Electromagnetics II **Final Examination** **2007.1.15**

注意：共六題，每題 20 分，選擇最高分之五題計算成績。

1. The input impedance of a lossy line of length 50 m is measured at a frequency of 100 MHz for two cases: with the output short-circuited, it is $(10+j49)\Omega$, and with the output open circuited, it is $(10-j49)\Omega$. Find: **(a)** the characteristic impedance of the line; **(b)** the attenuation constant of the line; and **(c)** the phase velocity in the line, assuming its approximate value to be 1.75×10^{8} m/s.

2. The electric field of a uniform plane wave propagating in free space is given in phasor form by

$$\overline{\mathbf{E}}=10\left(\mathbf{a}_x+j0.4\mathbf{a}_y+j0.3\mathbf{a}_z\right)e^{j(0.6y-0.8z)}$$

(a) Determine the frequency of the wave. **(b)** What is the direction of propagation? **(c)** Obtain the associated magnetic field in phasor form. **(d)** Discuss the polarization of the wave. **(e)** Find the time-average power flow per unit area normal to the direction of propagation.

3. TM mode is excited in a parallel-plate waveguide filled with a dielectric of $\varepsilon=4\varepsilon_0$ and $\mu=\mu_0$ and having the plates in the $x=0$ and $x=5$ cm planes by setting up at its input $z=0$ the magnetic field distribution

$$\mathbf{H}=H_0\cos 40\pi x\sin 8\pi\times10^9 t\ \mathbf{a}_y$$

Find the expressions for the electric and magnetic fields of the propagating wave.

4. Design a symmetric dielectric slab waveguide, with $\varepsilon_{r1}=2.25$ and $\varepsilon_{r2}=2.13$, by finding the value of d/λ_0 such that the TE_1 mode operates at 20% above its cutoff frequency.

5. A dielectric slab of thickness 4 cm and permittivity $2.25\varepsilon_0$ exists in an air-dielectric rectangular waveguide of dimensions $a=3$ cm and $b=1.5$ cm as shown in Fig. 1. Find the lowest frequency for which the dielectric slab is transparent (i.e., allows complete transmission) for $TE_{1,0}$ mode propagation in the waveguide.

6. Describe the definition of antenna directivity and prove that the directivity of the Hertzian Dipole is $D=1.5$.

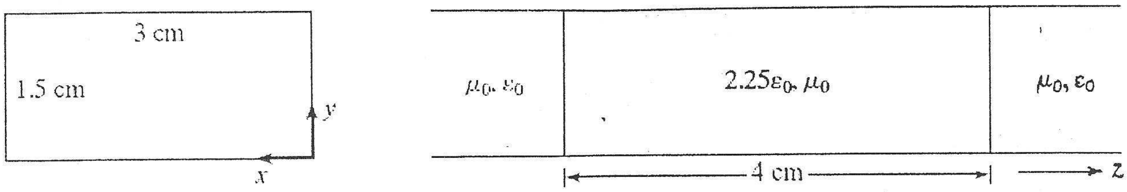

Fig. 1

Useful formula

1. $f_c = \dfrac{mc}{2d\sqrt{\varepsilon_{r1} - \varepsilon_{r2}}}$, $\quad m = 0,\ 1,\ 2,\ \ldots$

2. $\mathbf{E} = -\dfrac{\beta^2 I_0 dl \sin\theta}{4\pi\varepsilon\omega r}\sin(\omega t - \beta r)\,\mathbf{a}_\theta = -\dfrac{\eta\beta I_0 dl \sin\theta}{4\pi r}\sin(\omega t - \beta r)\,\mathbf{a}_\theta$

3. $\mathbf{H} = -\dfrac{\beta I_0 dl \sin\theta}{4\pi r}\sin(\omega t - \beta r)\,\mathbf{a}_\phi$

TABLE 9.1 Field Expressions and Associated Parameters for TE and TM Modes in a Rectangular Waveguide

Transverse electric (TE) waves	Transverse magnetic (TM) waves
Field Expressions:	Field Expressions:
($m, n = 0, 1, 2, \ldots,$ but not both zero)	($m, n = 1, 2, 3, \ldots$)
$\bar{E}_z = 0$	$\bar{H}_z = 0$
$\bar{H}_z = \bar{A}\cos\dfrac{m\pi x}{a}\cos\dfrac{n\pi y}{b}e^{\mp j\beta_z z}$	$\bar{E}_z = \bar{A}\sin\dfrac{m\pi x}{a}\sin\dfrac{n\pi y}{b}e^{\mp j\beta_z z}$
$\bar{E}_x = j\dfrac{\lambda_c^2}{4\pi^2}\omega\mu\dfrac{n\pi}{b}\bar{A}\cos\dfrac{m\pi x}{a}\sin\dfrac{n\pi y}{b}e^{\mp j\beta_z z}$	$\bar{E}_x = \mp j\dfrac{\lambda_c^2}{2\pi\lambda_g}\dfrac{m\pi}{a}\bar{A}\cos\dfrac{m\pi x}{a}\sin\dfrac{n\pi y}{b}e^{\mp j\beta_z z}$
$\bar{E}_y = -j\dfrac{\lambda_c^2}{4\pi^2}\omega\mu\dfrac{m\pi}{a}\bar{A}\sin\dfrac{m\pi x}{a}\cos\dfrac{n\pi y}{b}e^{\mp j\beta_z z}$	$\bar{E}_y = \mp j\dfrac{\lambda_c^2}{2\pi\lambda_g}\dfrac{n\pi}{b}\bar{A}\sin\dfrac{m\pi x}{a}\cos\dfrac{n\pi y}{b}e^{\mp j\beta_z z}$
$\bar{H}_x = \mp\dfrac{\bar{E}_y}{\eta_g}$	$\bar{H}_x = \mp\dfrac{\bar{E}_y}{\eta_g}$
$\bar{H}_y = \pm\dfrac{\bar{E}_x}{\eta_g}$	$\bar{H}_y = \pm\dfrac{\bar{E}_x}{\eta_g}$
$f_c = \dfrac{1}{2\sqrt{\mu\varepsilon}}\sqrt{\left(\dfrac{m}{a}\right)^2 + \left(\dfrac{n}{b}\right)^2}$	$f_c = \dfrac{1}{2\sqrt{\mu\varepsilon}}\sqrt{\left(\dfrac{m}{a}\right)^2 + \left(\dfrac{n}{b}\right)^2}$
$\lambda_c = \dfrac{2}{\sqrt{(m/a)^2 + (n/b)^2}}$	$\lambda_c = \dfrac{2}{\sqrt{(m/a)^2 + (n/b)^2}}$
$\lambda_g = \dfrac{\lambda}{\sqrt{1 - (\lambda/\lambda_c)^2}} = \dfrac{\lambda}{\sqrt{1 - (f_c/f)^2}}$	$\lambda_g = \dfrac{\lambda}{\sqrt{1 - (\lambda/\lambda_c)^2}} = \dfrac{\lambda}{\sqrt{1 - (f_c/f)^2}}$
$v_{pz} = \dfrac{1}{\sqrt{\mu\varepsilon}\sqrt{1 - (f_c/f)^2}} = \dfrac{1}{\sqrt{\mu\varepsilon}\sqrt{1 - (\lambda/\lambda_c)^2}}$	$v_{pz} = \dfrac{1}{\sqrt{\mu\varepsilon}\sqrt{1 - (f_c/f)^2}} = \dfrac{1}{\sqrt{\mu\varepsilon}\sqrt{1 - (\lambda/\lambda_c)^2}}$
$\eta_g = \dfrac{\sqrt{\mu/\varepsilon}}{\sqrt{1 - (f_c/f)^2}} = \dfrac{\sqrt{\mu/\varepsilon}}{\sqrt{1 - (\lambda/\lambda_c)^2}}$	$\eta_g = \sqrt{\dfrac{\mu}{\varepsilon}}\sqrt{1 - \left(\dfrac{f_c}{f}\right)^2} = \sqrt{\dfrac{\mu}{\varepsilon}}\sqrt{1 - \left(\dfrac{\lambda}{\lambda_c}\right)^2}$