國立中央大學 111 學年度碩士班考試入學試題

所別： 光電類　　共 2 頁　第 1 頁

科目： 電磁學

※計算題需計算過程，無計算過程者不予計分

1. (27%) The electric field component of a uniform plane wave in free-space is given by

$$\mathbf{E}(x) = 1e^{j20\pi x}\left[\hat{\mathbf{y}}e^{-j\pi/3} - \hat{\mathbf{z}}e^{j\pi/3}\right] \quad \text{mV/m}$$

with $e^{j\omega t}$ type of time dependence. Answer the following questions:

(a) (4%) Find the wavelength λ_0 and frequency f.

(b) (4%) Explain the term "uniform plane wave".

(c) (8%) Determine the corresponding magnetic field $\mathbf{H}(x)$.

(d) (6%) Draw the locus (軌跡) of the electric field vector to determine the polarization of this wave.

(e) (5%) Find the total time-average power density carried by this wave.

2. (8%) Explain the reasons why the electric displacement $\mathcal{D}(\mathrm{r}, t)$ and the magnetic field intensity $\mathcal{H}(\mathrm{r}, t)$ vanish within a perfect electric conductor in a time-varying situation.

3. (25%) (Similar to Inan's book, Problem 10.14) The only electric field component of a particular mode in a parallel-plate, air-filled waveguide having a plate separation of 1 cm is given by

$$E_y(x, z) = 5e^{-60\pi x}\sin(100\pi z) \ \text{kV/m},$$

where x and z are both in meters.

(a) (5%) In which direction is the structure assumed to be invariant? Explain your answer.

(b) (5%) Find the mode type (TE or TM) and the mode order of this mode. Is it a propagating or a nonpropagating mode? Explain your answer.

(c) (5%) What is the operating frequency?

(d) (5%) If the structure of the parallel-plate waveguide remains unchanged, obtain the condition for the waveguide to allow one propagating mode.

(e) (5%) Obtain the condition for having the waveguide become single-mode without changing the operating frequency and the dielectric filling.

注意：背面有試題

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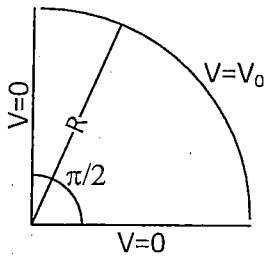
4. A certain configuration of charges produces the electric potential $V(\bar{r})=\frac{1}{r}e^{-r}$.
   a. Find the electric field $\bar{E}(\bar{r})$ and justify whether it is an appropriate electrostatic field. (5 pts)
   b. Find the configuration of charges by specifying its charge density $\rho(\bar{r})$. (5 pts)
   c. Find the total charge of the configuration. (5 pts)

5. Consider an infinitely long conducting tube with a fan-shaped cross section. The potential for the circular sector is maintained at V_0, and the straight walls are grounded and joint with it insulatedly, as shown in the following figure. Find the potential $V(r,\phi)$ at any point within the tube. (10 pts)



6. Picture the earth as a sphere of radius R, carrying a uniform surface charge σ, and is spinning at an angular velocity ω. Suppose the axis of spin is tilted from the polar axis by an angle ψ.
   a. Find the magnetic fields at the equator and that at the North Pole. (10 pts)
   b. Energetic charged particles from the solar wind can be trapped by the earth's magnetic field, forming the so called Van Allen radiation belt. Sketch the trajectory of these particles under the influence of the magnetic field. And explain the origin of the northern/southern lights (aurorae). (5 pts).

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