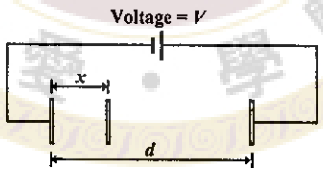
※ 請於答案卷上非選擇題作答區標明題號作答。計算題請詳列過程。 $\varepsilon_0 = 10^{-9}/(36\pi)$ F/m, $\mu_0 = 4\pi\times10^{-7}$ H/m

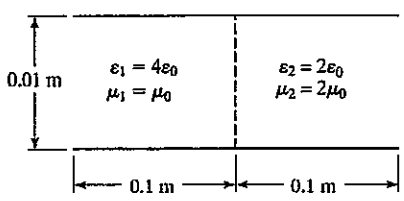
1. Consider one medium (Medium 1) with $\varepsilon_r = 1$ and $\mu_r = 1$, and another medium (Medium 2) with $\varepsilon_r = 4$ and $\mu_r = 1$. It is well known that the velocity of light in free space is c.
   (a) **(2%)** What is the phase velocity in Medium 1?
   (b) **(2%)** What is the phase velocity in Medium 2?
   (c) **(2%)** What is the refractive index of Medium 1?
   (d) **(2%)** What is the refractive index of Medium 2?
   (e) **(3%)** If an electromagnetic wave enters Medium 1 from Medium 2 through an interface, what is the critical angle of incidence θ_c?
   (f) **(3%)** If an electromagnetic wave enters Medium 2 from Medium 1 through an interface, what is the Brewster angle?

2. **(5%)** Consider a single-frequency uniform plane wave propagating in the +z direction in free space, where the velocity of light is c. Assume the magnetic field (as a function of time t) at $z = 0$ is $\mathbf{H_0} = A\cos(\omega t + \theta)\,\mathbf{a}_y$, where A, ω, and θ are real and fixed. What is the magnetic field (as a function of time t) at $z = l$? For your answer, please use the symbols given above in this problem.

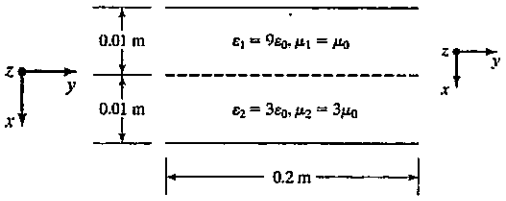
3. *Mechanical Force of Electric Origin* - In this problem, all the plates are in free space, and please ignore fringing of the electric field at the edges of the plates.
   (a) **(5%)** Consider a capacitor consisting of two conducting plates with the same area A, separated by a distance x. If a voltage V is applied across the capacitor, what is the mechanical force $\mathbf{F}_e$ of electric origin (attractive in this case, and as a function of x) between the two plates?
   (b) **(10%)** Consider a device consisting of three conducting plates with the same area A, as shown in the figure below. The distance d is fixed, and the distance x is a variable. What is the *net* mechanical force of electric origin (as a function of x) exerted on the middle plate?



4. **(8%)** Two parallel-plate transmission lines consist of arrangements of two perfect dielectrics, as shown by the transverse cross sections in figures (a) and (b) below. Neglect fringing of fields and compute the values of impedance Z_0 of the lines (a) and (b), respectively.



(a)



(b)

見背面

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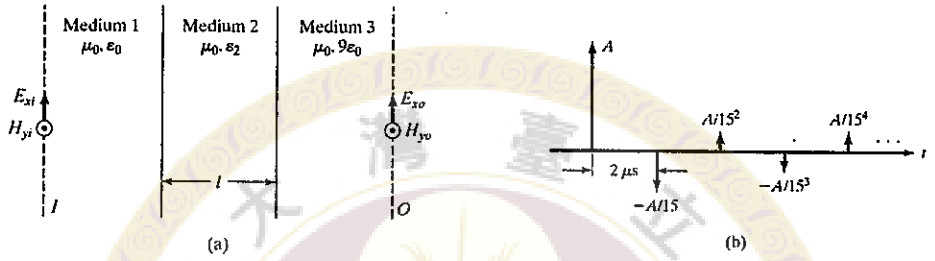
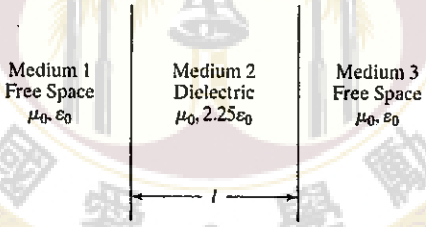
5. In figure (a) below, the plane I is the input plane from which a uniform plane wave is incident normally on the interface between medium 1 and medium 2, and the plane O is the output plane in which the response of the system is observed. For an incident wave of $E_{xi}(t)=\delta(t)$, find the minimum value of the thickness l and the corresponding value of the permittivity ε_2 of medium 2 required to obtain the electric field E_{xo} in the output plane, as shown in figure (b) below, in which the interval between successive impulses is $2\ \mu s$. Then
   (a) **(5%)** Find the value of A in figure (b) below.
   (b) **(5%)** Sketch the reflected wave electric field in the plane I in figure (a) below.



6. In the figure below, assume uniform plane waves of frequency f incident normally onto the interface from medium 1.
   (a) (5%) Find the SWR in medium 1 for $f = 10^9\,Hz$ if $l = 5cm$.
   (b) (5%) Find the three lowest values of f for which complete transmission occurs if $l = 5cm$.
   (c) (5%) Find the three lowest values of l for which complete transmission occurs for $f = 10^9\,Hz$.



7. In the laser optics experiments, sometimes we will use a crystal to change or maintain the laser polarization. Consider a medium with thickness L is nonmagnetic with anisotropic perfect dielectric [ε] as shown in the figure below. A polarized uniform plane wave having the electric field $E_i = E_1[\cos(6\pi\times10^9 t - 2\pi z)]a_x + E_2[\cos(6\pi\times10^9 t - 2\pi z)]a_y$ is incident from free space ($z<0$) normally onto the medium ($z>0$).
(a) **(4 %)** Find the reflected electric field E_r and its polarization.
(b) **(4 %)** Find the transmitted electric field E_t and its polarization.
(c) **(6 %)** Find the minimum thickness of the medium so that it is transparent for the incident wave.
(d) **(8 %)** Find the minimum thickness of the medium and the amplitude ratio of E_1/E_2, so that you can produce a "circularly polarized" wave.

接次頁

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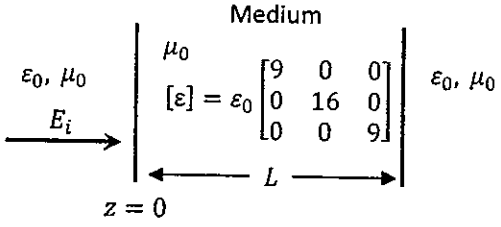

8. **(11 %)** Consider two antennas with the power density pattern of $f_1(\theta,\phi) = \sqrt{\sin(\theta)}$ and $f_2(\theta,\phi) = (\sin\theta)^5$. Which one is more suitable for a cell phone design? Justify your answer.