所別：太空科學研究所碩士班 一般生 科目：電磁學

1. A point charge q is embedded in a linear, isotropic, and homogeneous dielectric medium of infinite extent. Calculate

   (a) the electric field intensity $\vec{E}$, (2 points)

   (b) the electric flux density $\vec{D}$, (2 points)

   (c) the polarization vector $\vec{P}$, (2 points)

   (d) the bound surface charge density ρ_{sb}, (3 points)

   (e) the bound volume charge density ρ_{vb}, (3 points)

   (f) total charge on the surface of the dielectric next to the charge q. (5 points)

   (g) total charge which is responsible for the $\vec{E}$ field. (3 points)

2. The current density vector $\vec{J}$ changes when passing through an interface between media of conductivities σ_1 and σ_2.

   (a) Apply the equation of current continuity ($\oint_s \vec{J} \cdot d\vec{s} = 0$) to show the boundary condition, $J_{n1} - J_{n2} = 0$, pertaining to the normal component of $\vec{J}$ at an interface. (6 points)

   (b) Apply conservative $\vec{E}$ field ($\oint_c \vec{E} \cdot d\vec{l} = 0$) to show the boundary condition, $\frac{J_{t1}}{\sigma_1} - \frac{J_{t2}}{\sigma_2} = 0$, pertaining to the tangential component of $\vec{J}$ at an interface. (6 points)

   (c) Show that electric field intensity $\vec{E}$ is practically nonexistent in a highly conducting medium $\sigma_1 \gg \sigma_2$. (8 points)

3. A proton with mass m and charge q is revolving in a uniform magnetic field $B\vec{a}_z$ (where $B > 0$) with a velocity $\vec{u} = u_p\vec{a}_z + u_n\vec{a}_\phi$. Determine

   (a) the force acting on the proton, (3 points)

   (b) the direction of rotation, (4 points)

   (c) the radius of the orbit, (3 points)

   (d) the time period, (3 points)

   (e) the cyclotron frequency, and (3 points)

   (f) the distance traveled in one period. (4 points)

4. (a) What are the integral forms of Maxwell's equations? (4 points)

   (b) Derive the general wave equation of the $\vec{E}$ field from the differential forms of Maxwell's equations. (8 points)
   (Vector Identity: $\nabla \times \nabla \times \vec{F} = \nabla(\nabla \cdot \vec{F}) - \nabla^2\vec{F}$)

   (c) Under which conditions, the general wave equation will become wave (or Helmholtz) equation? (2 points)

   (d) What will happen to a plane wave if the wave is propagating in a conducting medium? (2 points)

   (e) What are the definitions of a good conductor and a good dielectric? (4 points)

注：背面有試題

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5. A very long, thin, straight wire located along the z axis carries a current I in the z direction.

   (a) Find the magnetic flux density and magnetic field intensity at any point in free space using Biot-Savart law. Note that explain Biot-Savart law before you do the calculation. (12 points)

   (b) Find the magnetic flux density and magnetic field intensity at any point in a magnetic medium with relative permeability μ_r using Ampere's circuital law. Note that explain Ampere's circuital law before you do the calculation. (8 points)