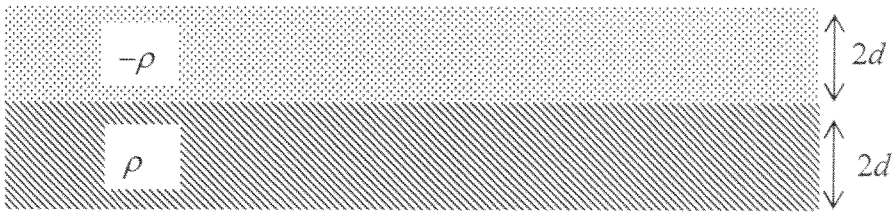
國　立　清　華　大　學　命　題　紙

98 學年度工程與系統科學系丙組、先進光源科技碩士學位學程工程與系統科學組碩士班入學考試
科目電磁學 科目代碼 2802、3003 共 2 頁第 1 頁 *請在【答案卷卡】內作答

1. (a) Write down the expression for the "*divergence theorem*" and explain its geometric/physical meaning.
(b) Using the divergence theorem, show that $\nabla \cdot (\nabla \times \mathbf{A}) = 0$, where **A** is a vector field (or function).
(note: in your hand writing, please write the vector as $\bar{A}$.) (10 %)

2. Two *infinite* plane slabs, of thickness $2d$, carry a uniform volume charge density of opposite types, ρ and $-\rho$, respectively, and are placed next to each other, as shown in Fig. 1 (cross sectional view). Find the electric field everywhere. (15 %)

Fig. 1



3. Consider a hollow infinite long rectangular pipe formed by perfect conductors of width a and height b, as illustrated in Fig. 2. Two sides of the pipe are held at electric potential V_0 while the other two are held at a potential $-V_0$. Find the potential distribution inside the pipe. (15 %)

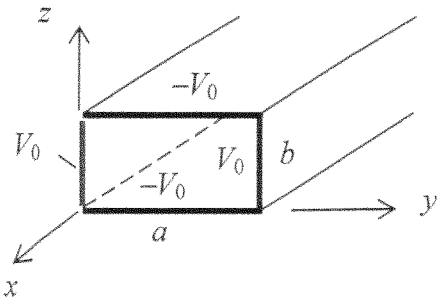


Fig. 2

4. (a) Write down the expression for conservation of charges, i.e., *continuity equation*, and explain the physical meaning of each term in the expression.
(b) Write down the expression for conservation of energy in the presence of electromagnetic field, i.e., the *Poynting theorem*, and explain the physical meaning of each term in the equation. (15 %)

5. (a) Write down the *Lorentz force law*. (15 %)

(b) Show that magnetic forces do no work.

(c) Describe the trajectory of an ***electron*** initially at rest ($\mathbf{v} = 0$) in a region having an electric field **E** (in x-direction) and a magnetic field **B** (in z-direction), i.e., $\mathbf{E} \perp \mathbf{B}$, and both are uniform, as shown in Fig. 3. Briefly explain why the electron follows such a trajectory (from the electric and magnetic force on the electron).

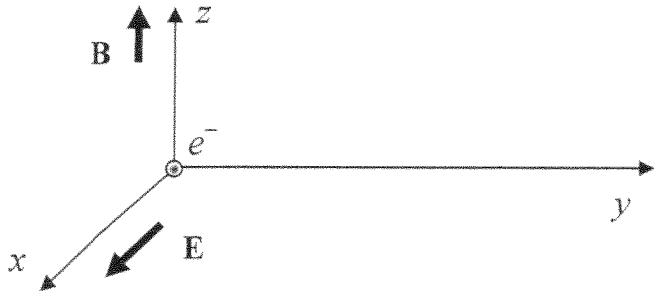


Fig. 3

6. For a very long cylindrical solenoid, consisting of current carrying thin wires of 100 turns/m tightly wounded on a cylinder of radius 10 cm with a steady current 0.01 A and coaxially filled with a cylindrical rod of radius 5 cm and dielectric constant $\varepsilon_r = 10$ and permeability $\mu = \mu_0$, as shown in Fig. 4, (15 %)

(a) find the **H** field everywhere. (b) find the **B** field everywhere.

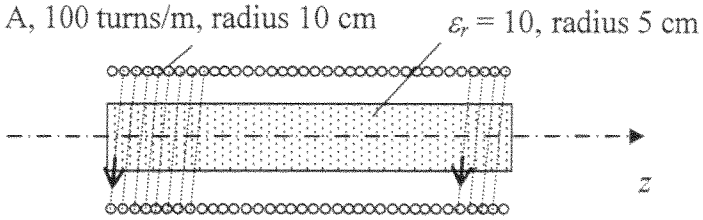


Fig. 4

7. Consider an oscillating electric dipole located at the origin and oriented along the z-direction, e.g., $\mathbf{p} = p_0 \cos\omega t\, \hat{\mathbf{z}}$, where p_0 is a constant and ω is the angular frequency. (15 %)

(a) Please qualitatively plot the "*radiation pattern*" in the far field zone.

(b) An observer is located on the x-axis and at a distance d from the dipole.

(i) What is the direction of the electric field and magnetic field seen by the observer?

(ii) How much the "intensity" of the radiation from the dipole would change if the observer moves along the radial direction (away from the dipole) by a distance d (i.e., a distance $2d$ from the dipole)??