※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. (10 分)

In time-domain the Poynting vector is defined as $\vec{P} = \vec{E} \times \vec{H}$, where $\vec{E}$ and $\vec{H}$ are (x, y, z) and time-varying functions. If all the fields are time-harmonic, it is convenient to use their phasor forms $\vec{E}_s(x, y, z)$ and $\vec{H}_s(x, y, z)$, which are complex fields. The relations between the phasors and time-varying fields are $\vec{E}(x, y, z, t) = \mathrm{Re}\left[\vec{E}_s(x, y, z) e^{j\omega t}\right]$ and $\vec{H}(x, y, z, t) = \mathrm{Re}\left[\vec{H}_s(x, y, z) e^{j\omega t}\right]$, respectively. Explain why the complex Poynting vector is defined as $\vec{P}_c = \dfrac{1}{2}\vec{E}_s \times \vec{H}_s^*$, where * denotes complex conjugate.

2. (10 分)

For static fields, the Ampere's law is $\nabla \times \vec{H} = \vec{J}$, where $\vec{H}$ is the magnetic intensity field and $\vec{J}$ the conduction current density. Explain why it is necessary to include a displacement current density in the Ampere's law for time-varying conditions, i.e., $\nabla \times \vec{H} = \vec{J} + \dfrac{\partial \vec{D}}{\partial t}$, where $\vec{D}$ is the displacement flux density field and $\dfrac{\partial \vec{D}}{\partial t}$ is the displacement current density.

3. (10 分)

Describe the general characteristics of the following electromagnetic waves: (a) uniformly plane waves, (b) attenuated waves, (c) guided waves, (d) evanescent waves, and (e) radiated waves.

4. (10 分)

A conducting sphere of radius a has a total charge Q uniformly distributed on its surface. If the sphere is embedded in a medium with permittivity ε, find the energy stored.

5. (10 分)

A metal bar of conductivity σ is bent to form a flat 90° sector of inner radius a, outer radius b, and thickness t as shown below. Find the resistance of the bar between the vertical curved surfaces at $\rho = a$ and $\rho = b$ if $b/a = 6/5$, $\sigma = 4 \times 10^7 \ \mathrm{S \cdot m^{-1}}$ and $t = 0.5 \ \mathrm{cm}$.
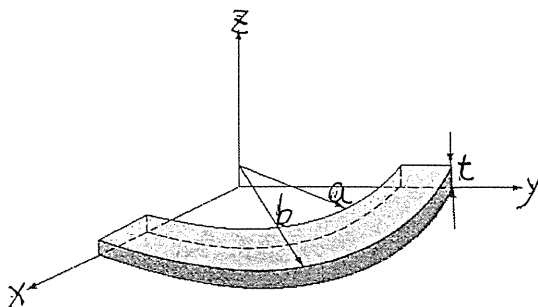
6. (10 分)

A planar boundary is formed by two regions. Region 1 ($x < 0$) is free space, while region 2 ($x > 0$) is a magnetic material with $\mu = 50\mu_0$. If magnetic flux density field in region 1 is given by

$\vec{B}_1 = 40\hat{a}_x - 30\hat{a}_y + 10\hat{a}_z$ mWb/m^2, find the magnetic intensity field in region 2.

7. (10 分)

A rectangular loop is located near an infinite line current, as illustrated below. If the loop moves with velocity v away from the linear conductor and the current in the linear conductor is $I_0 \cos(\omega t)$, what is the induced voltage in the loop at x?
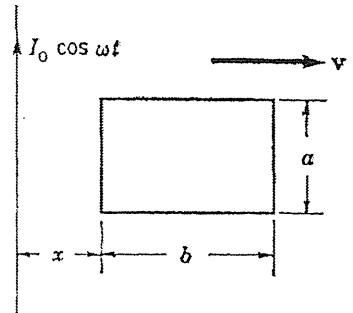
8. (10 分)

In a source-free vacuum region, a magnetic field in cylindrical coordinates is given by

$$\vec{H} = \frac{1}{\rho}\cos(\omega t - 3z)\hat{a}_\phi \text{ A/m}$$

Find the associated electric field and numerical value of ω.

9. (10 分)

A lossless transmission line, with characteristic impedance 50 Ω and electrical length of $l = 0.27\lambda$, is terminated by a load impedance $40 - j25$ Ω. Determine reflection coefficient at load Γ_L, standing-wave ratio (SWR), and input impedance Z_{in}.

10. (10 分)

Determine the size of an air-filled cubic cavity made of copper that it will give a dominant resonant frequency of 12 GHz.

Some formula:

In cylindrical coordinates, $\nabla^2 V = \dfrac{1}{\rho}\dfrac{\partial}{\partial \rho}\left(\rho\dfrac{\partial V}{\partial \rho}\right) + \dfrac{1}{\rho^2}\dfrac{\partial^2 V}{\partial \phi^2} + \dfrac{\partial^2 V}{\partial z^2}$

$$\nabla \times \vec{A} = \left[\frac{1}{\rho}\frac{\partial A_z}{\partial \phi} - \frac{\partial A_\phi}{\partial z}\right]\hat{a}_\rho + \left[\frac{\partial A_\rho}{\partial z} - \frac{\partial A_z}{\partial \rho}\right]\hat{a}_\phi + \frac{1}{\rho}\left[\frac{\partial(\rho A_\phi)}{\partial \rho} - \frac{\partial A_\rho}{\partial \phi}\right]\hat{a}_z$$