題號： 416　　國立臺灣大學 108 學年度碩士班招生考試試題

科目： 電磁學(C)

節次： 7

※ 請於答案卷上非選擇題作答區標明題號作答。計算題請詳列過程。 $\varepsilon_0 = 10^{-9}/(36\pi)$ [F/m], $\mu_0 = 4\pi\times10^{-7}$ [H/m]

1. (計算題) Consider a finite-width parallel-plate transmission line formed by two **perfectly conducting** plates of width w separated by a spacing d. A **perfect dielectric** ($\mu_r = 1, \varepsilon_r > 1$) filled in between them. Assume that the fringing fields can be neglected and the transverse electromagnetic waves propagate along the z-axis are given by $\mathbf{E} = (V_0/d)\cos(8\pi\times10^9 t - 50\pi z)\mathbf{a}_x$ [V/m] and $\mathbf{H} = (I_0/w)\cos(8\pi\times10^9 t - 50\pi z)\mathbf{a}_y$ [A/m], where V_0, I_0, d, and w are constants.
   (a) (4%) What is the frequency f of the electromagnetic waves in the parallel-plate transmission line?
   (b) (4%) What is the phase velocity v_p of the electromagnetic waves in the parallel-plate transmission line?
   (c) (4%) According to (b), what is the relative permittivity ε_r of the dielectric filled in between the two conducting plates?
   (d) (4%) Based on (c), what is the capacitance per unit length C of the parallel-plate transmission line for static fields?
   (e) (4%) Based on (d), what is the characteristic impedance Z_0 of the parallel-plate transmission line?
   (f) (4%) Based on (e), if one end of the parallel plate transmission line is short-circuited, what is the voltage reflection coefficient Γ?
   (g) (4%) Based on (e), if the parallel plate transmission line is terminated with a resistive load without reflection, what is the load resistance R_L?
   (h) (4%) Please find the instantaneous Poynting vector $\mathbf{P}$ associated with the electromagnetic waves.
   (i) (4%) Please find the time-average Poynting vector $\langle\mathbf{P}\rangle$ associated with the electromagnetic waves.
   (j) (4%) Please find the time-average power flow $\oint\langle\mathbf{P}\rangle\cdot d\mathbf{s}$ along the parallel-plate transmission line.

2. (推導) (10%) A dielectric material of permittivity ε sliding freely in a cylindrical capacitor experiences a mechanical force $\mathbf{F}_e$ of electrical origin in the axial direction ah shown in **Fig. P2**. Show that $\mathbf{F}_e = \dfrac{V_0^2\pi(\varepsilon-\varepsilon_0)}{\ln(b/a)}\mathbf{a}_x$

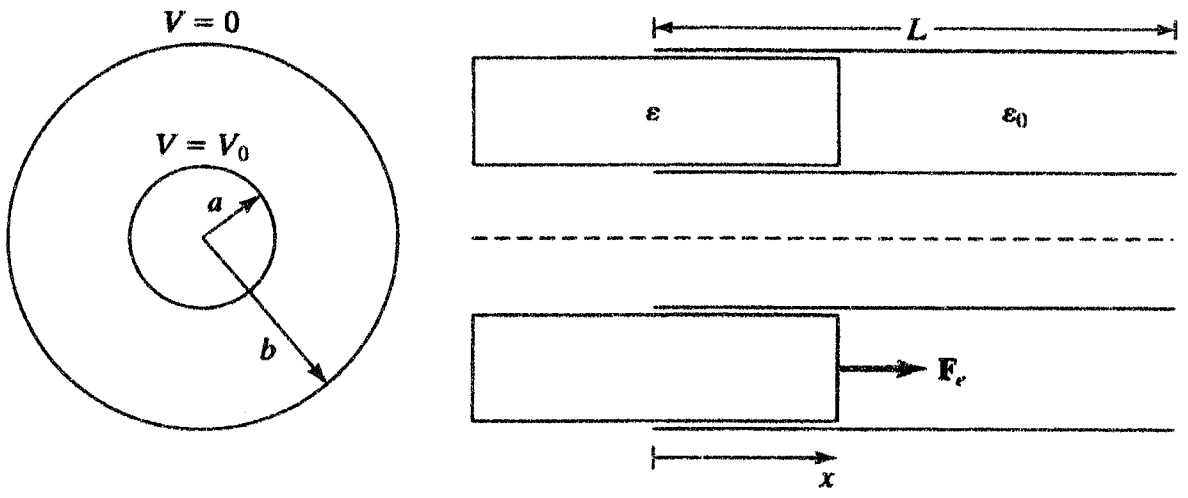

Fig. P2

3. (計算題) (20%) **Fig. P3** shows a parallel-plate waveguide discontinuity. Please find the power reflection coefficients for $TE_{1,0}$ and $TM_{1,0}$ waves of frequency f = 6 GHz incident on the junction from the free space side.

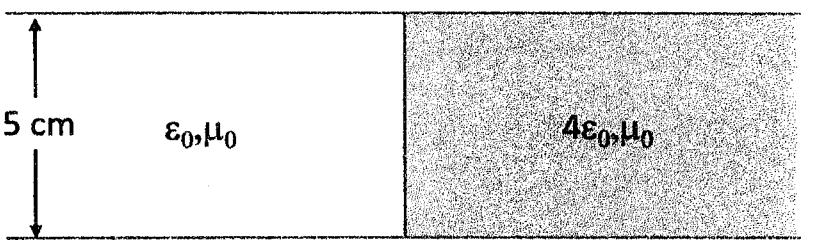

Fig. P3

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4. (a) (推導) (20%)Please derive the transmitted intensity ratio I_t/I_i of a Fabry-Perot etalon as shown in **Fig. P4** .

$$\frac{I_t}{I_i} = \frac{(1-R)^2}{(1-R)^2 + 4R\sin^2(\delta/2)}$$

$$\text{where } R = \Gamma^2, \delta = k_0 n \cdot 2d = \frac{4\pi n d}{\lambda_0}, I_i = |E_i|^2, \text{and } I_t = |E_t|^2.$$

Assume normal incidence. E_i and E_t are the amplitudes of incident and transmitted electric fields, respectively. n, Γ, d, and λ_0 are the refractive index of the cavity, the amplitude reflected coefficient at the interface, the length of the cavity, and the wavelength in free space, respectively.

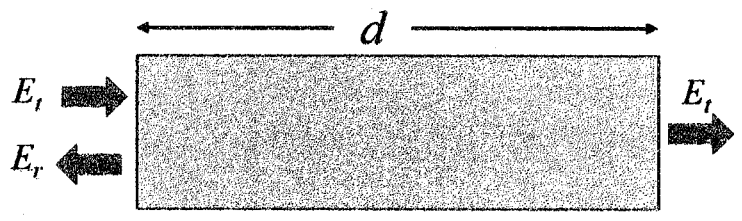

Fig. P4

(b) (計算題) (5%) The maximum transmission of unity occurs for $\delta = 2m\pi$, $m = 1, 2, 3, \ldots$. Please find nearest integer m for d = 300 μm, n = 3.5, and λ_0 = 850 nm.

(c) (計算題) (5%) The wavelength satisfies such m is called the resonant wavelength λ_m. (λ_m is close to 850 nm.) Please find the wavelength difference between two resonant modes, $\Delta\lambda = (\lambda_{m+1} - \lambda_m)$.

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