the approximation that the cylinder is infinitely long.)

5. (20%) A current flowing in a short and thin straight wire of length ℓ is described by $I(t)=I_0e^{j\omega t}$, where the physical current is the real part of $I(t)$. Let us assume the short wire lies along the *z*-axis with the center of the wire at the origin. Obtain (a) the vector potential $\vec{A}(\vec{r},t)$; (b) the $\vec{B}$ field; (c) the $\vec{E}$ field; and (d) a drawing qualitatively depicting the radiation profile. (Note that keep only the terms proportional to 1/*r*.)