所別：光電科學與工程學系碩士班 不分組(一般生)　科目：電磁學　共 2 頁 第 1 頁
光電科學與工程學系碩士班 不分組(在職生)

本科考試可使用計算器，廠牌、功能不拘

＊請在試卷答案卷（卡）內作答

1. (18%) 一個與無窮大導體平板與 xy 平面重合且接地，其上下兩側為一對正負電荷 $q_1 = q$, $q_2 = -q$ 分別置於 $\mathbf{r}_1 = (d,0,d)$ 與 $\mathbf{r}_2 = (-d,0,-d)$，如下圖所示。導體平板以外的空間都是真空。
(a) 求空間各點的電位。(b) 求 q_1 所受的力。(c) 求導體平板上的面電荷密度。

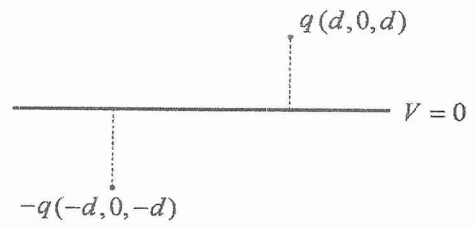


Fig. 1

2. (15%) 如下圖，一無窮長螺線管 (solenoid) 內分別於半徑 $0 < r < a$ 與 $a < r < b$ 兩區域內填入具有磁導率 (permeability) μ_1 與 μ_2 的兩種線性磁材料 (linear magnetic materials)。包圍螺線管之導線電流為 I，每單位長度所繞圈數為 n，求(a) H 場，(b) B 場，(c) 沿軸向每單位長度之電感 (inductance per unit length)。

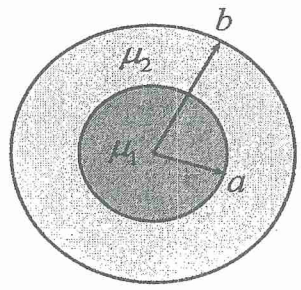


Fig. 2

3. (33%) A time-harmonic, linearly-polarized uniform plane wave travelling along the x direction in air is normally incident on an unknown material, as shown in Fig. 3, where $(\mathbf{E}_i, \mathbf{H}_i)$, $(\mathbf{E}_r, \mathbf{H}_r)$, and $(\mathbf{E}_t, \mathbf{H}_t)$ denote the incident, reflected, and transmitted electric and magnetic fields, respectively. The incident wave carries a time-average power density $S_{av} = 10$ mW/cm^2. The total magnetic field phasor in air is given by

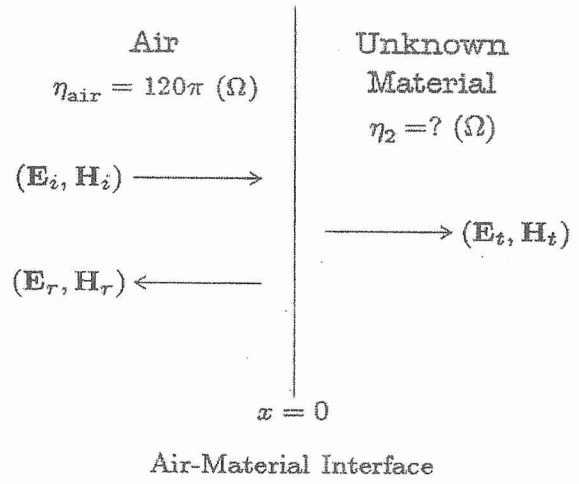
$$\mathbf{H}_z(x) = \hat{\mathbf{a}}_z H_0 \cos(2\pi x) \quad \text{(A/cm)}$$

where $\hat{\mathbf{a}}_z$ represents the unit vector in the z direction and H_0 is the unknown magnetic field amplitude.

(a) (5%) What is a uniform plane wave?
(b) (5%) Given the instantanous Poynting vector $\mathbf{a}_x \mathcal{S}(x,t)$, explain the physical meaning of time-average power density and how it is defined.
(c) (10%) Calculate the intrinsic impedance η_2 of the unknown material.
(d) (5%) Find out the amplitude H_0 of the magnetic field.

注意：背面有試題

(e) (8%) Determine the minimum distance from the air-material interface at which the *total electric* field in air is minimum. Express your answer in terms of the wavlength λ.



Air-Material Interface

Fig. 3

4. (24%) A point charge q moving circularly in x-y plane with angular velocity $\omega\hat{z}$ and radius a. Assume that $\omega a / c << 1$.
   (a) (14%) Find the radiated electric and magnetic field at any point $P(r, \theta, \varphi)$.
   (b) (10%) Discuss the polarization state of the electromagnetic field when $\theta = 0$ and $\theta = \pi/2$, where θ is the angle between the z axis and $\hat{r}$.

5. (10%) A conducting cylinder acting as an electromagnetic generator was installed on a bike subject to a radial field $\vec{B} = 1\hat{r}$ (Tesla). A bulb was connected as shown in the following figure. To provide sufficient illumination, the potential difference between the two ends of the sliding contact has to be larger than 1.5 Volt.
   (a) (5%) At what speed should the cylinder rotate? Please express your answer in unit of revolutions/minute.
   (b) (5%) If the bulb is replaced by an LED light source, describe the correct way of installation by specifying the polarities on the sliding contacts.

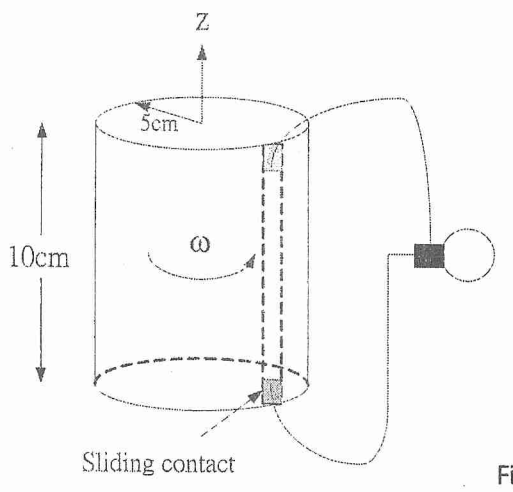


Fig. 4