國立中央大學99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 不分組(一般生)　科目：電磁學　共 1 頁 第 1 頁

本科考試禁用計算器

＊請在試卷答案卷（卡）內作答

1. Answer the following 12 questions briefly:

   (a) What is the physical meaning of Gauss's law for electric fields. (5 points)

   (b) How do we define a vector field conservative? (5 points)

   (c) If there is no surface charge at a boundary, what is the relation between the normal components of the electric flux density on both sides of the boundary? (5 points)

   (d) What does it mean when we say that a medium is *isotropic*? (5 points)

   (e) Write down the charge continuity equation in differential form and explain its physical meaning. (5 points)

   (f) why is the electric field intensity created by a charged particle in free space is larger than that in a dielectric medium. (5 points)

   (g) Are the normal components of the magnetic flux density on both sides of a boundary *always* the same? (5 points)

   (h) How do we calculate the energy in a magnetic field? (5 points)

   (i) How does an electric generator work? (5 points)

   (j) What term in Maxwell's equations enabled James C. Maxwell discover that electromagnetic fields should propagate as waves? (5 points)

   (k) What kind of medium can make propagating electromagnetic waves losing energy? (5 points)

   (l) What is the electromagnetic mechanism behind an electric motor? (5 points)

2. Use the generalized Ohm's law with finite conductivity ($\vec{\mathbf{E}} + \vec{\mathbf{u}} \times \vec{\mathbf{B}} = \eta \vec{\mathbf{J}}$), Faraday's law ($\nabla \times \vec{\mathbf{E}} = -\partial \vec{\mathbf{B}}/\partial t$), and Ampere's law ($\nabla \times \vec{\mathbf{B}} = \mu_0 \vec{\mathbf{J}}$) to derive

$$\frac{\partial \vec{\mathbf{B}}}{\partial t} = \nabla \times (\vec{\mathbf{u}} \times \vec{\mathbf{B}}) + (\eta/\mu_0)\nabla^2 \vec{\mathbf{B}}$$

   where $\vec{\mathbf{B}}$ is the magnetic flux density, $\vec{\mathbf{E}}$ is the electric field intensity, and $\vec{\mathbf{u}}$ is the velocity of plasma; η is the resistivity and μ_0 is the permeability in free space. The first term on the right-hand side describes the convection of the field with the plasma, while the second term describes the diffusion of the field across the plasma. (20 points)

   Useful vector identity: $\nabla \times \nabla \times \vec{\mathbf{A}} = \nabla(\nabla \cdot \vec{\mathbf{A}}) - \nabla^2 \vec{\mathbf{A}}$

3. The motion of a charged particle is governed by the Lorentz Force equation($\vec{\mathbf{F}} = q\vec{\mathbf{E}} + q\vec{\mathbf{v}} \times \vec{\mathbf{B}}$), where $\vec{\mathbf{B}}$ is the magnetic flux density, $\vec{\mathbf{E}}$ is the electric field intensity, and q is the charge and $\vec{\mathbf{v}}$ is the velocity of the particle. With the equation, discuss the possible trajectories and the velocity change of a negative charge moving with a non-zero initial velocity $\vec{\mathbf{v}}_0$ under the following conditions of the electric and magnetic fields:

   (a) No electric and magnetic fields, (5 points)

   (b) Uniform magnetic fields only, (7 points)

   (c) Uniform electric fields only. (8 points)