國立成功大學 103 學年度碩士班招生考試試題

系所組別：光電科學與工程學系甲、乙組

考試科目：電磁學

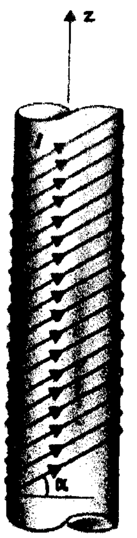
考試日期：0223，節次：2

※ 考生請注意：本試題不可使用計算機。 請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. Find the force between a charged circular loop of radius b with uniform charge density ρ_l and a point charge Q located on the loop axis at a distance h from the plane of the loop. What is the force when $h >> b$, and when $h = 0$. (14%).

2. An uncharged conducting sphere of radius b is placed in an initially uniform electric field $\bar{E}_0 = \hat{z}E_0$. If $V(R{=}b, \theta) = V_0$, determine the potential distribution $V(R, \theta)$ and the electric field intensity $\bar{E}(R, \theta)$ after the introduction of the sphere. (20%)

3. An infinitely long solenoid with air core having a radius b and n closely wound turns per unit length is shown below. The windings are slanted at an angle α and carry a current I. Determine the magnetic flux density both inside and outside the solenoid. (16%)



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4. (15 %) Consider in metal with free electron charge q_e, mass m_e and density N_e. Assume the effective collision frequency of electrons in metal is ν. Please derive the relative permittivity of the metal (the Drude model).

5. Consider a plane wave incident on a planar boundary at x = 0 from a dielectric medium with μ_0 and $\varepsilon = 9\varepsilon_0$ (region I) upon another dielectric medium with μ_0 and ε_t (region II). The right-hand circularly polarized incident electric field is

$$\vec{E}_i = E_0(\sqrt{3}\hat{x} + \hat{z})\cos(k_x x - k_z z - \omega t) + 2\hat{y}\sin(k_x x - k_z z - \omega t)$$

where E_0 is a real constant. The reflected field is

$$\vec{E}_r = E_0[2R^{TE}\hat{y}\sin(k_x x + k_z z - \omega t) + R^{TM}(-\sqrt{3}\hat{x} + \hat{z})\cos(k_x x + k_z z - \omega t)$$

(5 %) (a) What is the incident angle?

(5 %) (b) For $k_x = 2\pi / m$, find the frequency (Hz) and wavelength (m) in region I.

(5 %) (c) Find the value of ε_t $(0 < \varepsilon_t / \varepsilon_0 < \infty)$ for which the reflected wave is linearly polarized.

6. In an air-filled rectangular waveguide with dimensions $a = 3\sqrt{2}\ cm$ and $b = a/2$, the guided wave is given by

$$\overline{E} = \hat{y}E_0 \sin(\frac{\pi}{a}x)\sin(\frac{\pi}{a}z - \omega t)$$

$$\overline{H} = \hat{x}H_0 \sin(\frac{\pi}{a}x)\sin(\frac{\pi}{a}z - \omega t) + \hat{z}H_0 \cos(\frac{\pi}{a}x)\cos(\frac{\pi}{a}z - \omega t)$$

where E_0 and H_0 are real constants.

(a) (4 %) What is the mode for this wave? Indicate the mode and the mode numbers m and n.

(b) (4 %) What is the frequency?

(c) (4 %) What is the phase velocity in $\hat{z}$ direction in terms of the light speed c?

(d) (4 %) What is the cutoff frequency of this mode?

(e) (4 %) If the waveguide is used as a rectangular cavity resonator for frequency f = 5 GHz by closing the ends at z = 0 and z = d using perfectly conducting plates, what is the value of d for the lowest mode? Indicate this lowest mode and the mode numbers m, n and p.