

國立中央大學97學年度碩士班考試入學試題卷

所別：太空科學研究所碩士班

科目：電磁學 共 一 頁 第 一 頁

\*請在試卷答案卷(卡)內作答

1. (a) Write down Ohm's law and the differential forms of Maxwell's equations? (5 points)
- (b) Which Maxwell's equation leads to a discovery of electromagnetic fields propagating in free space with the speed of light? (3 points)
- (c) What does the linear, homogeneous, and isotropic medium mean? (3 points)
- (d) Under an assumption of the linear, homogeneous, isotropic, and source-free medium, derive the following general wave equation of the electric fields  $\vec{E}$  from Maxwell's equations: (8 points)

$$\nabla^2 \vec{E} = \mu\sigma \frac{\partial \vec{E}}{\partial t} + \mu\epsilon \frac{\partial^2 \vec{E}}{\partial t^2}$$

(Vector Identity:  $\nabla \times \nabla \times \vec{F} = \nabla(\nabla \cdot \vec{F}) - \nabla^2 \vec{F}$ ;  $\epsilon$ : dielectric constant;  $\mu$ : magnetic permeability;  $\sigma$ : conductivity)

- (e) Under which conditions, the general wave equations will become time-dependent wave (or Helmholtz) equations? (3 points)
  - (f) What will happen to a plane wave if the wave is propagating in a conducting medium? (3 points)
2. (a) Explain Coulomb's law and Gauss's law for the electric fields. (6 points)
  - (b) Derive the electric field intensity at any point due to an infinite plane with a surface charge density  $\rho_s$  using **Coulomb's law**. (10 points)
  - (c) Derive the electric field intensity at any point due to an infinite plane with a surface charge density  $\rho_s$  using **Gauss's law for the electric fields**. (9 points)
3. (a) Explain the Biot-Savart law and Ampère's circuital law. (6 points)
  - (b) Derive the magnetic flux density at any point due to a very long, very thin, straight wire carrying a current  $I$  using **the Biot-Savart law**. (10 points)
  - (c) Derive the magnetic flux density at any point due to a very long, very thin, straight wire carrying a current  $I$  using **Ampère's circuital law**. (9 points)
4. The motion of a charged particle is governed by the Lorentz Force equation. With the equation, discuss the possible trajectory and the energy change of a positive charge moving with a velocity  $\vec{v}$  under the following conditions of the electric and magnetic fields:
    - (a) No electric and magnetic fields; (5 points)
    - (b) Uniform electric fields; (5 points)
    - (c) Uniform magnetic fields; (5 points)
    - (d) Uniform electric and magnetic fields, but the electric fields are perpendicular to the magnetic fields; (5 points)
    - (e) Nonuniform magnetic fields with a gradient perpendicular to the magnetic fields. (5 points)

參考用