112DE03

國立臺北科技大學 112 學年度碩士班招生考試

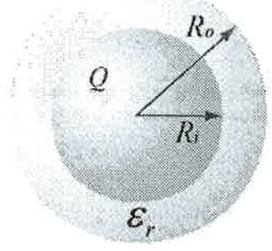
系所組別：2402 光電工程系碩士班

第二節　電磁學　試題（選考）

注意事項：

1. 本試題共 6 題，共 100 分。
2. 不必抄題，作答時請將試題題號及答案依照順序寫在答案卷上。
3. 全部答案均須在答案卷之答案欄內作答，否則不予計分。

1. A metal sphere of radius R_i carries a charge Q. It is surrounded by linear material of dielectric constant ε_r, out to radius R_o as in the figure.
   (a) Find the potential inside the dielectric material, $R_i < r < R_o$. (relative to infinity) [10%]
   (b) What is the total surface bound charge on the inner surface of the dielectric material? [10%]
   (c) Find the energy of this configuration. [10%]

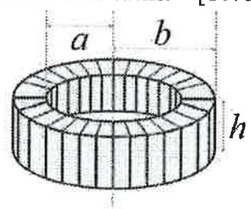


2. A perfect dipole p is situated at the origin, pointing in the z direction.
   (a) What is the force on a point charge q at *(0, d, 0)* (Cartesian coordinates)? [10%]
   (b) How much work is required to move q from *(0, d, 0)* to *(0, 0, d)*? [10%]
   [for your reference: The electric field and the potential at r, θ due to a dipole at origin is given by, $\vec{E}_{dip}(\vec{r}) = \frac{p}{4\pi\varepsilon_0 r^3}(2\cos\theta\hat{r} + \sin\theta\hat{\theta})$ and $V_{dip}(\vec{r}) = \frac{1}{4\pi\varepsilon_0}\frac{\vec{p}\cdot\hat{r}}{r^2}$.]

3. Find the magnetic dipole moment of a particle with charge q and mass m moving in a circle of radius R with constant angular velocity $\vec{\omega}$. [10%]

4. A current flows down a long straight wire of radius R. The wire is made of linear material with susceptibility χ_m, and the current density is proportional to the distance from the axis, $J = kr$, for some constant k.
   (a) What is the magnetic field $\vec{B}$ a distance r from the axis? [10%]
   (b) Find the bound surface current density. [10%]

5. Find the self-inductance of a toroid with rectangular cross section (inner radius a, outer radius b, height h, as in the figure), that carries a total of N turns. [10%]



6. In a source-free lossy medium the homogeneous vector Helmholtz's equation is given by $\nabla^2\vec{E} - \gamma^2\vec{E} = 0$. For a plane wave in good conductors, the propagation constant γ is approximated as $\gamma \simeq (1+j)\sqrt{\pi f \mu\sigma}$. The skin depth in copper at the frequency of 1 Mhz is 66 μm. What is its skin depth at 1 GHz? [10%]