1. A point charge q with mass m moves inside a region with uniform fields,

   $$\vec{B} = B\hat{z}, \qquad \vec{E} = E\hat{y}.$$

   Assuming its velocity $\vec{v}$ is much less than the speed of light.
   (a) If the total force on the charge particle is zero, determine the trajectory of the particle. (5%)
   (b) If the particle started from rest at the origin, determine the trajectory of the particle. (10%)

2. A spherical cavity of radius a is hollowed out from the interior of a perfect conducting sphere of radius R. The distance between the centers of the sphere and the cavity is d. A point charge q is placed at the center of the cavity.

   (a) Determine the induced charge distribution on the conductor. (10%)
   (b) Determine the electric field everywhere. (10%)
   (c) If there is another charge Q brought near the conductor. Does the charge Q act a force on the charge q in the cavity ? (5%)

3. A dielectric sphere of radius R and permittivity ε is situated in a vacuum and is charged throughout its volume by a charge density $\rho(r) = \kappa r$, r being the distance from the center of the sphere. Find the energy of the configuration. (16%)

4. (16%)
   (a) Derive the boundary condition of $\vec{H}$ at the interface between two different media.
   (b) The $\vec{H}$ field in air just above a perfect conductor is given by $\vec{H}_1 = 4\hat{x} + 3\hat{z}$ ampere per meter. Find the surface current $\vec{J}_s$ on the surface of the perfect conductor. The conductor occupies the space $y < 0$.

5. (18%)
   A uniform plane wave propagating in free space is characterized by the complex electric vector,
   $$\vec{E} = (j3\hat{x} + 5\hat{y} - j4\hat{z})e^{j[\omega t - 0.2\pi(4x + 3z)]}.$$
   (a) Find the equation of the plane of constant phase.
   (b) Determine the frequency and wavelength.
   (c) Find the magnetic field $\vec{H}$ associated with the given $\vec{E}$.
   (d) Find the average Poynting's vector.
   (e) What is the polarization of the wave in the plane of constant phase.

6. Use the conservation of energy to show that there are a reflected wave and a transmitted wave when a plane wave is incident normally on the interface between two different simple dielectric media. (10%).