

97 學年度 工程與系統科學系(所) 丙組、先進光源科技學位學程乙組 碩士班入學考試
 科目 電磁學 科目代碼 3002、3203 共 2 頁第 1 頁 *請在試卷【答案卷】內作答

1. A uniformly charged sphere of total charge Q ($= 1 \text{ C}$) and radius a ($= 1 \text{ m}$) is placed at a distance $2a$ from a grounded conducting plane, as shown in Fig. 1. Find (20%)
- (a) *electric field* at the center of the charged sphere, and
- (b) *surface charge distribution* (e.g., $\sigma(x, y)$, σ being surface charge density) on the surface of the grounded conducting plane.

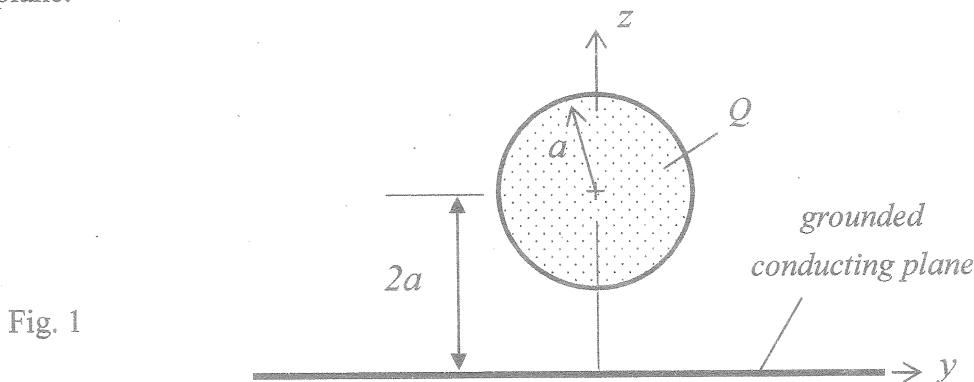


Fig. 1

2. An electron is released from rest (velocity $\mathbf{v} = 0$) in a region of uniform electric (\mathbf{E}) and magnetic field (\mathbf{B}). Find the trajectory of the electron for (15%)
- (a) \mathbf{E} parallel to \mathbf{B} , and
- (b) \mathbf{E} perpendicular to \mathbf{B} .
- Briefly explain why the electron follows such a trajectory (from the electric and magnetic forces on the electron).
3. (a) For electromagnetic waves, explain the *physical meaning* of (20%)
- (i) phase velocity, (ii) group velocity, and (iii) Poynting vector.
- (b) An oscillating magnetic dipole, $\mathbf{m}(t) = m_0 \cos(\omega t) \hat{x}$, is located at the origin, as shown in Fig. 2.
- (i) For the radiation from the dipole, what do we mean “far fields”??
- (ii) In the far field zone, qualitatively draw the “radiation pattern” of this dipole.

What are the directions of the *electric field*, *magnetic field* and *Poynting vector* at positions A and B , respectively.

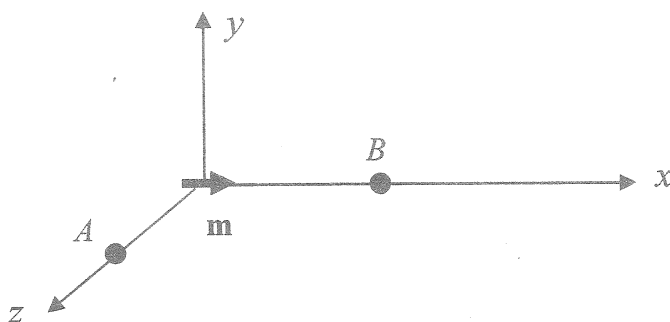


Fig. 2

4. An infinite long square (width = height = 1 cm) conducting tube is filled with a dielectric of dielectric constant 5 ($\epsilon_r = 5$), and the four sides of the square tube are held at different electrostatic potentials, as shown in Fig. 3 (cross sectional view). Find the *potential distribution* (i.e., $V(x,y)$) everywhere inside the square tube. (15%)

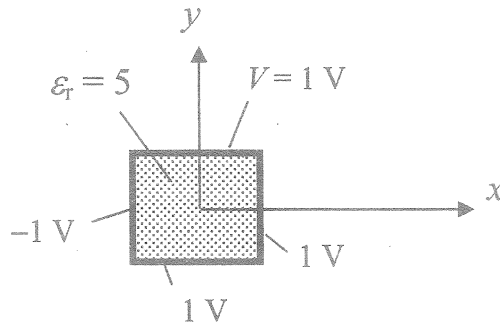


Fig. 3

5. An infinite long cylindrical solenoid of diameter $D = 100$ cm and a winding 100 turns per meter is partially filled with a magnetic material rod ($\mu_r = 1000$) of diameter $d = 50$ cm, as shown in Fig. 4. (15%)
- (a) Find (i) the *magnetic field* \mathbf{B} (direction and magnitude) everywhere and (ii) the *magnetic energy per unit length* stored in the solenoid, if the current per turn $I = 1$ A.
- (b) *Inductance per unit length* of the solenoid.

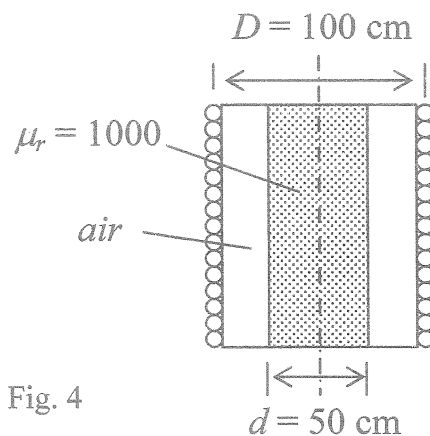


Fig. 4

6. A coaxial waveguide is formed by two perfect conducting tubes of cylindrical cross section with inner and outer radius 1.0 cm and 2.0 cm, respectively. A dielectric material of dielectric constant 2.0 is filled between the two conductors. For an electromagnetic wave of a frequency 100 MHz propagating along the waveguide at the *fundamental mode* (waveguide mode with the lowest cutoff frequency), find the *propagation constant*, *phase velocity* and *guide wavelength* of the wave. (15%)