※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 a uniform plane wave propagating in a lossless medium. Assume the electric field in the medium is $\mathbf{E} = E_0 \cos(4\pi\times10^{12}\, t - 2\pi\times10^{4}\, y)\, \mathbf{a}_z$. The permeability of the medium is equal to that of free space, μ_0.
   (a) (5%) What is the propagation direction? $+x$, $-x$, $+y$, $-y$, $+z$, or $-z$?
   (b) (5%) What is the frequency f (in Hz) of the plane wave?
   (c) (5%) What is the phase constant β?
   (d) (5%) What is the wavelength within the medium?
   (e) (5%) What is the relative permittivity ε_r of the medium?
   (f) (5%) Which direction is the magnetic field intensity $\mathbf{H}$ parallel to? $\mathbf{a}_x$, $\mathbf{a}_y$, or $\mathbf{a}_z$?

2. Consider a parallel-plate waveguide of two perfectly conducting plates separated by an air gap. Assume the air gap to be 2 mm.
   (a) (7%) Find the cutoff frequency f_c of $TE_{2,0}$ mode.
   (b) (7%) For $f = 2\times10^{11}$ Hz, find the guide wavelength λ_g of $TE_{2,0}$ mode.
   (c) (6%) For $f = 2\times10^{11}$ Hz, find the phase velocity (along the guide axis) of $TE_{2,0}$ mode.

3. A dielectric layer on a substrate is employed as a quarter-wave transformer to completely eliminate reflections of uniform plane waves of 1500 THz incident normally from the free space side as shown in Figure P3.
   (a) (5%) What is the optimal dielectric constant ε_1 of the dielectric layer?
   (b) (5%) What is the minimum required thickness t_1 of the dielectric layer?
   (c) (6%) Please analytically find the bandwidth between frequencies on either side of 1500 THz at which the SWR in free space is 2.0.
   (d) (6%) What is the maximum SWR in free space as the frequency is varied on either side of 1500 THz?

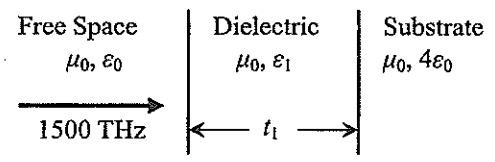

Figure P3

4. (a) (6%) An uniform plane wave is incident from the air (refractive index n=1) onto a perfect dielectric (n=1.5) plane boundary at an incidence angle θ. Please choose the correct plot of the magnitude of reflection coefficient vs. θ for the TE polarization from Figure P4(A)-(D) and calculate the parameters Γ0 and θi (i=1 or/and 2) shown in that plot.
   (b) (6%) If the wave is of TM polarization and incident from a perfect dielectric (n=1.5) onto the air (n=1) plane boundary at an incidence angle θ. Please choose the correct plot of the magnitude of reflection coefficient vs. θ for the TM polarization from Figure P4(A)-(D) and calculate the parameters Γ0 and θi (i=1 or/and 2) shown in that plot.

見背面

※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

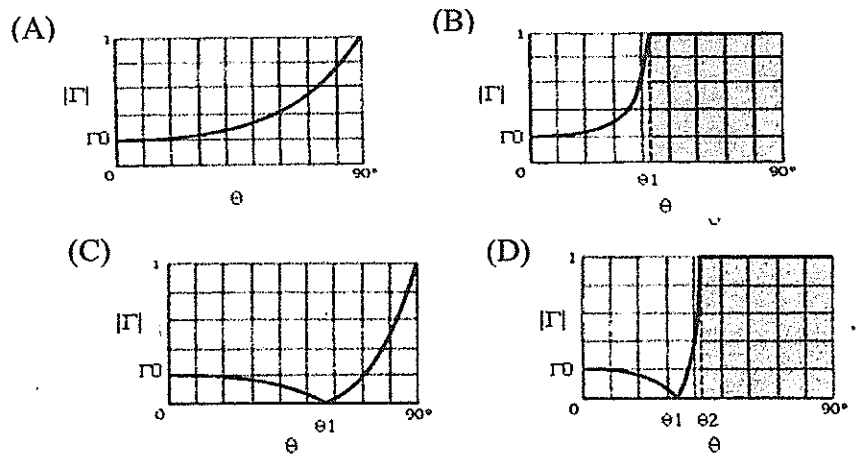

Figure P4

5. A current density due to flow of free charges is given by $\boldsymbol{J} = -(x\,\boldsymbol{a}_x + 2y^2\,\boldsymbol{a}_y + 3z\,\boldsymbol{a}_z)$.

(a) (6%) Please show that the surface integral of displacement current is equal to minus of the surface integral of current in general cases. (Hint: from Ampère's circuital law) That is,

$$\frac{d}{dt}\oint_S \mathbf{D}\cdot d\mathbf{S} = -\oint_S \mathbf{J}\cdot d\mathbf{S}$$

(b) (5%) By using surface integrals directly, find the displacement current emanating from the closed surface of the cubic box bounded by the planes $x = \pm1$, $y = \pm1$, $z = \pm1$.

(c) (5%) Redo (b) by using an appropriate volume integral. (hint: use divergence theorem)

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