國 立 清 華 大 學 命 題 紙

九十一 學年度第一學期 電機工程 學系 博士班研究生資格考試

科目 電磁理論 科號 共 2 頁第 1 頁 *請在試卷(答案卷)內作答

1. An anisotropic dielectric material is characterized by the **D** to **E** relationship as

$$\begin{bmatrix} D_x \\ D_y \\ D_z \end{bmatrix} = \varepsilon_0 \begin{bmatrix} 3 & 1 & 1 \\ 1 & 3 & 1 \\ 1 & 1 & 3 \end{bmatrix} \begin{bmatrix} E_x \\ E_y \\ E_z \end{bmatrix}$$

(a) Find **D** for $\mathbf{E} = E_0(\mathbf{a}_x + \mathbf{a}_y)$ (4%)
(b) Find **D** for $\mathbf{E} = E_0(\mathbf{a}_x - \mathbf{a}_y)$ (4%)
(c) Find **D** for $\mathbf{E} = E_0(\mathbf{a}_x + \mathbf{a}_y - 2\mathbf{a}_z)$ (4%)

2. Find the numerical values of k, if any, such that the electric field in a source-free free space given by:

$$\mathbf{E} = \mathbf{a}_y E_0 \sin 6x \sin(3\times 10^9 t - kz)$$

satisfies both of Maxwell's curl equations. (13%)

3. For a normalized load impedance of $0.8 + j\,0.6$, find the location of first voltage minimum and the first voltage maximum from the load in terms of the wavelength λ. (10%)

4. The power flow of electromagnetic waves can be represented using the Poynting theorem. Please derive the theorem and name each term of the equation. (10%)

5. All transmission channels have certain bandwidths because of physical phenomenon associated with the channels.
(i) Can we direct send digitalized computer messages via two-parallel transmission lines without using a modem? Please explain. (4%)
(ii) Can we choose ordinary radio frequencies in outer-space satellite communication system? Please explain. (4%)
(iii) Please draw the schematic curve of the power loss versus frequencies of coaxial cables. Please also explain why such characteristics are formed. (4%)

6. Please prove that there is a cut-off frequency in hollow metallic waveguides. (6%)

7. In fighter planes, a kind of "smart" antennas capable of finding distance targets is installed. Of course, these types of smart antennas are different from those antennas installed in commercial airliners. Please give the schematic picture of such a smart antenna and explain its working principle. (6%)

8. In a time-harmonic electromagnetic field, that is, the variation of the field in t can be expressed as $e^{j\omega t}$, the electric field $\mathbf{E}(\mathbf{r})$ can be uniquely determined entirely from the magnetic vector potential $\mathbf{A}(\mathbf{r})$. Express the electric field $\mathbf{E}(\mathbf{r})$ explicitly in terms of the magnetic vector potential $\mathbf{A}(\mathbf{r})$. (11%)

9. A coaxial cable is composed of an inner conductor with radius a and an outer conductor with radius b. The space between the inner and outer conductor is source-free and is filled with air. Suppose that between the two conductors the time-harmonic vector potential is given as

$$\mathbf{A}(\rho, \varphi, z) = -\hat{z}\frac{1}{c}V_0(\ln \rho)e^{-jk_0 z}, \qquad a < \rho < b$$

where V_0 is a constant. Find the associated field $\mathbf{H}(\rho, \varphi, z)$. (10%)

10. The electric field and the magnetic field are not independent. If the distribution of electric field over a space is known, then the magnetic field can be determined, and *vice versa*. Assume that in a source-free space filled with a uniform material with μ and ϵ the time-harmonic electric field is given as

$$\mathbf{E} = \hat{z}E_0 e^{-jkx},$$

where E_0 is a constant. Find the associated magnetic field intensity $\mathbf{H}(x, y, z)$. (10%)