填充題請將答案填寫於答案卷內，只寫在本題目卷不計分，計算過程不計分。
推導與計算題請詳列過程。 $c = 3 \times 10^8$ [m/s], $\varepsilon_0 = 10^{-9}/(36\pi)$ [F/m], $\mu_0 = 4\pi \times 10^{-7}$ [H/m]

1. (填充題)(12%) For a system shown in the figure below, a uniform plane wave having the electric field $\mathbf{E} = E_0 \cos 4\pi \times 10^{14} t\, \boldsymbol{a}_x$ (MKS system) at $z = 0$ is normally incident on the interface from Medium 1. (a) The lowest value of d should be (填充 1.a) μm for which the minimal reflection occurs. (b) The lowest value of d should be (填充 1.b) μm for which the maximal reflection occurs.

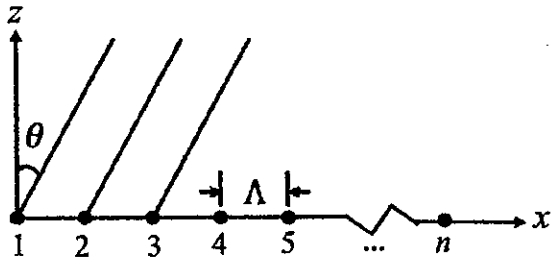
Medium 1	Medium 2	Medium 3
μ_0, ε_0	$\mu_0, 2.25\varepsilon_0$	$\mu_0, 4\varepsilon_0$
	$z = 0$	$z = d$

If the dielectric constant of Medium 2 is changed to $9\varepsilon_0$ from $2.25\varepsilon_0$. (c) The lowest value of d should be (填充 1.c) μm for which the minimal reflection occurs. (d) The lowest value of d should be (填充 1.d) μm for which the maximal reflection occurs. (Hint: Consider the destructive and constructive interferences due to the reflections.)

2. (填充題)(4%) The dimensions of a PEC rectangular cavity resonator are $a = 20$ cm, $b = 5$ cm, and $d = 5\sqrt{2}$ cm. The cavity is filled with a perfect dielectric of $\varepsilon_r = 4$. The lowest resonant frequency of the resonator is (填充 2) Hz.

3. (計算題)(12%) Consider a uniform plane wave of frequency 3 THz (THz = 10^{12} Hz) propagating in an anisotropic perfect dielectric medium characterized by the permittivity matrix $[\varepsilon] = \varepsilon_0 \begin{pmatrix} 2.25 & 0 & 0 \\ 0 & 2.56 & 0 \\ 0 & 0 & 2.25 \end{pmatrix}$, and $\mu = \mu_0$. It is linearly polarized at $z = 0$ and propagates in the z-direction. Its magnitudes of x-polarized and y-polarized components are the same. (a) Please find the propagation distance L (maybe more than one solution) for which the plane wave becomes circularly polarized. (b) Please find the propagation distance L (maybe more than one solution) for which the plane wave becomes linearly polarized again.

4. (推導與計算題)(22%) Consider a uniform linear array of n antennas of spacing Λ, as shown in the figure below. Assume the currents are of equal amplitude I_0 and progressive phase shift δ, that is, in the manner $I_0 \cos \omega t$, $I_0 \cos(\omega t + \delta)$, $I_0 \cos(\omega t + 2\delta)$, … for antennas 1, 2, 3,…, respectively. (a) (8%) Please derive the group pattern of antennas 1 and 2 based on their far-field interference. (b) (10%) Please derive the group pattern of the n antennas. (c) (4%) Please find the angles θ for which the nulls and local maxima of the group pattern occur from the results of (b).



5. (計算題) Consider a coaxial cable formed by two **perfectly conducting** cylinders of radii a and b ($b > a$) as its inner and outer conductors, respectively. A **perfect dielectric** ($\mu_r = 1, \varepsilon_r > 1$) filled in between them. Assume that the transverse electromagnetic waves propagate along the z-axis are given by

$$\mathbf{E}(r,\phi,z,t) = \frac{V_0}{r \ln(b/a)} \cos(6\pi \times 10^9 t - 30\pi z)\mathbf{a}_r \text{ [V/m] and } \mathbf{H}(r,\phi,z,t) = \frac{I_0}{r \ln(b/a)} \cos(6\pi \times 10^9 t - 30\pi z)\mathbf{a}_\phi \text{ [A/m]},$$

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where V_0, I_0, a, and b are constants.

(a) (4%) What is the **frequency** f of the electromagnetic waves in the coaxial cable?

(b) (4%) What is the **phase velocity** v_p of the electromagnetic waves in the coaxial cable?

(c) (4%) What is the **capacitance per unit length** $\mathcal{C}$ of the coaxial cable for static fields?

(d) (4%) What is the **inductance per unit length** $\mathscr{L}$ of the coaxial cable for static fields?

(e) (4%) What is the **characteristic impedance** Z_0 of the coaxial cable?

(f) (4%) If one end of the coaxial cable is **open-circuited**, what is the **voltage reflection coefficient** Γ?

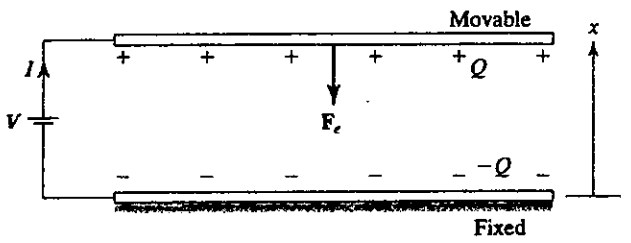
(g) (4%) If the coaxial cable is terminated with a resistive load **without reflection**, what is the **load resistance** R_L?

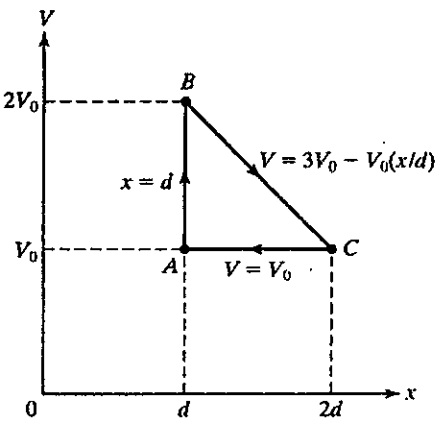
(h) (4%) Please find the **instantaneous Poynting vector** $\mathbf{P}$ associated with the electromagnetic waves.

(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** $\oint \langle \mathbf{P} \rangle \cdot d\boldsymbol{s}$ along the parallel-plate transmission line.

6. (推導與計算題) (10%) Assume that in the parallel-plate capacitor shown below (left), a source of mechanical force **F** is applied to the movable plate such that F is always maintained equal to $-\mathbf{F}_e$. By appropriately varying V and **F**, the system is made to traverse the closed cycle in the V-x plane shown below (right). Calculate the **energy converted per cycle** and determine **whether the conversion is from electrical to mechanical or vice versa**.





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