106 DE 03

國立臺北科技大學 106 學年度碩士班招生考試

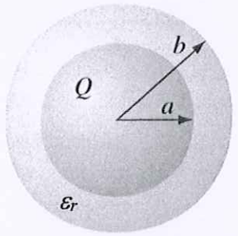
系所組別：2402 光電工程系碩士班

第二節　電磁學　試題　（選考）

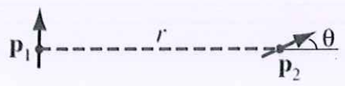
注意事項：

1. 本試題共 6 題，配分共 100 分。
2. 請標明大題、子題編號作答，不必抄題。
3. 全部答案均須在答案卷之答案欄內作答，否則不予計分。

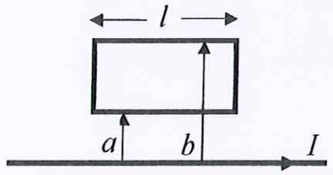
1. A metal sphere of radius a carries a charge Q. It is surrounded, out to radius b, by linear dielectric material of relative permittivity ε_r, as shown in the figure.
   (a) Find the potential V at the center, using infinity as your reference point. (10%)
   (b) Determine the surface bound charge density at the inner surface of the dielectric shell. (10%)



2. As shown in the figure, $\vec{p}_1$ and $\vec{p}_2$ are dipoles a distance r apart. What is the torque on $\vec{p}_2$ due to $\vec{p}_1$? (15%)



3. A flat loop and a long straight wire lie in the same plane as shown in the figure. The current in the wire varies according to $I = I_0 \sin(\omega t)$. Find the emf induced in the loop. (15%)



4. A right-hand circularly polarized plane wave in air represented by the phasor $\vec{E}(x) = E_0(\hat{y} - j\hat{z})e^{-j\beta x}$ is incident on a perfectly conducting wall at $x = 0$.
   (a) Determine the electric and magnetic field phasors. (10%)
   (b) Find the induced current on the conducting wall. (10%)
   (c) What is the time-average Poynting vector in air (the region x < 0)? (5%)

5. The electric field of an electromagnetic wave propagating through a medium with a permeability $\mu = \mu_0$ and a relative permittivity $\varepsilon_r = 9$ is given by $\vec{E} = 0.3\cos(2\times10^8 t + \beta x)\hat{y}$ (V/m), where $\beta > 0$.
   (a) What is the speed of the wave? (5%)
   (b) Determine β. (5%)
   (c) What is the direction of propagation? (5%)

6. Show that u_E and u_B, the energy densities of the electric and magnetic fields, are equal to each other in an electromagnetic wave. (10%)

For Your Reference:

The potential at r, θ due to a dipole at the origin and pointing in the z direction is given by $V_{dip}(r,\theta) = \dfrac{\hat{r}\cdot\vec{p}}{4\pi\varepsilon_0 r^2}$. This may help you to find out the electric field at r, θ.

In spherical coordinates,

$$\nabla f = \frac{\partial f}{\partial r}\hat{r} + \frac{1}{r}\frac{\partial f}{\partial \theta}\hat{\theta} + \frac{1}{r\sin\theta}\frac{\partial f}{\partial \phi}\hat{\phi}$$

$$\nabla\cdot\vec{F} = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 F_r) + \frac{1}{r\sin\theta}\frac{\partial}{\partial \theta}(\sin\theta F_\theta) + \frac{1}{r\sin\theta}\frac{\partial F_\phi}{\partial \phi}$$