※請在答案卷內作答

Note: Detailed derivations are required to obtain a full score for each problem.

1. (5 pts) Use the energy formulas

$$W_e = \frac{1}{2}\int_{V'} \epsilon E^2\, d\nu = \frac{1}{2}CV^2,$$

where V' is the volume of the region where the electric field E exists, to find the unit-length capacitance of a cylindrical capacitor having an inner conductor of radius r_1, an outer conductor of inner radius r_2, and a dielectric of permittivity $\epsilon_0\epsilon_r$ and permeability $\mu_0\mu_r$.

2. (10 pts) What is the *uniqueness theorem* for electrostatic solutions? And **prove** it.

3. (10 pts) Consider an **ideal transformer**:

(a) (4 pts) Plot schematic diagram for such an ideal transformer.

(b) (3 pts) Derive the current **I** and **N** (number of turns) equation.

(c) (3 pts) Derive the voltage **V** and **N** equation.

4. (10 pts) Explain following terms by using **B** and **H**.

(a) (2 pts) Diamagnetic material;

(b) (2 pts) Ferromagnetic material;

(c) (6 pts) Plot and explain **Hysteresis loop diagram** in terms of B-H for ferromagnetic material.
Here, you need to indicate and explain *residual flux density* (B_r), and *coercive field intensity* (H_c) in the hysteresis loop diagram.

注意：背面有試題

參考用

※請在答案卷內作答

5. (15 pts) A **TE** wave propagating in a dielectric-filled metallic waveguide of unknown permittivity has dimension $a = 5\,cm$ and $b = 3\,cm$. If the x component of its electric field is given by

$$E_x = -36\cos(40\pi x)\,\sin(100\pi y)\,\sin(2.4\pi\times 10^{10}t - 52.9\pi z), \quad (V/m)$$

Determine

(a) (5 pts) the mode number,

(b) (5 pts) ϵ_r of the filled dielectric material, and

(c) (5 pts) the cutoff frequency.

6. (10 pts) Helmholtz equation and plane waves:

(a) (5 pts) Please derive the homogeneous **vector Helmholtz's equations** from time-harmonic Maxwell's equations in a simple, nonconducting source-free medium.

(b) (5 pts) Write the *phasor expressions* for the electric and magnetic field intensity vectors of an x-polarized uniform plane wave propagating in the $+z$ direction.

7. (10 pts) A dielectric layer of thickness d and intrinsic impedance η_2 is placed between media 1 and 3 having intrinsic impedances η_1 and η_3, respectively.

Explain

(a) (5 pts) half-wave dielectric window, and

(b) (5 pts) quarter-wave impedance transformer in this case.

8. (7 pts) The standing-wave ratio on a lossless $50\,\Omega$ transmission line terminated in an unknown load impedance is found to be 3.0. The distance between successive voltage minima is $20\,cm$, and the first minimum is located at $5\,cm$ from the load. Determine

(a) (5 pts) the reflection coefficient, and

(b) (2 pts) the load impedance.

注意：背面有試題

※請在答案卷內作答

9. (8 pts) The short-circuit and open-circuit impedances measured at the input terminal of a lossless transmission line of length ℓ (m), which is less than a quarter wavelength, are $j150$ (Ω) and $-j50$ (Ω), respectively.

(a) (2 pts) Find the characteristic impedance of the line, and

(b) (3 pts) the propagation constant of the line.

(c) (1 pts) Without changing the operating frequency, find the input impedance of a short-circuited line that is twice the given length.

(d) (2 pts) How long should the short-circuited line be, in order for it to appear as an open circuit at the input terminals? Give the shortest possible length.

For these questions, you may find possible use of the following results:

$\tan(jA) = j\tanh A$; $\tanh(jA) = j\tan A$; $j\tanh^{-1} A = \tan^{-1}(jA)$;
$\tanh^{-1}(jA) = j\tan^{-1} A$; $\tan\frac{\pi}{6} = \frac{1}{\sqrt{3}}$; $\tan\frac{\pi}{4} = 1$; $\tan\frac{\pi}{3} = \sqrt{3}$; and $\sqrt{3} \approx 1.732$.

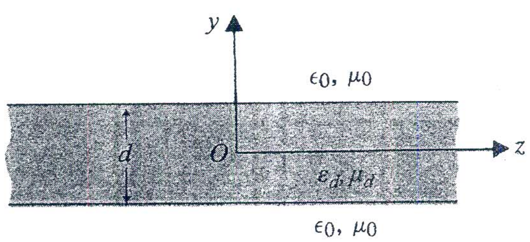
10. (15 pts) Consider a dielectric-slab waveguide of thickness d, shown in the following Figure. Let ϵ_d and μ_d be the permittivity and permeability, respectively, of the dielectric slab, which is situated in free space (ϵ_0, μ_0). For simplicity, there is no dependence on the x-coordinate and the dielectric is lossless.

For the wave propagating in the $+z$-direction,

(a) (5 pts) find the corresponding *dispersion relation* for **TM** waves.

(b) (6 pts) For *even* **TM** modes, find $E_z(y)$, and

(c) (4 pts) the corresponding nonzero electric and magnetic field components.



Problem 10: A longitudinal cross-section of a dielectric-slab waveguide.