國立中山大學 101 學年度碩士暨碩士專班招生考試試題

科目：電磁學【電機系碩士班戊組、電波領域聯合】

題號：4073

1. (20%) A long straight conducting wire of radius a, length l and conductivity σ carries a direct current I. Find
   (a) the current density and the electric field intensity in the wire. (10%)
   (b) the magnetic field intensity at a distance $a/2$ from the axis of the wire. (5%)
   (c) the power loss. (5%)

2. (20%) The boundary condition for the tangential $\mathbf{H}$ is $\mathbf{a}_{n2} \times (\mathbf{H}_1 - \mathbf{H}_2) = \mathbf{J}_s$, where $\mathbf{a}_{n2}$ is the outward unit normal from medium 2 at the interface. Given in air a surface current density $\mathbf{J}_s = \mathbf{a}_x$ 3 A/m flowing on the xy-plane, calculate
   (a) the 3 components B_x, B_y, B_z of the magnetic flux density $\mathbf{B}$ at (1,1,1). (15%)
   (b) the curl of $\mathbf{B}$ at (1,1,1). (5%)

3. (8%) Determine the polarization of the following electric fields:
   (a) $\mathbf{E} = \mathbf{a}_z E_0 \cos(\omega t - \beta y) + \mathbf{a}_x E_0 \sin(\omega t - \beta y)$ (2%)
   (b) $\mathbf{E} = \mathbf{a}_y E_0 \cos(\omega t + \beta x) + \mathbf{a}_z E_0 \sin(\omega t + \beta x)$ (2%)
   (c) $\mathbf{E} = \mathbf{a}_x E_0 \cos(\omega t - \beta y) - \mathbf{a}_z E_0 \sin(\omega t + \beta y)$ (2%)
   (d) $\mathbf{E} = \mathbf{a}_x E_0 \cos(\omega t - \beta y) + \mathbf{a}_z E_0 \cos(\omega t - \beta y)$ (2%)

4. (20%) Consider a rigid square conducting loop located in the xy-plane with its vertices at $(x, 1, 0)$, $(x, 3, 0)$, $(x + 2, 1, 0)$, and $(x + 2, 3, 0)$. A magnetic field given by
   $$\mathbf{B} = \mathbf{a}_z B_0 \cos \pi(x - v_0 t) \ \text{Wb/m}^2$$
   exists in the space.
   (a) Find the expression for the emf induced around the loop. (10%)
   (b) What would be the induced emf if the loop is moving with the velocity $\mathbf{v} = \mathbf{a}_x v_0$ m/s instead of being stationary? (10%)

5. (12%) An electromagnetic wave from an underwater source with perpendicular polarization is incident on a water-air interface at $_i = 30$. Using $_r = 81$ and $_r = 1$ for water, find
   (a) critical angle $_c$, (3%)
   (b) reflection coefficient $_\perp$, (3%)
   (c) transmission coefficient $_\perp$, (3%)
   (d) attenuation for each wavelength into the air. (3%)

6. (20%) This problem goes through the procedure to find the TE modes inside a metallic rectangular waveguide of dimensions $a \times b$, with $a > b$.
   (a) First, write down the time-harmonic Maxwell's equations. (4%)
   (b) Derive the equations expressing the transverse components of electric and magnetic fields in terms of the longitudinal components. (8%)
   (c) Solve the longitudinal component from the Helmholtz equation and related boundary conditions, and then the rest of the field components from the longitudinal component. (8%)