國立中央大學 114 學年度碩士班考試入學試題

系所： 光電類

科目： 電磁學

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請在答案卷(作答區內)作答。

Part A: Multiple-Choice Questions (40 marks) (Each question is worth 4 marks. Choose the correct option.)

1. The energy stored in a capacitor with capacitance C and voltage V is:

   (a) $\frac{1}{2}CV^2$ (b) CV^2 (c) $\frac{1}{2}\frac{V^2}{C}$ (d) $\frac{1}{2}C^2V$

2. For a system with bound charges, the polarization $\mathbf{P}$ leads to a bound surface charge density σ_b. Which expression correctly represents σ_b? ($\hat{n}$ is the unit normal vector of the surface)

   (A) $\sigma_b = -\nabla \cdot \mathbf{P}$ (B) $\sigma_b = \mathbf{P} \cdot \hat{n}$ (C) $\sigma_b = \nabla \cdot \mathbf{D}$ (D) $\sigma_b = \mathbf{D} \cdot \hat{n}$

3. The wave equation for the electric field in free space is derived from which of Maxwell's equations?

   (a) Faraday's law and Ampère-Maxwell law (b) Gauss's law for electricity and Faraday's law (c) Gauss's law for magnetism and Ampère-Maxwell law (d) None of the above

4. Which boundary condition is correct at the interface between two media for the tangential component of the electric field (**E**)? Here $\hat{n}$ is the unit normal vector of the interface.

   (a) $\mathbf{E}_1 = \mathbf{E}_2$ (b) $(\mathbf{E}_1 - \mathbf{E}_2) \cdot \hat{n} = 0$ (c) $(\mathbf{E}_1 - \mathbf{E}_2) \times \hat{n} = 0$ (d) $\nabla \cdot \mathbf{E} = 0$

5. In an electromagnetic wave propagating in free space, the relationship between the electric field $\mathbf{E}$ and magnetic field $\mathbf{B}$ is:

   (a) $\mathbf{E} \parallel \mathbf{B}$ (b) $\mathbf{E} \perp \mathbf{B}$ (c) $\mathbf{E} \cdot \mathbf{B} = 0$ (d) Both (b) and (c)

6. The Poynting vector $\mathbf{S}$ represents:

   (a) The energy density of an electromagnetic wave

   (b) The rate of energy flow per unit area in an electromagnetic wave

   (c) The total energy stored in the electromagnetic field

   (d) The momentum density of the wave

7. Which boundary condition is satisfied by the electric field at the surface of a perfect conductor? (Here E_t means the tangential component of the electric field.)

   (a) $E_t = 0$ (b) $E_t \neq 0$ (c) $\nabla \cdot \mathbf{E} = 0$ (d) $\nabla \times \mathbf{E} = 0$

注意:背面有試題

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8. In the absence of charges and currents, the magnetic field in an electromagnetic wave satisfies:

   (a) $\nabla \cdot \mathbf{B} = 0$ (b) $\nabla \times \mathbf{B} = \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t}$ (c) Both (a) and (b)

   (d) None of the above

9. The displacement current in Maxwell's equations is required to:
   (a) Conserve magnetic flux
   (b) Satisfy charge conservation
   (c) Ensure electric fields are solenoidal
   (d) Allow magnetic monopoles

10. In free space, the energy density u in an electromagnetic wave is given by:

    (a) $u = \frac{1}{2}\epsilon_0 E^2 + \frac{1}{2}\frac{B^2}{\mu_0}$ (b) $u = \epsilon_0 E^2$ (c) $u = \frac{B^2}{\mu_0}$ (d) $u = \frac{1}{2}\epsilon_0 E^2$

Part B: Fill-in-the-Blanks (20 Marks) (Each blank is worth 4 marks.)

1. The additional term Maxwell introduced to Ampère's law is called the _____.
2. The _____ time accounts for the delay of electromagnetic influence due to finite speed of light.
3. The energy flux in an electromagnetic wave is described by the _____ vector.
4. For a plane electromagnetic wave, the ratio of the magnitudes of the electric and magnetic fields is equal to _____ in vacuum.
5. The radiation pattern of an ideal electric dipole is strongest in the direction _____ to its axis.

Part C: Calculation Problems (40 Marks)

1. (20marks) A plane electromagnetic wave propagates in free space along the z-axis. The electric field is given by:

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$$\mathbf{E}(z,t) = \mathbf{E}_0 \cos(kz - \omega t)\,\hat{x}.$$

(a) Write the corresponding magnetic field $\mathbf{B}(z,t)$ using Maxwell's equations. (10 marks)

(b) Calculate the magnitude and direction of the Poynting vector $\mathbf{S}$. (10 marks)

2. (20marks) Two parallel conducting sheets located at $z = \pm d$ carry surface currents $\mathbf{K}_+ = K_0\hat{\mathbf{x}}$ $(z = d)$ and $\mathbf{K}_- = -K_0\hat{\mathbf{x}}$ $(z = -d)$, respectively.

(a) Find the magnetic field $\mathbf{B}$ in the region above $(z > d)$, between

$(-d < z < d)$, and below $(z < -d)$ the two sheets. (10 marks)

(b) Calculate the interacting force per unit area between these two sheets.

(10 marks)