科目：電磁學B(3008)　　校系所組：交通大學電子研究所(甲組、乙A組、乙B組)
清華大學光電工程研究所
陽明大學生物醫學工程學系（醫學電子組）

一、(10%) Consider a lossless transmission line of real characteristic impedance Z_0 and length l. As shown in Figure 1, the line is driven by a sinusoidal voltage source $v_s(t)=V_0\cos\omega t$ with an internal resistance of $R_s=2Z_0$, and terminated by a resister of resistance $R_L=3Z_0$.

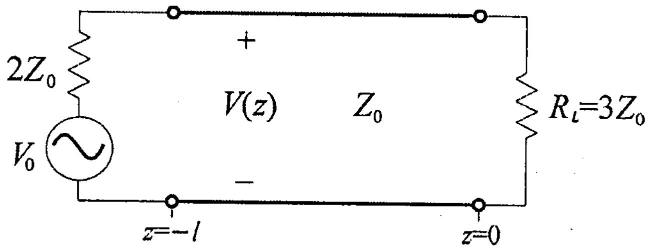

Figure 1.

The voltage phasor across the transmission line $(-l\le z\le 0)$ is written as:

$$V(z)=V^+e^{-j\beta z}+V^-e^{j\beta z},$$

where $\beta=\omega/v_p=2\pi/\lambda$ is the propagation constant, v_p is the phase velocity, and λ denotes the wavelength of the voltage wave. If the length of the line is $l=\lambda/3$, sketch the normalized magnitude of voltage phasor $|V(z)/V^+|$ for $-l\le z\le 0$. Denote the values of $|V(z)/V^+|$ at $z=0$, $-0.75l$, $-l$, respectively.

二、(13%) For a uniform plan wave impinging on a perfect conductor at $z=0$ (i.e. the x-y plane) at an angle θ, as shown in Figure 2, the incident electrical field can be expressed as

$$\mathbf{E}^i=E_0\left[\hat{\mathbf{y}}-j(\hat{\mathbf{x}}\cos\theta+\hat{\mathbf{z}}\sin\theta)\right]e^{-jk(\ldots)}$$

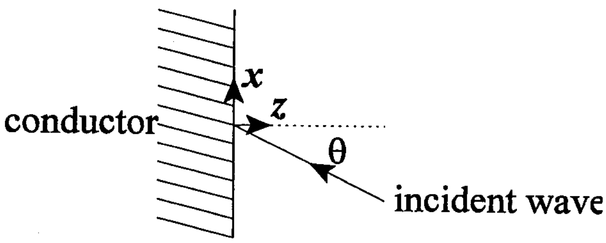

Figure 2.

(一)、Determine whether the incident wave is of perpendicular polarization, parallel polarization, left hand circular polarization, or right hand circular polarization?

(二)、How about the polarization of the reflected wave? Is it perpendicular polarization, parallel polarization, left hand circular polarization, or right hand circular polarization? Why?

注意：背面有試題

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(三)、Please write down the complete mathematical expression for the incident electrical field. i.e., what is in the bracket?

三、(15%) A lossy dielectric has an intrinsic impedance of $(50\sqrt{3}+j50)\Omega$ at a particular frequency. If the plane wave propagating through the dielectric has the magnetic field component as

$$\mathbf{H}=5e^{-\alpha x}\cos(\omega t-x)\hat{\mathbf{y}} \quad \text{(A/m)}$$

(一)、Find the electric field E. (6 points)

(二)、Determine the skin depth. (9 points)

四、(12%) Problem on waveguide

(一)、Is it possible for TE_0 mode to exist in a parallel waveguide? Please explain why in plain language. And how about for the TM_0 mode? What is the difference between TM_0 and TEM mode in this parallel plate?

(二)、For a square waveguide, please write down the fundamental modes (such as TE_{10}, TE_{11}, TE_{01}, TE_{11}, TM_{11}, TM_{21}…) that have the lowest cutoff frequency. (There could be just one such mode or many, and it is you who have to decide.)

(三)、Is it possible for the TM_{10} mode (not necessarily the fundamental mode) to exist in this square waveguide? Why?

五、(5%) Consider a rectangular waveguide for which $a=2b$ (a and b are the dimensions in the x- and y-directions, respectively). If the cutoff frequency for the TE_{20} mode is 10 GHz, what is the cutoff frequency for TM_{11} mode?

六、(5%) How many degenerate dominant modes exist in a cubic cavity resonator of equal sides (i.e., $a=b=c$, where a, b, and c are the dimensions in the x-, y-, and z-directions, respectively)?

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七、(10%) The index of refraction can be derived from the damped forced oscillator model.

(一)、Write down the mathematical expression for the damped forced oscillator. Explain the meaning of the corresponding terms. (5 points)

(二)、Use your equation, derive the oscillator phase lag when exactly on resonance. (5 points)

八、(10%) Consider the ABCD matrix:

(一)、Explain the physical meaning of each element within the matrix. (5 points)

(二)、Assume you have a simple imaging system, what will be the signature of its corresponding ABCD matrix? (5 points)

九、(15%) Assuming a round object in the vacuum is incident by light at 1 μm wavelength with an angle of $\theta = 60^\circ$ (Figure 3).

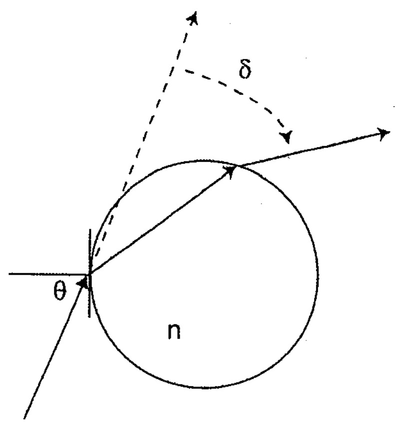

Figure 3. n is the refractive index of the round object.

(一)、If the deviation angle after the light passing through the object is $\delta = 60^\circ$, what is the refractive index of the object?

(二)、How long in time does the light travel inside the object if the radius is $R = \frac{300}{\sqrt{3}}$ meter?

(三)、Assuming the object has a normal dispersion at 1 μm wavelength. Will the time that the light travels inside the object become longer or shorter if the incident light has a lightly longer wavelength? Why?

注意：背面有試題

參考用

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十、(5%) Consider the setup of an interferometer as shown in Figure 4. The light from a point source with a frequency of 300 THz (3×10^{14} Hz) is collimated by a collimation lens and separated into two paths in the air ($n = 1$) by the beamsplitter. The lights in paths 1 and 2 are reflected back to the beamsplitter by mirrors 1 and 2 (M_1 and M_2) with the path lengths of L_1 and L_2, respectively, and overlapped on the screen below. If $L_1 = 10$ cm and $L_2 = L_1 + 5.25$ μm, what will be the phase difference of the lights from path 1 and path 2 on the screen?

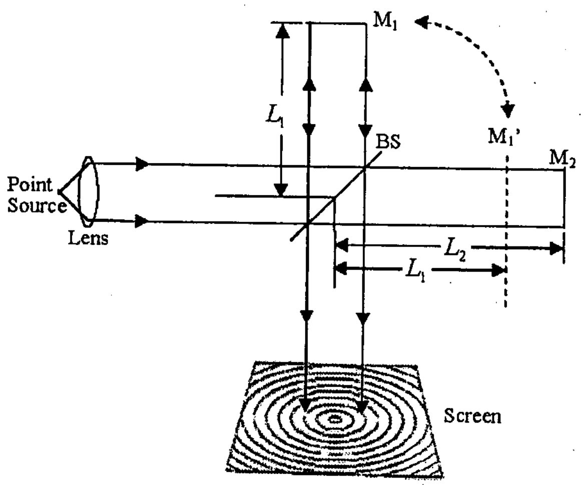

Figure 4. BS: beamsplitter. M_i: mirror (i=1,2).