國立成功大學
111學年度碩士班招生考試試題

編　號：43

系　所：光電科學與工程學系

科　目：電磁學

日　期：0220

節　次：第 2 節

備　註：不可使用計算機

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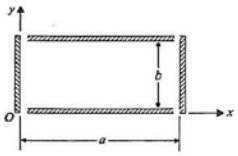
※ 考生請注意：本試題不可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

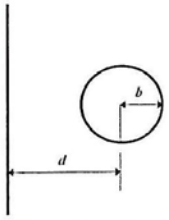
Part 1

1. **(16%)** A spherical distribution of charges $\rho = \rho_0\left[1-\left(R^2/b^2\right)\right]$ exists in the region $0 \le R \le b$. This charge distribution is concentrically surrounded by a dielectric shell (dielectric constant ϵ_r) with inner radius R_i ($> b$) and outer radius R_0. Determine the electric field intensity $\vec{E}$ and the electric potential V as functions of the radial distance R.

2. **(17%)** Consider the rectangular region shown below as the cross section of an enclosure formed by four conducting planes. All planes are assumed to be infinite in extent in the z-direction. Determine the electric potential distribution within this region if the top and bottom planes are grounded, and the left and right planes are kept at constant potentials V_1 and V_2, respectively.



3. **(17%)** A very long, straight wire and a conducting circular loop of radius of b are arranged as shown below. (a) Determine the mutual inductance between them. (b) Find the force on the circular loop that is exerted by the magnetic field due to an upward current I_1 in the long straight wire. The circular loop carries a current I_2 in the counterclockwise direction. ($\int_0^{\pi} \frac{d\theta}{p+q\cos\theta} = \frac{\pi}{\sqrt{p^2-q^2}}$)



Part 2

For a time harmonic wave with a time dependence $e^{j\omega t}$, the instantaneous field $\tilde{E}(x,y,z,t)$ can be expressed in terms of the phasor form of the electric field $\vec{E}(x,y,z)$ as

$$\tilde{E}(x,y,z,t) = Re[\vec{E}(x,y,z)e^{j\omega t}]$$

4. **(5%)** Assume a wave $\vec{E}(x,y,z) = \hat{x}E_x(z)$ propagating in a simple (homogeneous, isotropic, linear, lossless, source free), unbounded medium. Please use Helmholtz equation to obtain $E_x(z)$. **(5%)** Then, please derive the corresponding $\vec{H}$.

5. **(15%)** In a simple but lossy media ($\sigma \neq 0$), the uniform plane wave will have a complex propagation constant $\gamma = \alpha + j\beta$, please derive α and β in terms of permittivity ϵ, permeability μ, and conductivity σ.

6. **(20%)** In a rectangular waveguide with perfect conductor for the four sidewalls, the wave propagates in the +z direction. The width of the waveguide is b in the y direction and a in the x direction. Please solve the TM modes in the waveguide and show the following field components E_x, E_y, E_z, H_x, H_y. **(5%)** Please derive the cutoff angular frequency ω_{mn} of this waveguide.