

- In what ways does the electric field intensity vary with distance for
 - a point charge? (3%)
 - an electric dipole? (3%)
- Sketch the electric field lines of an electric dipole and the magnetic flux lines of a magnetic dipole respectively. (8%)
- What is the wavelength range of visible light? (3%) Write the wavenumber in terms of angular frequency, permittivity, and permeability. (3%)
- Determine the values of the following products of base vectors:
 - $\hat{\mathbf{a}}_\theta \cdot \hat{\mathbf{a}}_\phi$ (2%)
 - $\hat{\mathbf{a}}_R \cdot \hat{\mathbf{a}}_r$ (2%)
 - $\hat{\mathbf{a}}_\theta \times \hat{\mathbf{a}}_z$ (2%)
 - $\hat{\mathbf{a}}_R \times \hat{\mathbf{a}}_z$ (2%)

- The magnetic flux density \mathbf{B} , without a current-carrying wire, is circumferential and inversely proportional to the distance to the z-axis ($\mathbf{B} = \hat{\mathbf{a}}_\phi \left(\frac{k}{r}\right)$). Find $\nabla \cdot \mathbf{B}$ (4%) and $\nabla \times \mathbf{B}$. (4%)

Hint: $\nabla \cdot \mathbf{F} = \frac{1}{h_1 h_2 h_3} \left[\frac{\partial}{\partial u_1} (h_2 h_3 F_1) + \frac{\partial}{\partial u_2} (h_1 h_3 F_2) + \frac{\partial}{\partial u_3} (h_1 h_2 F_3) \right]$

$$\nabla \times \mathbf{F} = \frac{1}{h_1 h_2 h_3} \begin{vmatrix} \hat{\mathbf{a}}_{u_1} h_1 & \hat{\mathbf{a}}_{u_2} h_2 & \hat{\mathbf{a}}_{u_3} h_3 \\ \frac{\partial}{\partial u_1} & \frac{\partial}{\partial u_2} & \frac{\partial}{\partial u_3} \\ h_1 F_1 & h_2 F_2 & h_3 F_3 \end{vmatrix}$$

- A very large slab of material of thickness d lies perpendicular to a uniform magnetic field of intensity $\mathbf{H}_0 = \hat{\mathbf{a}}_z H_0$. Ignoring edge effect, determine the magnetic field intensity in the slab:

- if the slab material has permeability μ (4%)
- if the slab is a permanent magnet having a magnetization vector $\mathbf{M} = \hat{\mathbf{a}}_z M$. (4%)

Hint: $\mathbf{H} = \mathbf{B}/\mu_0 - \mathbf{M}$

- Two orthogonal linearly polarized waves are combined. State the conditions under which the resultant will be
 - another linearly polarized wave (3%)
 - a circularly polarized wave (3%)
 - an elliptically polarized wave. (3%)

科目 電磁學 科目代碼 2901 共 三 頁第 二 頁 *請在試卷【答案卷】內作答

8. A spaceship in lunar orbit (the Earth-Moon distance is ~ 380 Mm) transmits plane waves with an antenna operating at 1 GHz and radiating a total power of 1 MW isotropically. Find

- the time-average power density on the earth's surface (3%)
- the peak electric field on the earth's surface (3%)
- the time it takes for these waves to travel from the spaceship to the earth. (3%)

Hint: $\eta_0 = 377 (\Omega)$

9. An electromagnetic wave with frequency of 10 MHz is incident onto a human brain tissue. The dielectric constant for that tissue is $\epsilon_r = 72$ and the resistivity $\rho = 1.0 (\Omega\text{-m})$. What is the wavelength of this radiation in the brain? (10%)

Hint: A good conductor is a medium for which $\sigma/\omega\epsilon \geq 1$ and the propagation constant

$\gamma = \alpha + i\beta \cong (1+i)\sqrt{\pi f\mu\sigma}$; the permittivity and permeability in free space are:

$$\epsilon_0 = \frac{1}{4\pi \times 9 \times 10^9} \text{ (F/m)}, \quad \mu_0 = 4\pi \times 10^{-7} \text{ (H/m)}$$

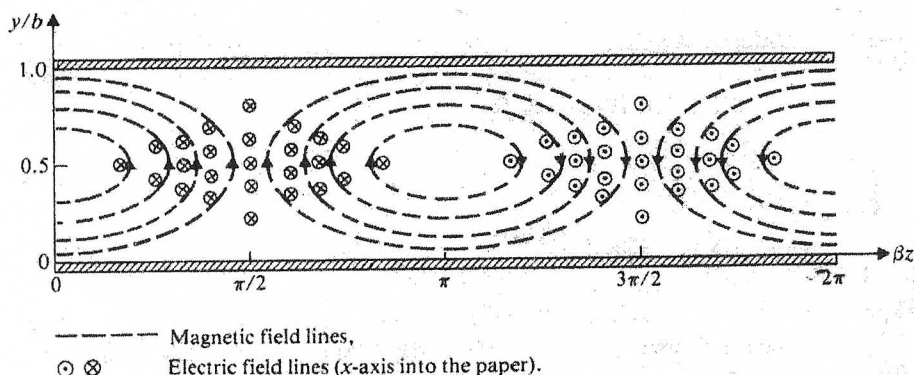
10. A 30 (m) long lossless transmission line with $Z_0 = 50 (\Omega)$ operating at 2 (MHz) is terminated with a load $Z_L = 60 + i40 (\Omega)$. If $u = 0.6c$ on the line, with the help of Smith chart (see next page) to find

- The reflection coefficient Γ (3%)
- The standing wave ratio S (3%)
- The input impedance Z_{in} (3%)

11. A transparent dielectric coating is applied to glass ($\epsilon = 3\epsilon_0$, $\mu_r = 1$) to eliminate the reflection of red light ($\lambda_0 = 0.70\text{-}\mu\text{m}$, i.e. in free space). Determine the required dielectric constant and the thickness of the coating. (8%)

12. The parallel-plate structure can be used both in transmission lines and waveguides. Describe the differences when this structure is used in transmission lines and waveguides. (5%)

13. Determine what the mode is for a parallel-plate waveguide in the following figure. (6%)



The Smith chart for problem 10:

