

國立中央大學98學年度碩士班考試入學試題卷

所別：光電科學與工程學系碩士班 一般生 科目：電磁學 共 2 頁 第 1 頁

\*請在試卷答案卷(卡)內作答

1. (10%, 填充題) A point charge  $q$  is located inside and at distance  $d$  from the center of a grounded spherical conducting shell of radius  $a$  (where  $a > d$ ). Use the method of images to determine (a) the potential outside the shell; (b) the charge  $q_i$  induced on the inner surface of the shell.

- (a) \_\_\_\_\_  
(b) \_\_\_\_\_

2. (10%, 填充題) A solid cylinder (實心圓柱) of radius  $a$  carries a uniform charge density  $\rho$ . The cylinder is rotated about its axis (the  $z$ -axis) with constant angular frequency  $\omega$ . Find the  $\mathbf{B}$  field inside ( $r < a$ ) and outside ( $r > a$ ) the cylinder.

- (a)  $B_{inside} =$  \_\_\_\_\_  
(b)  $B_{outside} =$  \_\_\_\_\_

3. (5%, 單選題) 以下關於  $\mathbf{E}$ ,  $\mathbf{D}$ ,  $\mathbf{B}$ ,  $\mathbf{H}$  場在兩介質 I 與 II 之介面 (interface) 上的邊界條件 (各分量的連接方式) 的敘述, 何者為錯誤?

假定自由電荷與電流皆為零 ( $\rho_f = \mathbf{J}_f = 0$ ), 並以下標 1, 2 表示對應於介質 I 與 II;  $t$  與  $n$  分別表示向量的切分量 (tangential component) 與法分量 (normal component)。

- (A)  $E_{1t} = E_{2t}$ ; (B)  $B_{1t} = B_{2t}$ ; (C)  $D_{1n} = D_{2n}$ ; (D)  $H_{1t} = H_{2t}$ ; (E)  $B_{1n} = B_{2n}$ 。

4. (5%, 複選題) 下列各敘述何者為正確?

(A) 一個等角速度旋轉的均勻帶電圓球會輻射電磁波; (B) 上述均勻帶電圓球不會輻射電磁波; (C) 一個均勻長直導線 (半徑不為零) 當有均勻直流電沿軸向流動的時候, 其表面的波印廷向量 (Poynting vector) 是由外指向內; (D) 上述直導線表面的波印廷向量指向外; (E) 上述直導線的波印廷向量之方向與軸向平行。

5. (20%, 計算題) A conducting sphere of radius  $R$  is placed in an uniform electric field  $\mathbf{E}_0 = E_0 \hat{z}$ , where  $\hat{z}$  is the unit vector along the  $z$ -axis. After introducing the sphere, find the electric potential  $V(r, \theta)$  and electric field  $\mathbf{E}(r, \theta) = E_r \hat{r} + E_\theta \hat{\theta}$  for an observation point outside the sphere ( $r > R$ ). ( $\hat{r}$  and  $\hat{\theta}$  are the unit vectors along the  $r$  and  $\theta$  directions respectively.)

參考用

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6. (10%) A sealed plastic box contains an antenna that radiates electromagnetic waves. How could you tell whether the antenna is an electric or a magnetic dipole?

7. (20%, True-False questions) For each correct answer you get 4 points, while for each incorrect answer, you lose 4 points. You may leave one or more questions unanswered, and in which case, you will neither gain nor lose points. Your total score for this problem will not be less than zero. Please fill in "T" or "F" in each box, or leave it blank as unanswered.

- The Brewster angle exists only if  $\epsilon_r > \mu_r$  for a wave incident in air on a nonconducting magnetic medium.
- An electromagnetic wave is totally reflected at the interface between two media and the E field of the incident wave has components parallel and normal to the plane of incidence. Under this circumstance, the reflected wave must be elliptically polarized.
- The instantaneous Poynting vector of a circularly polarized plane wave propagating in a lossless medium is a constant that is independent of time and distance.
- For TE wave, the dominant mode in rectangular waveguide is  $TE_{10}$ , but for TM wave the dominant mode is  $TM_{01}$ .
- Waves along a lossy transmission line can be purely TEM.

a.  b.  c.  d.  e.

8. (Fill in the blanks) A TE wave propagating in a dielectric-filled waveguide of unknown permittivity has dimensions  $a = 5$  cm and  $b = 3$  cm. If the x-component of its electric field is given by

$$E_x = -36\cos(40\pi x) \sin(100\pi y) \sin(2.4\pi \times 10^{10}t - 52.9\pi z) \quad (\text{V/m}).$$

Determine:

- (5%) \_\_\_\_\_ What mode propagates in this waveguide?
- (5%) \_\_\_\_\_  $\epsilon_r$  of the material in the guide.
- (5%) \_\_\_\_\_ the cutoff frequency.
- (5%) \_\_\_\_\_ the expression for  $H_y$ .

參考用

注意：背面有試題