# 國立成功大學 108 學年度碩士班招生考試試題

系　　所：電腦與通信工程研究所

考試科目：電磁學及電磁波

考試日期：0224，節次：2



※ 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。

For your reference: $\varepsilon_0 = 10^{-9}/36\pi$ (F/m); $\mu_0 = 4\pi\times10^{-7}$ (H/m); $\eta_0 = 120\pi$ ($\Omega$)

Permittivity $\varepsilon$ ($=\varepsilon_r\varepsilon_0$); Permeability $\mu$ ($=\mu_r\mu_0$); Conductivity $\sigma$

1. Please calculate

(a) The volume in cylindrical coordinates between $r$ = 2 m and $r$ = 3 m contains a uniform charge density $\rho$ (C/m$^3$), as shown in **Fig. A**. Use Gauss's law to find the electric flux density $\vec{D}$ in all regions. [6%]

(b) A spherical conducting shell of radius $a$, centered at the origin, has a potential field

$$V(r) = \begin{cases} V_0, & r \le a \\ V_0 \cdot \dfrac{a}{r}, & r > a \end{cases}$$

with the zero reference at infinity. Find the electric field $\vec{E}$ anywhere and the stored electrostatic energy $W_e$ in this system. [9%]

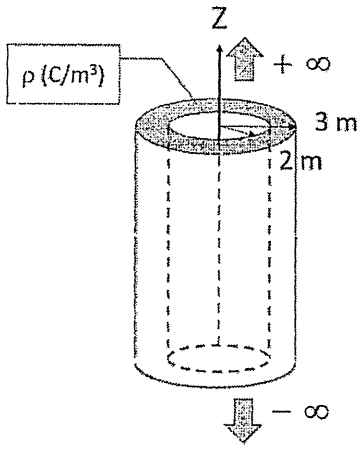


**Fig. A**

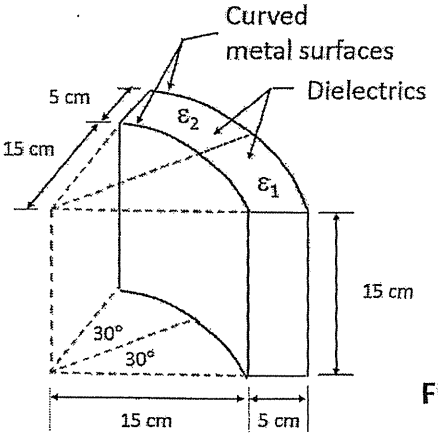


**Fig. B**

2. Find the total capacitance between the inner ($r_i$ = 15 cm) and outer ($r_o$ = 20 cm) curved metal surfaces as referred to the cylindrical coordinates and shown in **Fig. B**. The dielectric constants are $\varepsilon_1 = 2.5\varepsilon_0$ and $\varepsilon_2 = 4\varepsilon_0$, respectively. Neglect the fringing field effect. [10%]

3. In free space, an electromagnetic plane wave propagates along the z-axis. The magnetic field is

$$\vec{H}(z,t) = \frac{0.4}{3}\cos(4\times10^7 t - \beta z)\,\hat{a}_y \quad (\text{A/m}).$$

Find the electric field $\vec{E}(z,t)$, the phase constant $\beta$, and the wave length $\lambda$. [15%]

4. As shown in **Fig. C**, a rectangular conducting loop with resistance R = 0.2 Ω rotates with 300 rpm. The vertical conductor at $r_1$ = 0.03 m is in a flux density $\vec{B}_1 = 0.25\,\hat{a}_r$ (T), and the conductor at $r_2$ = 0.05 m is in $\vec{B}_2 = 0.8\,\hat{a}_r$ (T). The vertical conductor length is 0.5 m. Find the induced current in the loop. [15%]

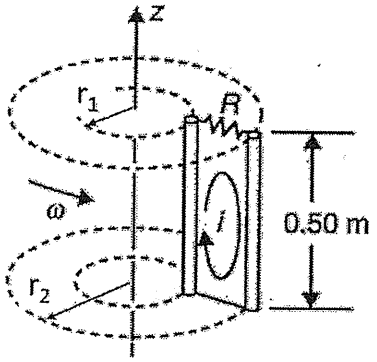


**Fig. C**

magnetic

5. A parallel-wire transmission line is constructed of #6 AWG copper wire (diameter = 0.162 in; $\sigma_c = 5.8\times10^7$ S/m) with a 12-inch separation in air. Neglect the internal inductance,

(a) find the transmission line parameters of L, C, G, the dc resistance $R_{dc}$, and the ac resistance $R_{ac}$ at 1 MHz; [10%] and

(b) find the characteristic impedance, propagation constant, propagation velocity, and wavelength while the operation frequency is at 5 kHz. [10%]

6. A rectangular waveguide having dimensions of a = 3.484 cm and b = 1.58 cm is filled with a dielectric material ($\varepsilon = 2.25\,\varepsilon_0$; $\mu = \mu_0$). The operation frequency is 4 GHz.

(a) Find the phase constant β, the guided wavelength $\lambda_g$, the phase velocity $v_p$, the group velocity $v_g$, and the wave impedance Z of the dominant mode. [10%]

(b) Compute the propagation constant when the operation frequency is 2 GHz. How much does the wave attenuate over the distance of 1 cm? [5%]

7. The radiation fields of a half-wave dipole antenna in phasor expression are given by

$$\vec{E}_\theta = j\eta_0 2I_0 \frac{e^{-jkr}}{4\pi r}\frac{\cos(\frac{\pi}{2}\cos\theta)}{\sin\theta}\hat{a}_\theta \quad \text{and} \quad \vec{H}_\phi = \frac{\vec{E}_\theta}{\eta_0}\hat{a}_\phi$$

where $I_0$ is the current amplitude at the input port of the antenna. Calculate the radiation resistance and directivity of a half-wave dipole antenna. (Note: calculation is necessary.) [10%]