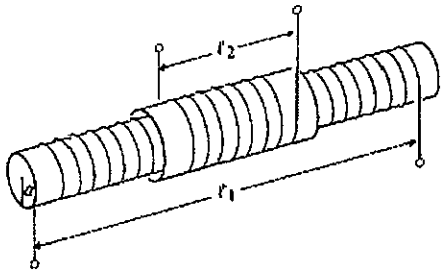
Electromagnetics 11 August 2010

1. **(15 pts)** Find the mutual inductance per length between two air coaxial solenoids of radius "a" with n_1 and n_2 turns/m, respectively.



2. (a) **(10 pts)** Solve Laplace's equation to find potential V as a function of angle ϕ. The boundary conditions are given as two infinite radial conducting planes, $V=50\,(V)$ *at* $\phi=0.1\,(rad)$, and $V=20\,(V)$ *at* $\phi=0.5\,(rad)$

(b) **(5 pts)** Find $\vec{E}$ when $\rho=10$, using the result of (a).

$$(\nabla^2 V=\frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho\frac{\partial V}{\partial\rho})+\frac{1}{\rho^2}\frac{\partial^2 V}{\partial\phi^2}+\frac{\partial^2 V}{\partial z^2},\ \nabla V=\hat{\rho}\frac{\partial V}{\partial\rho}+\hat{\phi}\frac{1}{\rho}\frac{\partial V}{\partial\phi}+\hat{z}\frac{\partial V}{\partial z})$$

3. **(10 pts)** Find the force on an electron moving in +x-direction at approximately the speed of light in the magnetic flux density $\vec{B}=-\hat{z}\,1(T)$.

4. **(10 pts)** $\vec{E}=\hat{x}\,6x^2+\hat{y}\,6y+\hat{z}\,4\,(V/m)$ in rectangular coordinates. If points M and N are specified by M(1,1,1) and N(2,2,2), find

(a) V_M if V=0 at Q(0,0,0),

(b) V_N if V=2 at P(-1,-1,-1).

5. **(10 pts)** A plane electromagnetic wave of 1.0 GHz propagates in an infinite medium. The medium is nonmagnetic and has a relative dielectric constant of 2.25 with a loss tangent of 0.1. Find the attenuation constant of the wave.

6. **(10 pts)** Consider a uniform transmission line having a characteristic impedance of Z_0 terminated by a load of Z_L. Derive the expression for reflection coefficient at the location of the load.

7. **(10 pts)** Define Brewster angle. In what situation does it exist at an interface of two nonmagnetic media?

8. **(10 pts)** An air-filled rectangular waveguide has dimensions a = 72.1 mm and b = 34.0 mm. Determine the cutoff frequency of the TE_{20} mode for the waveguide.

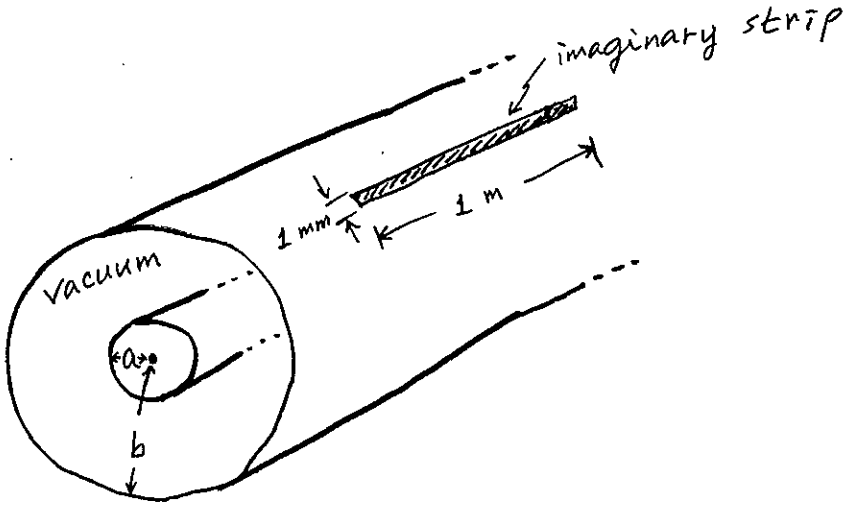
9. **(10 pts)** Two isotropic radiators are aligned along the z-axis with a separation distance d. The excitations in the two radiators are of equal amplitude and equal phase. Write the general expression for the far-zone electric field of this two-element array.

1. Suppose there is a coaxial line with the cross section shown below. The radius of the inner conductor is 10 mm, and the radius of the outer conductor is 30 mm. The space between the two conductors is filled with vacuum, and the conductors are assumed to be very thin. (30점)

   (a) Show a procedure to find the inductance of the coaxial line for a unit length in the longitudinal direction.

   (b) Imagine a narrow strip on the outer conductor. The arc of the strip is 1 mm wide, and the length of the strip in the longitudinal direction is 1 m long. If a DC current of 10 A flows in the coaxial line, find the direction and the magnitude of the force exerted on the narrow strip.

   (c) Assume that the material of the outer conductor is flexible, i.e., its radius can be increased or decreased easily. Suggest an application of the force.



$a = 10\ mm$

$b = 30\ mm$

2. (30점)

(a) We have a slab of Teflon ($\epsilon = 2.1\,\epsilon_0$) in the region $0 \le x \le a$, and assume free space elsewhere. Outside Teflon, there is a uniform field of $\overrightarrow{E_1} = \hat{x}E_0$ (V/m). Using the boundary conditions for two perfect dielectric materials, find $\overrightarrow{D}, \overrightarrow{E}, \text{and } \overrightarrow{P}(polarization)$ in the slab.

(b) A perfectly conducting plane (V=0) is located in free space at x=0, and an infinite uniform line charge of $\rho_L = 10\ (nC/m)$ lies along the line x=2,y=1. Use the method of images to find potential at point P(4,-1,0). $(\epsilon_0 = \frac{1}{36\pi}10^{-9})$

3. (40점)

(3-1) Impedance 측정만으로 주어진 전송선로(transmission line)의 characteristic impedance (Zo) 및 complex propagation constant (Γ)를 측정하는 방법과 이론적 배경을 설명하라.

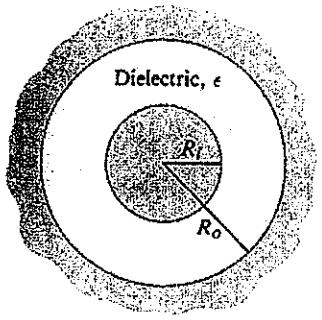
(3-2) 도체의 sheet resistance (Zs)에 대해 설명하고 어떤 주파수에서 특정한 sheet resistance값을 갖는 도체로 만들어진 coaxial cable의 단위 길이 당 resistance 값을 구하라. (Coaxial cable 의 내부 반경 및 외부 반경은 각각 a 및 b로 가정할 것)

(3-3) N개의 element가 선형으로 배열된 Binomial arrays (broadside 및 endfire arrays)의 array factor (AF)에 관해 설명하라.

(3-4) 평면파가 plane dielectric boundary에 입사하는 경우에 있어서 Brewster Angle (Θ_B) 및 Critical Angle (Θ_C)에 대해 설명하라

전자기학 (Nov. 14 , 2008)

1. (30점) For the following spherical capacitor,



(a) solve the Laplace's equation to find $V(r)$, when the boundary conditions are ; $V(R_0)=0$, and $V(R_i)=V_0$.

(b) Find the surface charge densities $\rho_s(R_i)$ and $\rho_s(R_0)$.

(c) Find the capacitance.

(Use $\nabla^2 V = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2\frac{\partial V}{\partial r}) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\frac{\partial V}{\partial\theta}) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2 V}{\partial\phi^2}$,

$\nabla V = \hat{r}\frac{\partial V}{\partial r} + \hat{\theta}\frac{1}{r}\frac{\partial V}{\partial\theta} + \hat{\phi}\frac{1}{r\sin\theta}\frac{\partial V}{\partial\phi}$)

2. (30점)

A standard rectangular waveguide for L-band has inside dimensions 165.1 mm x 82.55 mm, and is filled with vacuum. In the waveguide a microwave of 2.5 GHz propagates in the TE20 mode.

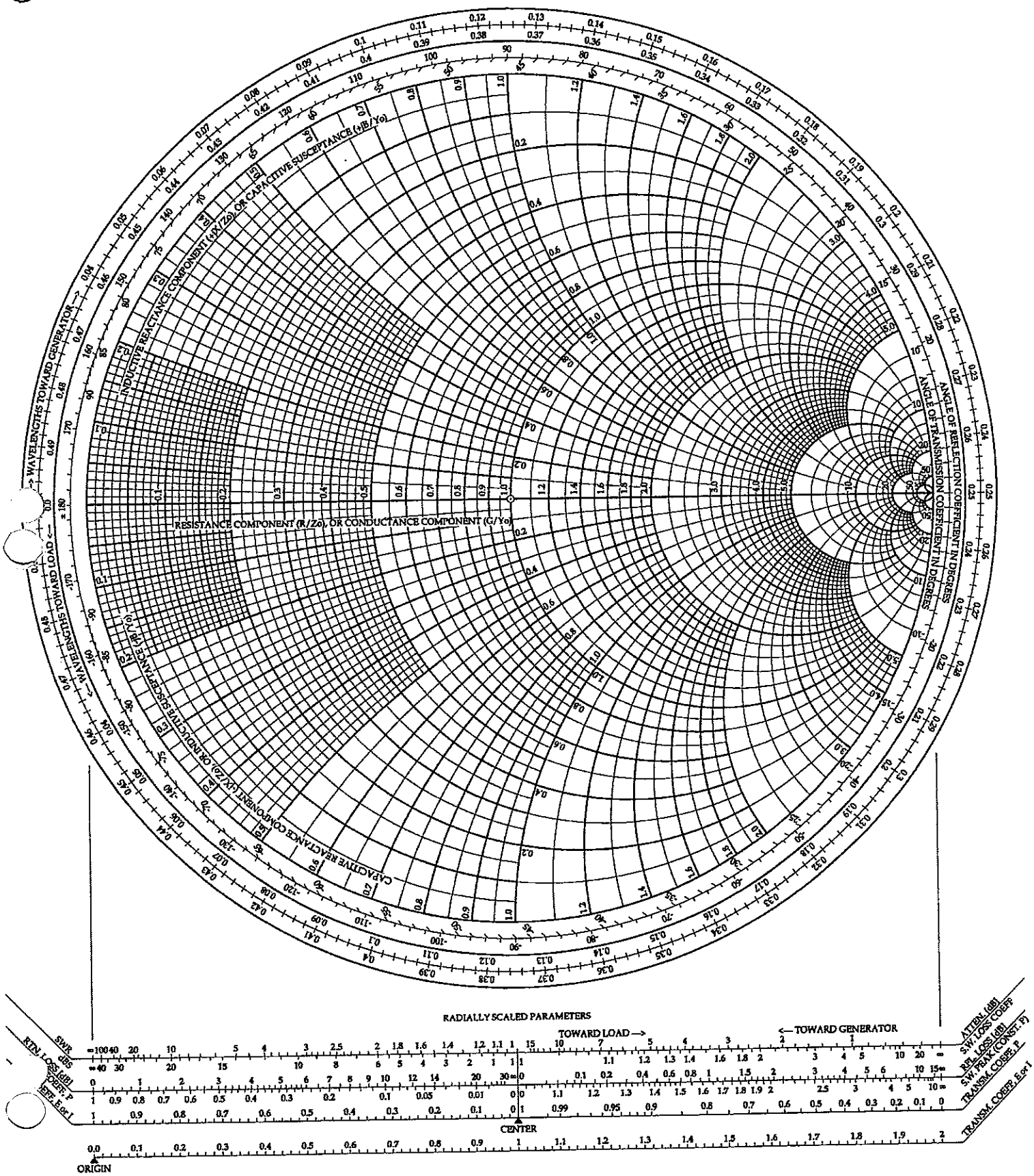
a) Find the cutoff frequency for the TE20 mode.

b) At a certain instant of time sketch the surface current line map on the inside bottom surface for one guide wavelength in the longitudinal direction.

c) Locate the points on a transverse plane of the waveguide where the electric field intensity is the largest. The end.

The Complete Smith Chart

Black Magic Design

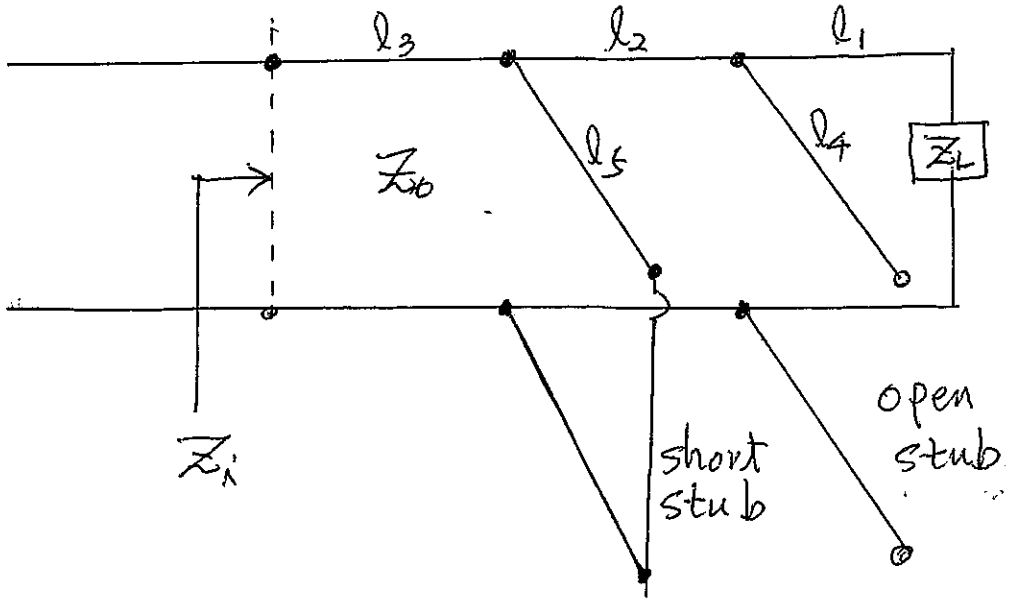


3 (a) (10점) What is meant by a "distortionless transmission line"? What relation must the distributed parameters of a transmission line satisfy in order for the line to be distortionless?

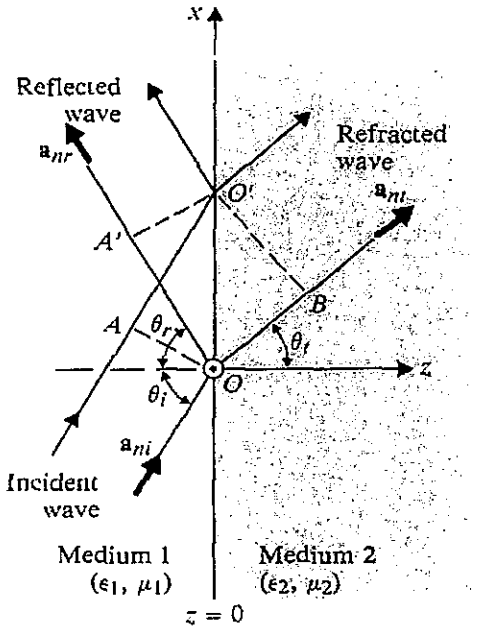
(b)(10점) Explain how the value of characteristic impedance Z_o, and propagation constant γ of a transmission line can be determined by measurement.

(c)(20점) Use the Smith chart to find the input impedance Z_i of the a transmission line, as shown below.

(Assume that $Z_o=300\Omega$, $Z_L=(100+j100)\Omega$, $l_1=2.5\,Cm$, $l_2=2.5\,Cm$, $l_3=2.5\,Cm$, $l_4=5.0\,Cm$, $l_5=2.5\,Cm$, $f=3\,GHz$)



1. (20 pts) For a uniform plane wave incident obliquely on a plane dielectric boundary as shown,
(a) write down Snell's law of reflection.
(b) Write down Snell's law of refraction, for nonmagnetic media, $\mu_1 = \mu_2 = \mu_0$.
(c) Explain when total reflection occurs.
(d) What happens if medium 1 is air, and medium 2 is a metamaterial whose index of refraction, $n_2 < 0$?



2. (10 pts) The U.S. Standard for personal safety in a microwave environment is that the average power density in air be less than 10 (mW/cm^2). Calculate the corresponding standard in terms of the magnitudes of E and H.

3. A rectangular waveguide is arranged such that the longitudinal direction is the z-axis and the transverse plane lies on the x-y plane. The dimensions of the guide are a in the x-axis and b in the y-axis, where a is greater than b. An electromagnetic wave propagates along the rectangular waveguide and the operating frequency is chosen so that there exists only the dominant mode.
a) Sketch the electric field line on the transverse plane.
b) Sketch the magnetic field line on the x-z plane.

4. Two isotropic radiators are separated by a half wavelength, and the amplitudes and phases of the currents of the two radiators are identical each other. Plot the normalized radiation pattern on the plane containing the array axis.

5. Assuming the earth to be a large conducting sphere (radius = 6370 *km*) surrounded by air, find

a) the capacitance of the earth;

b) the maximum charge that can exist on the earth before the air breaks down. (Note that the dielectric strength of the air is 3×10^6 V/m.)

6. Write the boundary conditions that the field vector *E, D, B* and *H* must satisfy at the interfaces between two regions of different constitutive parameters.

(문제 1) (a) A 10 *GHz* signal is to be transmitted inside a hollow circular conducting pipe. Determine the inside diameter of the pipe such that its lowest cutoff frequency is 20% below this signal frequency. (b) If the pipe is to operate at 15 *GHz*, what waveguide modes can propagate in the pipe?

(참조)

Zeros of $J_n(x)$, x_{np}

p \ n	n=0	n=1	n=2
P=1	2.405	3.832	5.136
P=2	5.520	7.016	8.417

Zeros of $J_n'(x)$, x'_{np}

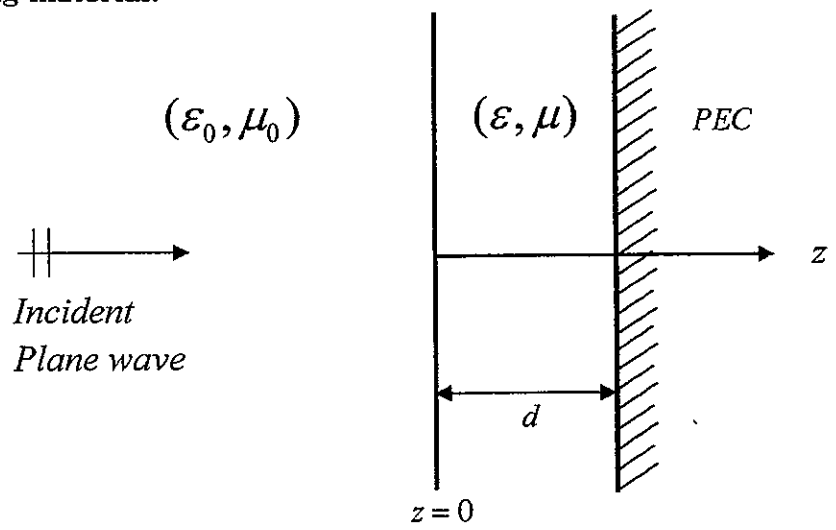
p \ n	n=0	n=1	n=2
P=1	3.832	1.841	3.054
P=2	7.016	5.331	6.706

(문제 2) As shown in the figure below, a uniform plane wave with

$$\bar{E}^i = \hat{x}\, E_0\, e^{-jk_0 z}$$

is incident normally onto an infinite conducting plane coated with a RAM (Radar Absorbing Material) whose permittivity and permeability are ε and μ respectively.

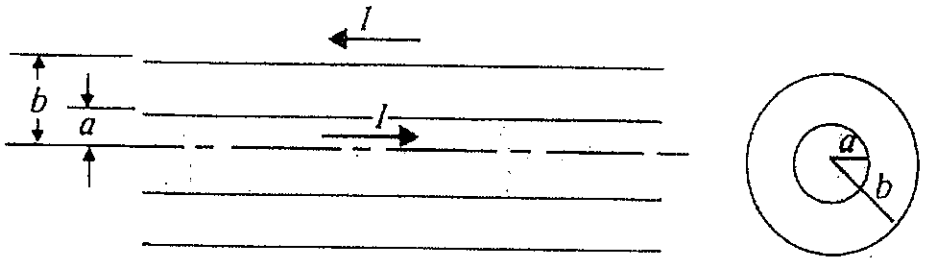
Find the reflection coefficient (Γ_b) at the boundary between air and absorbing material.



(문제 3) (a) Define the magnetization vector $\overline{M}$ of magnetic materials. State its relationship with the equivalent volume current density. Explain how it is used to define the relative permeability.

(b) Define the polarization vector $\overline{P}$ of dielectric materials. State its relationship with the equivalent volume charge density. Explain how it is used to define the relative permittivity.

(문제 4) By using the relationship between the inductance and the stored magnetic energy, determine the inductance per unit length of an air coaxial transmission line ($\mu = \mu_0$).



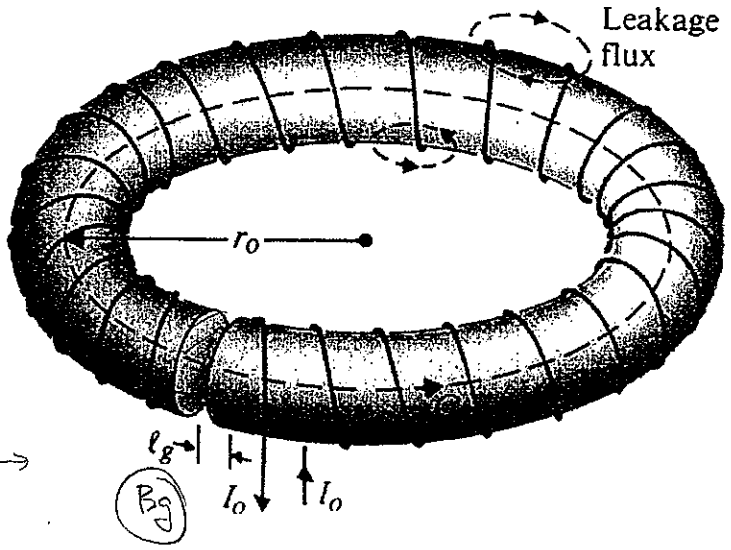
전기자기학

2005.10.26

1. (25 점) (a) Find the input impedance of a quarter-wave long, 50-ohm, lossless transmission line terminated in a load impedance Z_L .

(b) Repeat for a half-wave section.

2. (25 점) Assume that N turns of wire are wound around a toroidal core of a ferromagnetic material with permeability (μ). The core has a mean radius (r_0) and a narrow air gap of length (l_g) as shown. Neglect the leakage flux. Find the current (I_0) to be applied to have magnetic flux density (B_g) (W_b/m^2) in the air gap.



3. (25 점) Constitutive parameters (ϵ, μ, σ) 가 서로 다른 2개의 매질의 경계면에서 $\vec{D}$ 및 $\vec{B}$ 의 normal components 와 $\vec{E}$ 및 $\vec{H}$ 의 tangential components가 만족해야 하는 경계조건 (boundary conditions)을 Maxwell 방정식으로부터 유도하라.

4. (25 점) 다음의 용어를 간단히 설명하라.

(a) Lorentz condition

(b) Plasma frequency

(c) Snell's law of reflection and refraction

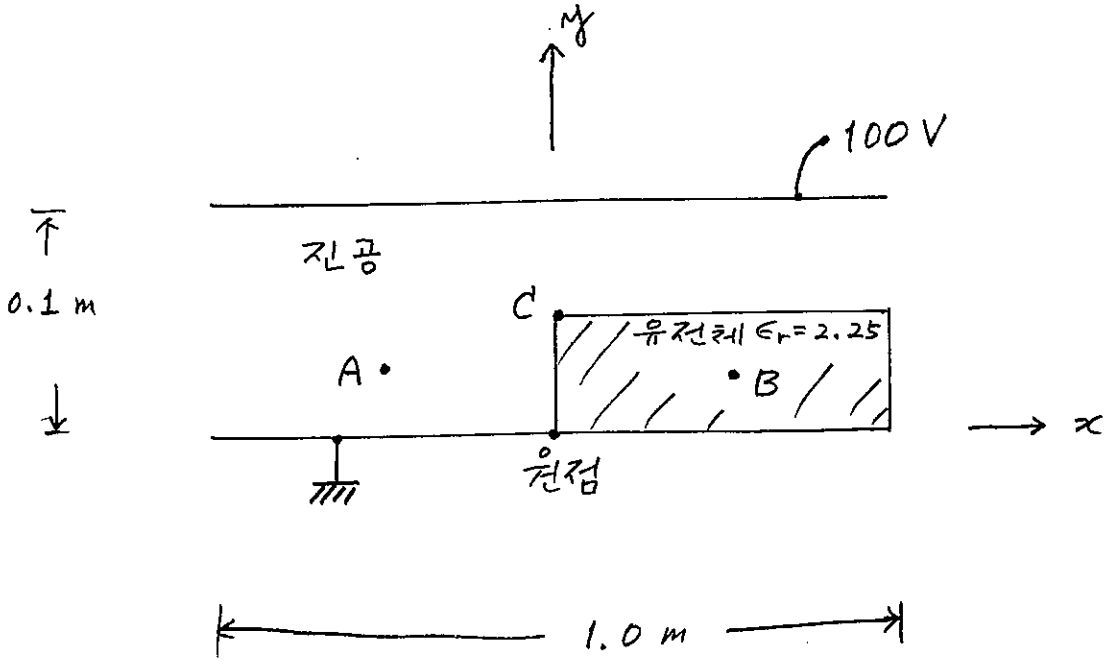
(d) Brewster angle

2004. 11. 3

전자기학 문제.

(50점) 1. 한 변의 길이가 1 미터인 정사각형 평면 도체 2 개가 0.1 미터 떨어져 있어 그림과 같이 하나의 capacitor를 이루고 있다. 아래에 있는 도체는 접지되어 있고 위에 있는 도체에는 100 V 의 DC 전압이 걸려있다. 두 도체 간의 공간 전체의 4 분의 1 인 우측 하반부는 비유전율 2.25 인 물질로 채워져 있고 나머지 공간은 진공이다. Cartesian coordinate system에서 아래 도체의 중앙은 좌표 원점과 일치하며, 점 A 의 좌표 (x, y, z) 는 (-0.25, 0.025, 0) 이고, 점 B의 좌표는 (0.25, 0.025, 0) 이며, 점 C는 유전체와 진공 간의 경계점으로서 이의 좌표는 (0, 0.05, 0)이다.

1) 이 capacitor 의 capacitance 를 구하라.
2) 점 A 에서의 electric field intensity vector 의 크기와 방향을 구하라.
3) 점 B 에서 electric flux density vector의 크기를 구하라.
4) 점 B 에서 electric potential 을 구하라.
5) 경계 조건을 고려하여 점 C 부근에서의 electric field line을 확대하여 x-y 평면에서 도시하라.



전기자기학 (계속)

2. (20점) A sinusoidal electric field intensity of amplitude 100 (V/m) and frequency 1 (GHz) exists in a lossy dielectric medium with a relative permittivity of 2 and a loss tangent of 0.001. Find the average power dissipated in the medium per cubic meter. ($\epsilon_0 = 10^{-9}/36\pi$)

3. (20 점) A dielectric rod of a transparent material is used to guide light under the condition of total internal reflection. Determine the dielectric constant of the rod so that a wave incident on one end at any angle will be confined in the rod.

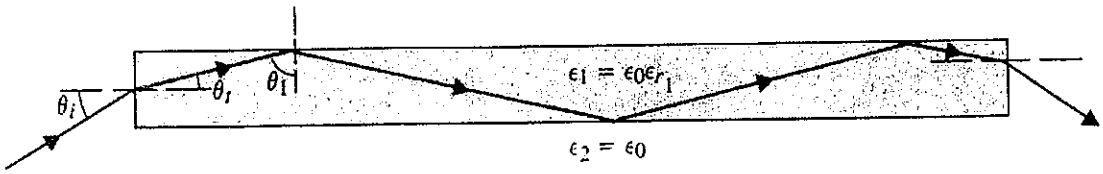
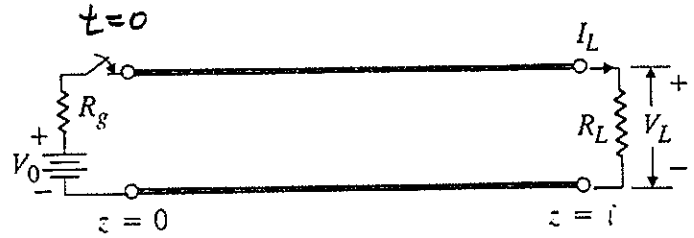


FIGURE 8-19
Dielectric rod or fiber guiding electromagnetic wave by total internal reflection.

4. (10점) A dc source is applied to a terminated lossless line ($\epsilon_r = 4$) at t=0. Assuming that the characteristic impedance of the line is R_0, and $R_g = R_L = R_0$, sketch V_L as a function of time.

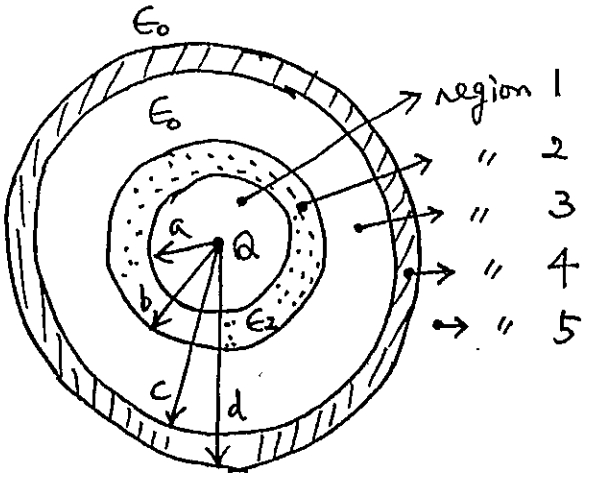


전기자기학

2003.11.5

문제 1 (40점)

1 - 1. (20점) A concentric spherical dielectric shell, enclosed by a conducting shell is shown below (regions 1, 3, 5 = air, region 2 = dielectric, region 4 = conductor).
If charge Q is placed at the center, find



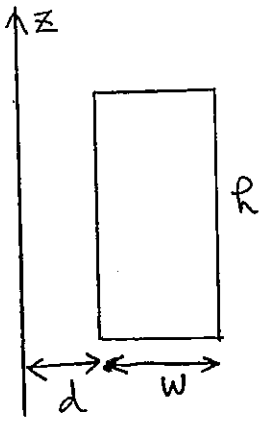
a) $\overline{D}$, $\overline{E}$, $\overline{P}$ in all regions.

b) potential V in region 1.

c) surface charge densities ρ_s on conductor surfaces, and ρ_{ps} on dielectric surfaces.

1 - 2. (10점) Explain Hall effect and explain where it is used.

1 - 3. (10점) Find the mutual inductance between a very long straight wire and a conducting rectangular loop as shown below.



문제 2. (30점)

A y-polarized uniform plane wave ($\mathbf{E}_i$, $\mathbf{H}_i$) with a frequency 100 (MHz) propagates in air in the $+x$ direction and impinges normally on a perfectly conducting plane at $x = 0$. Assuming the amplitude of $\mathbf{E}_i$ to be 6 (mV/m), write the phasor and instantaneous expressions for (a) $\mathbf{E}_i$ and $\mathbf{H}_i$ of the incident wave; (b) $\mathbf{E}_r$ and $\mathbf{H}_r$ of the reflected wave; and (c) $\mathbf{E}_1$ and $\mathbf{H}_1$ of the total wave in air. (d) Determine the location nearest to the conducting plane where E_1 is zero.

문제 3 (30점)

3-1. 어떤 도파관에서 dominant mode란 어떤 mode를 지칭하는가?

3-2. 어떤 도파관에서 evanescent mode는 어떤 상황에서 발생하는가?

3-3. 어떤 도파관에서 dispersion이 생기는 원인 2 가지를 열거하고 설명하라.

3-4. 어떤 동일한 전류를 가진 isotropic radiator 2 개가 z-축 상에 2 분의 1 파장 만큼의 거리를 두고 떨어져 있는 경우, 이 array의 array factor 를 구하라.

3-5. Half-wave dipole의 radiation resistance는 얼마이며, 이를 구하는 요령을 기술하라.

전기자기학 2002.10.30

1. Show that each of the following linearly polarized waves can be resolved into a right-hand circularly polarized wave and a left-hand circularly polarized wave of equal amplitude (a_x and a_y are the unit vectors).

(a) $E(z) = 10\,e^{-jkz}\,a_x$

(b) $E(z) = 8\,e^{-jkz}\,a_y$

2. A lossless coaxial transmission line at 180 MHz has the inductance per unit length of 1 (μH/m). If the insulator has $\epsilon_r = 6.25$, and $\mu_r = 1$, find the following.

(a) The velocity of wave propagation, u_p.

(b) The phase constant β.

(c) The capacitance per unit length, C.

3. The open-circuit and short-circuit impedances measured at the input terminals of a lossless transmission line are -j54.6 and j103 (Ω), respectively.

(a) Find Z_0 of the line.

(b) How long should the short-circuited line be in order for it to appear as an open circuit at the input terminals? Assume that the propagation constant $\gamma = j\beta = j0.628$.

4. Determine the capacitance per unit length between two long, parallel, circular conducting wires of radius a. The axis of the wires are separated by a distance D.

5. 내부 도체의 외부 직경이 3 mm이고 외부 도체의 내부 직경이 8 mm이며 진공으로 찬 동축케이블에 850 MHz의 전자파가 진행하고 있다.

1. 이 동축케이블의 특성 임피던스는 얼마인가?
2. 이 동축케이블 내부 공간에서 전계와 자계 선을 sketch하라.
3. 이 동축케이블의 내부에서의 파장은 얼마인가?
4. 이 동축케이블을 절단하고 내부 도체를 외부 도체보다 약 80 mm 나오도록 외부 도체를 잘라내어 monopole 안테나를 만들었다. 이 때 이 안테나로부터의 반사 계수의 크기의 근사 값을 구하라.

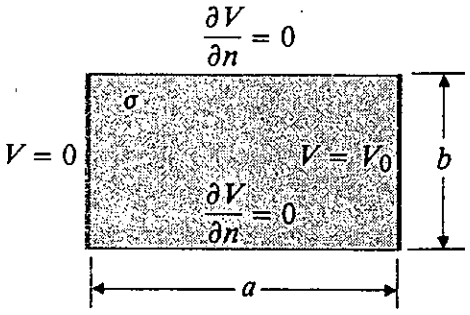
전기자기학 2001.10.31

1. A 12.5 MHz signal generator having an internal resistance 50 (ohm) and an open circuit voltage of 300 (V) is connected to a 50 (ohm) lossless transmission line. The line is 4 (m) long, and the velocity of wave propagation on the line is $2 \cdot 10^8 (m/s)$. For a load impedance of 100 (ohm), find the following.

a) (5점) The phase constant β.
b) (5점) The input impedance Z_i .
c) (5점) The input ($z=0$) current and voltage, I_i and V_i .
d) (10점) The load current ($z=4$).
e) (5점) The instantaneous expression for the load current.
f) (5점) The average power delivered to the load. Does this value satisfy the conservation of power law for a lossless line?

2. Assume a rectangular conducting sheet of conductivity σ, width a, and height b. A potential difference V_0 is applied to the side edges, as shown below. Find

a) the potential distribution,
b) the current density everywhere within the sheet. (*Hint:* Solve Laplace's equation in Cartesian coordinates subject to appropriate boundary conditions.)



A conducting sheet

문제 3 (총 35 점)

직경이 20 마이크로미터(μm)인 아주 작은 구리로 된 공(copper sphere)이 진공 속에 놓여 있다. 이 공에 주파수가 2.45 GHz이고 phasor 전계의 크기가 1000 V/m이며 임의의 한 방향으로 진행하는 평면파가 쪼이고 있다. 구리는 비자성 물질이고, 이의 conductivity σ 는 5.80 x 10**7 S/m이다. 이의 skin depth는 $1/\sqrt{\pi f \mu \sigma}$ 로 주어 지며, 여기서 f 는 주파수이고, μ 는 투자율로서 그 값은 4π x 10**(-7) H/m 이다.

가) 이 구리의 skin depth는 얼마인가?(5 점)

나) 이 구리 공 내부의 전계를 sketch하라.(10 점)

다) 이 구리 공이 소모하는 power 를 근사적으로 구하라.(10 점)

라) 만일 이 구리 공의 직경이 1000 분의 1로 줄어 20 나노미터(nm)인 경우, 이것이 소모하는 power 를 근사적으로 구하라.(10 점)

전기자기학 2000.10.27

1. Suppose the field vectors in free space are given by,

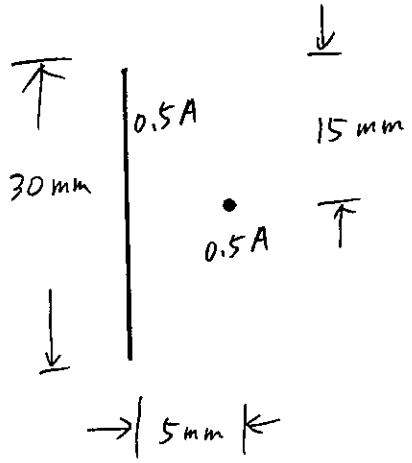
$$\overline{E} = \hat{z}\, 100\cos\left(\omega t + \frac{4\pi}{3} x\right)$$

$$\overline{H} = \hat{y}\, \frac{100}{120\pi} \cos\left(\omega t + \frac{4\pi}{3} x\right)$$

,where f=200 MHz.

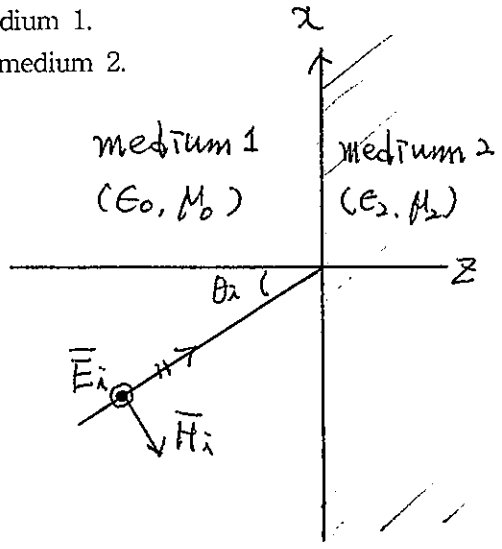
(a) (5점) Express these vectors in phasor form.
(b) (10점) Show that these field vectors satisfy Ampere's Law for free space (J=0). Use $\varepsilon_0 = 10^{-9}/(36\pi)$.
(c) (5점) Find the direction of power flow.
(d) (10점) Find the average power crossing the surface area bounded by y=2m, y=0 m, z=2m, z=0 m.

2-. The cross section of a long thin metal strip and a parallel wire is shown. Equal and opposite currents of 0.5 Amperes flow in the conductors. The strip is 30 mm wide and is at a distance of 5 mm from the wire. Determine the force per unit length on the parallel wire.



3. A uniform plane wave ($\bar{E}_i$, $\bar{H}_i$) of an angular frequency ω is incident from air (medium 1) on a very large plane dielectric medium (medium 2) at an angle of incidence θ_i with perpendicular polarization as shown in figure below.

(a) Find the expressions for the reflected fields ($\bar{E}r$, $\bar{H}r$) in medium 1.
(b) Find the expressions for the transmitted fields (Et, Ht) in medium 2.
(c) Find the Brewster angle(θ_B)
(d) Find the time-average Poynting vector in medium 1.



전기자기학

1999. 10. 27.

[1] 가) 단위 길이 당 line charge density $-\rho_\ell$ 과 ρ_ℓ 을 가지는 한 쌍의 무한히 긴 line charge 가 z-axis 와 평행하게 진공 속에 놓여 있으며, 각각 xy-plane 상에서 (-d, 0) 과 (d, 0) 을 통과하고 있다. 이 경우 xy-plane 상에서 임의의 electric potential V_0 를 갖는 equipotential line 의 방정식을 구하라.

나) 상기의 결과를 원용하여 진공 속에 있는 어떤 무한히 길고 동일한 단면을 가진 한 쌍의 parallel conducting wire 사이의 단위 길이 당 capacitance 를 구하라. 이 wire 의 단면은 원형이고 반경은 1.0 mm 이며, 이 wire 들의 중심 간의 거리는 5.0 mm 이다. -끝-

[2] 1. (15점) A microwave oven works at 2.45 GHz. For a beef steak that has a relative dielectric constant of 40 and a loss tangent of 0.35 at this frequency,

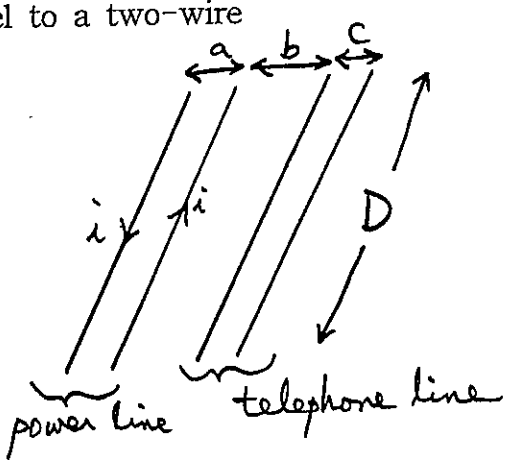
(a) find the effective conductivity of the medium.

(b) Calculate the average power dissipated in the steak per cubic meter, when a sinusoidal E-field of amplitude 250 (V/m) exists in the beef.

(c) If you think that the above results are only a rough estimate, explain the reason.

($\varepsilon_0 = 10^{-9}/(36\pi)$)

2. (15점) A two-wire telephone line runs parallel to a two-wire power line for a distance of D. Find the magnitude of the induced 60 Hz noise voltage in the phone line when the power line carries an 60 Hz AC current of amplitude I_0.



[3] If a dipole with length L is relatively short, the current distribution on the dipole can be approximated by the triangular distribution of the form

$$I(Z') = \frac{2Im}{L}\left(\frac{L}{2} - |Z'|\right), \qquad -\frac{L}{2} \le Z' \le \frac{L}{2}$$

(1) Find the far-zone electric field due to the dipole

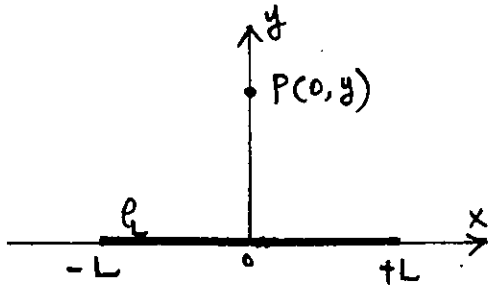
(2) Find the radiation resistance of the dipole

20점.(1) A finite line charge of length 2L carrying uniform line charge density ρ_L is coincident with x-axis.

a) Determine V at point P(0, y).

b) Determine $\overline{E}$ at point P(0, y).

(hint): $\int \frac{dx}{\sqrt{x^2+a^2}} = \ln(x+\sqrt{x^2+a^2})$



20점 (2) Explain polarization vector $\overline{P}$ of dielectric materials, and the magnetization vector $\overline{M}$ of magnetic materials. Also explain how they are used to define the relative permittivity and the relative permeability.

30점 (3) The general form of uniform plane wave can be expressed as $\overline{E} = \hat{a} E_0 e^{-j\overline{k}\cdot\overline{r}}$, where $\overline{k} = \hat{x}k_x + \hat{y}k_y + \hat{z}k_z$ and $\overline{r} = \hat{x}x + \hat{y}y + \hat{z}z$.

Show that both $\overline{E}$ and $\overline{H}$ are transverse to $\overline{k}$ in a sourse free region.

30점. (4) 진공으로 채워져 있고 가로 a, 세로 b의 내부 규격을 가진 구형(rectangular) 도파관 내에 존재하는 어떤 전자파의 phasor 자계 및 전계 성분이 다음과 같이 주어진 경우,

$$H_z = A\cos\left(\frac{2\pi}{a}x\right)e^{-j\beta z}$$

$$E_y = \frac{-j\omega\mu a}{2\pi}A\sin\left(\frac{2\pi}{a}x\right)e^{-j\beta z}$$

$$H_x = \frac{-j\omega\beta a}{2\pi}A\sin\left(\frac{2\pi}{a}x\right)e^{-j\beta z}$$

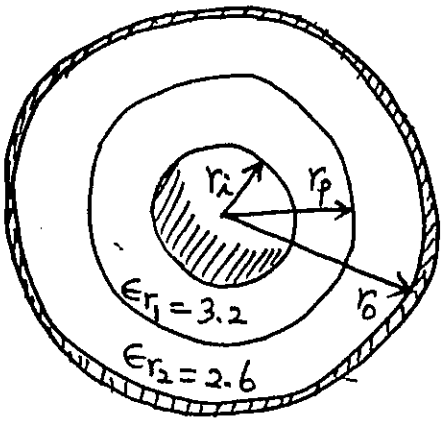
$$H_y = E_x = E_z = 0$$

A=임의의 상수

1. 이 전자파의 mode는 무엇인가 ?
2. 이 mode의 dispersion relation (ω 와 β 와의 관계)을 구하라.
3. 주파수가 4.8 GHz, a가 47.55 mm, b가 22.15 mm 일 때, guide wavelength를 구하라.
4. 이 mode를 coaxial line으로 만들어진 monopole로써 excite하고자 할 때, 그 구조를 sketch 하라.

전자기학 / 초고주파공학 (4문제 중 택3)

문 1. A coaxial cable is being designed to work at a voltage rating of 20 kV. Assume that the radius of the inner conductor is 4 mm, and that concentric layers of rubber (ε_{r1} = 3.2, and dielectric strength = 25 x 10^6 V/m) and polystyrene (ε_{r2} = 2.6, and dielectric strength = 20 x 10^6 V/m) are used as insulating materials. The maximum electric field intensities in the dielectrics are not to exceed 25 % of their dielectric strengths.



$r_i = 4\,mm.$

a) Find r_p and r_o .

b) Find the characteristic impedance of the cable, assuming that the dielectrics are lossless and nonmagnetic, such that the inductance per unit length is given by $L = \mu_o \ln (r_o / r_i) / 2\pi$, (H/m).

c) What other factors are considered when deciding the dimension of the inner concuctor?

문 2. A uniform plane wave ($\mathbf{E}_i$, $\mathbf{H}_i$) of an angular frequency ω is incident from air on a very large, perfectly conducting wall at an angle of incidence θ_i with perpendicular polarization. Find (a) the current induced on the wall surface, and (b) the time-average Poynting vector in medium 1.

3. 그림과 같이 무한히 넓은 grounded dielectric slab waveguide 에 y 방향으로 변화가 없는 TM 기본 모드의 마이크로파가 z 방향으로 전파하고 있을 때

a) 이 파의 z 방향 전계 성분의 크기를 $0 < x < \infty$ 인 영역에서 sketch 하라.

b) 이 TM 기본 모드의 cutoff 주파수는 얼마인가 ?

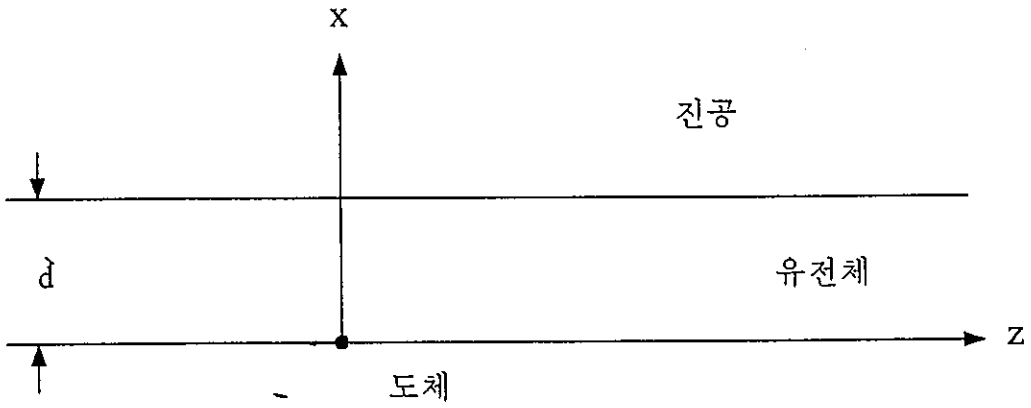
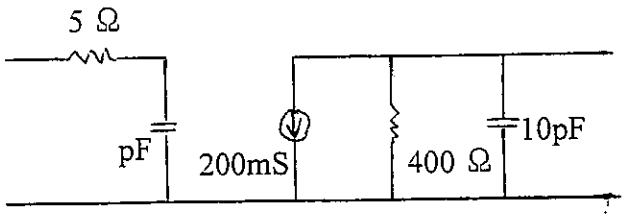


그림. **Grounded dielectric slab waveguide**

문4 • FET 의 등가회로 (at 1 GHz)



1) FET 의 S-parameter 를 구하시오.

2) Maximum Available Gain 은 얼마입니까 ?

전자기 및 초고주파 공학

1. In a rectangular waveguide for which a= 1.5 cm, b= 0.8 cm, $\sigma = 0$, (15점) $\mu = \mu_0$, $\epsilon = 4\epsilon_0$,

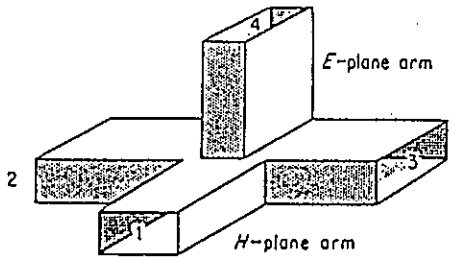
$$H_x = 2 \sin\left(\frac{\pi x}{a}\right) \cos\left(\frac{3\pi y}{b}\right) \sin\left(\pi \cdot 10^{11} t - \beta z\right) \text{ A/m}$$

Determine: a) the mode of operation
b) the cutoff frequency
c) the phase constant β
d) the propagation constant γ
and e) explain why the "b" in a normal waveguide is chosen as approximately " a/2".

2. Design a quarter-wave matching transformer to match a 40 Ohm load to (15점) a 75 Ohm line. Find the SWR's for f= $0.5f_0$, f_0, and $2f_0$, where f_0 is the frequency at which the line is $\lambda/4$ long.

문제 3 (30점)

a) 아래 그림의 magic T는 lossless하고 port 1과 port 4는 matched되어 있다. 이 magic T의 scattering matrix가 아래와 같이 주어짐을 유도하라.



$$[S] = \frac{1}{\sqrt{2}} \begin{bmatrix} 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & 1 \\ 1 & 0 & 0 & -1 \\ 0 & 1 & -1 & 0 \end{bmatrix}$$

b) 상기와 같은 magic T를 이용한 microwave 회로의 예를 하나들고 설명하라.

(문제 4, 5중 택일) 40점

4. Let a Green's function G(x, x′) satisfy the differential equation

$$\left[\frac{d^2}{dx^2} + k^2\right] G(x, x') = \delta(x - x') \quad 0 < x < b$$

and satisfy the boundary conditions

$$G'(0, x') = 0, \qquad G'(b, x') = 0.$$

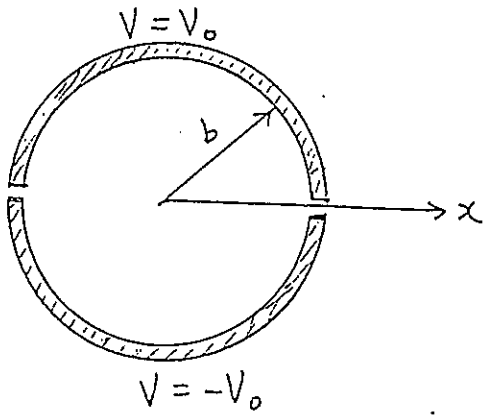
a) Find G(x, x′) in a closed form.

b) Find G(x, x′) in a eigenfunction series form.

5. A cross section of the split circular tube with infinite length is shown below. The boundary conditions are given as

$$V(b, \phi) = \begin{cases} V_0 & \text{for } 0 < \phi < \pi \\ -V_0 & \text{for } \pi < \phi < 2\pi \end{cases}$$

Determine $V(r, \phi)$ inside and outside the tube separately.



< 전기 자기학 >

1. Two parallel conducting plates infinite in y, z directions are located at X=-d and X=+d.

The space between them is filled with a dielectric medium and a space-dependent permittivity.

$$\epsilon = \frac{4\epsilon_0}{\left(\frac{x}{d}\right)^2 + 1}$$

The plate at X=+d is held at time-independent potential difference Vo with respect to the plate at X=-d.

a) Find the electric field and the potential distribution between the plates.

b) Find the polarization $\bar{P}$ and the polarization charge density ρ_p.

c) Find the capacitance per unit area.

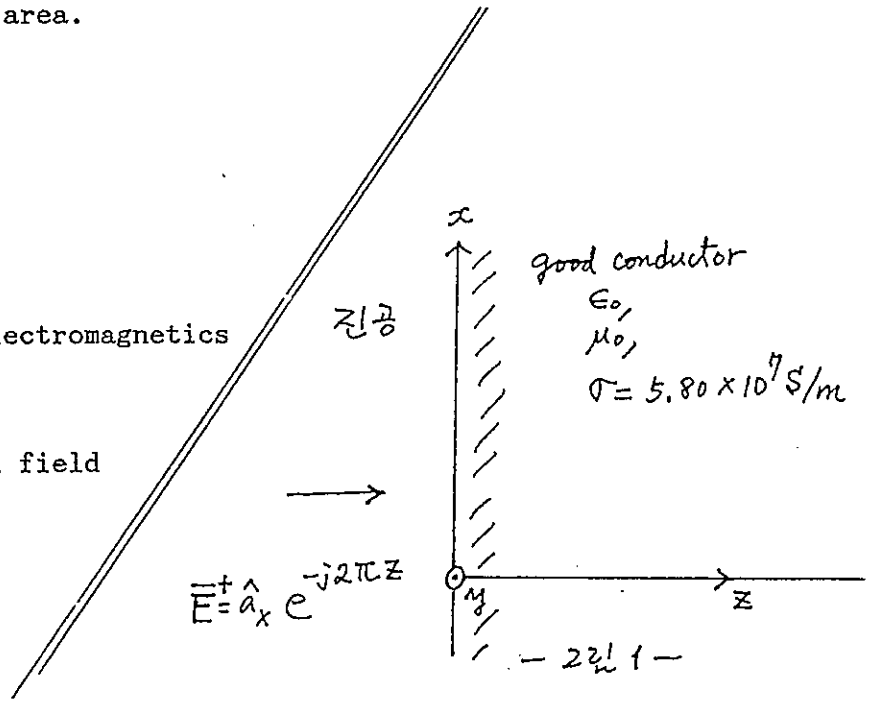
2. Explain the following terms in electromagnetics

a) Dispersive medium

b) Solenoidal field, irrotational field

c) Conservative field

d) Dielectric strength



— 그림 1 —

3. 그림 1에서 $z>0$의 공간은 어떤 good conductor로 채워져 있고 $z<0$ 공간은 진공이다. 이 conductor의 유전율과 투자율은 진공의 그것들과 같으며 전도도 σ는 그림에 표시된 바와 같다. 진공부분으로부터 phasor 전계가 그림과 같이 표시되는 uniform plane wave가 +z방향으로 입사할 때

a) 반사파의 phasor 전계 b) 투과파의 phasor 전계,

전기자기학

1. Consider a 300-ohm FM receiver (at 100 MHz), connected to a 300-ohm antenna through a 2-meter long, lossless 300-ohm antenna cable. Assuming that the peak voltage of 0.6 mV is induced at the antenna terminal,

   (a) find the input current at the antenna terminal, and
   (b) find the propagation constant of the 100 MHz wave inside the cable with $\epsilon_r = 1.44$,
   (c) find the power delivered to the receiver.
   (d) If two same receivers are connected to the single antenna, what will be the power delivered to each antenna?
   (e) Verify your calculation in (d), by comparing with the result of (c) and the reflected power.

2. 구좌표에서 $0 < r < a$ 와 $b < r < \infty$ 의 영역은 진공이며, $a < r < b$ 의 영역은 도체이다. 원점인 $r = 0$ 에 Q_1 의 전하를 가진 점전하가 존재하고, 도체에 존재하는 총전하는 Q_2 이다. $\vec{r}$ 은 position vector이고, r 은 $\vec{r}$ 의 크기를 나타낸다.

   모든 $\vec{r}$ 에 대하여,

   가) 전하밀도 $\rho(\vec{r})$ 을 구하시오.
   나) 전계의 세기 $\vec{E}(\vec{r})$ 을 구하시오.
   다) 정전압 $V(\vec{r})$ 을 구하시오.
   라) Q_1 을 $r = 0.5\ a$ 인 한 점으로 이동시켰을 때 형성된 $\rho(\vec{r})$ 과 가)항 에서 구한 $\rho(\vec{r})$ 과의 차이점을 개략적으로 설명하시오.

1. Place a positive point-charge Q at a distance d from the infinite grounded conducting plane of the Fig. Find a) the field on the conducting plane. b) the induced charge-density on the plane. c) the attractive force between the point-charge and the plane.

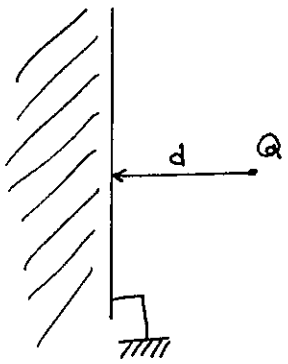
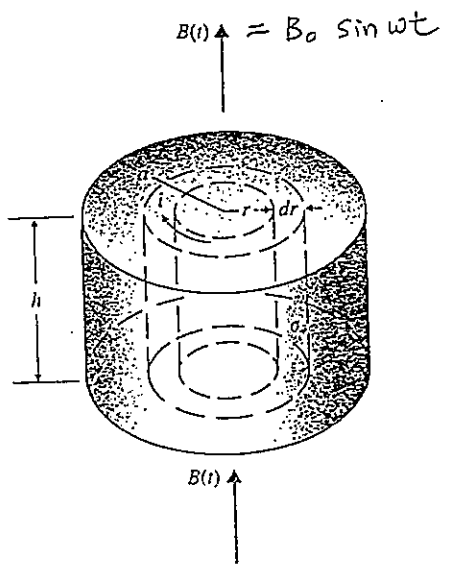


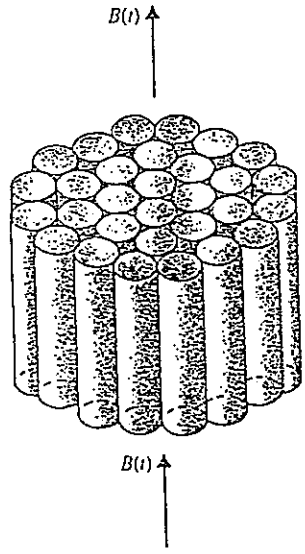
Fig.

1. A suggested scheme for reducing eddy-current power loss in transformer cores (conductivity = σ) with a circular cross section (radius = a) is to divide the cores into a large number of small insulated filamentary parts.

1) Explain eddy currents.
2) In Fig.1, find the induced emf in the differential ring.
3) Find the resistance of the differencial ring for the eddy current i.
4) Find the differential power loss in the ring.
5) Find the total power loss in the total volume.
6) Find the average eddy current power loss in the total volume.
7) If the core in Fig.1 is divided into 100 small insulated cores which take 81 % of the original cross-sectional area as in Fig.2, determine the ratio of the total average eddy current power loss in 100 filamentary cores to the original average loss in Fig.1.



< Fig. 1 >



< Fig. 2 >

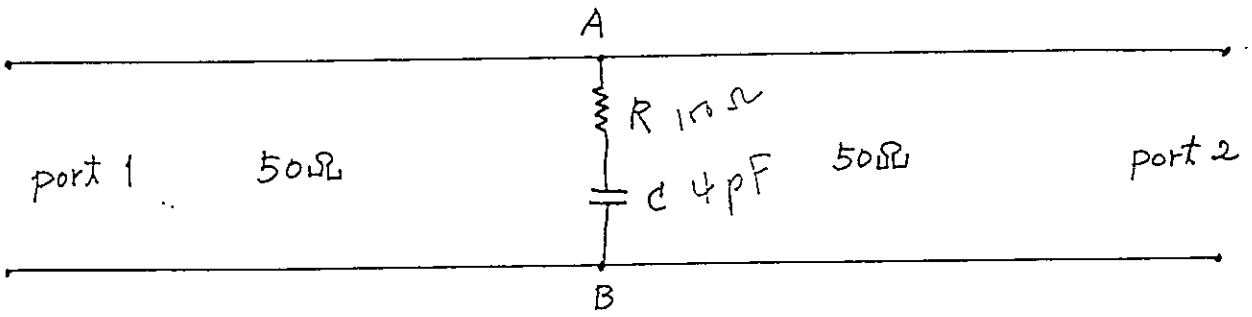
전자장, 전자기학

1. 아래의 전송선 모델은 그 특성 impedance가 50Ω이고, AB 면에 100Ω의 저항 R과 4 pF의 capacitor C가 shunt로 연결되어 있다. 이 전송선에 1 GHz의 전자파가 port 1 으로부터 port 2로 전파한다 (port 1과 port 2는 50Ω으로 terminate 되어 있음.)

a) AB 면에서의 반사계수를 구하라.

b) AB 면에서의 투과계수를 구하라.

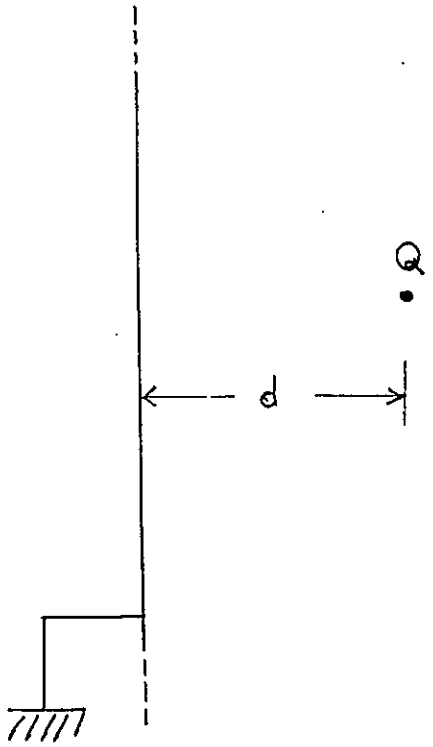
c) AB 면 좌측에 생기는 standing wave의 VSWR을 구하라.



전자장, 전자기학

2. Place a positive point-charge Q at a distance d from the infinite grounded conducting plane of the Fig.

Find (a) the field at the plane
(b) the induced charge-density at the plane
(c) the attractive force between the point-charge and the metal plate



(Fig)

EM 기초과목 시험

문제 2

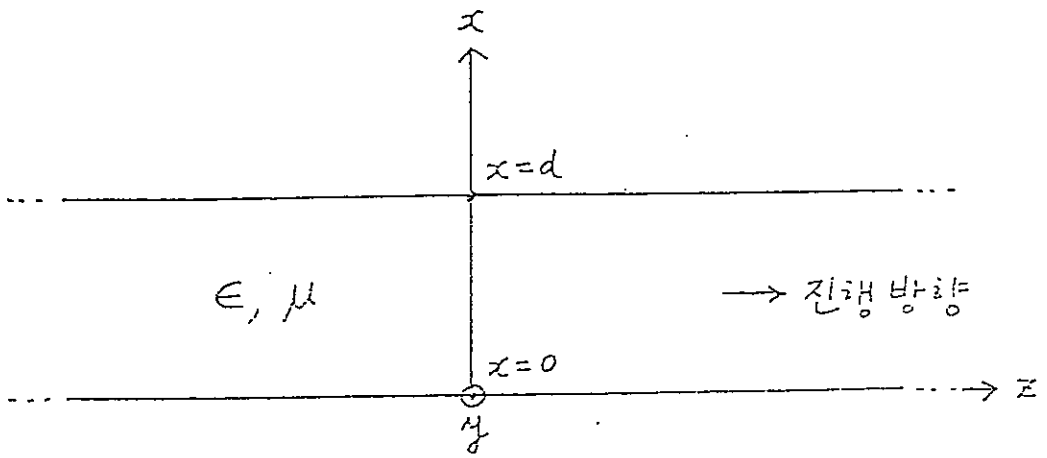
두 개의 infinite conducting plate가 그림과 같이 $x=0$, $x=d$ 평면에 위치하고 있으며, 이들 사이의 공간은 유전율 ϵ, 투자율 μ의 물질로 차여져 있다. 이 공간에 +z 방향으로 진행하는 전자파가 TEM (transverse electromagnetic) mode 인 경우

a) phasor 전계를 구하라 (이 전계의 크기는 임의임),

b) phasor 자계를 구하라,

c) 전파상수 β를 구하라,

d) $x=d/2$ 평면에서 전계와 자계를 sketch 하라.



(기초문제)

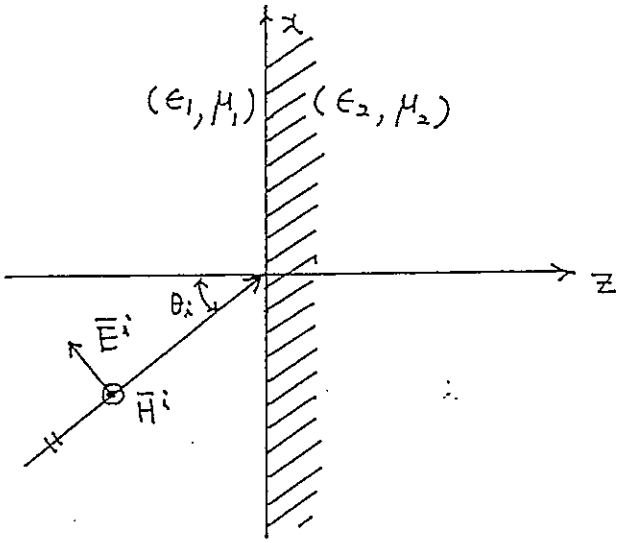
(Prob. 3)

Assume that the electric field of the uniform plane wave incident on a planar interface at an oblique angle, as shown in Figure, is oriented parallelly to the plane of incidence.

(a). Find the reflected fields $\overline{E}^r$ and $\overline{H}^r$.

(b). Find the transmitted fields $\overline{E}^t$ and $\overline{H}^t$.

(c). Find the Brewster angle for $\mu_1 = \mu_2$.



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1. 내부도체 외경이 5mm, 외부도체 내경이 10mm인 동축케이블 내에 주파수 500 MHz의 전자파가 dominant mode 형태로 한 방향 (+z 방향)으로만 진행하고 있다. 두 도체 사이를 채우고 있는 비자성 유전체의 비유전율은 4이고, 유전체강도 (dielectric strength)는 30 MV/m이다.

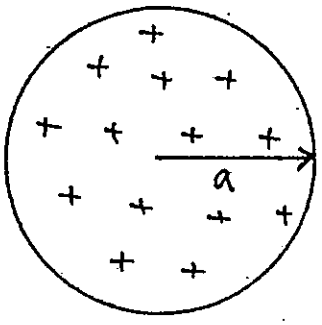
이 동축케이블이 최대의 power를 전송할 때,

a) Phasor electric field를 구하라,

b) Phasor voltage를 구하라,

c) 전송되는 최대의 average power는 얼마인가?

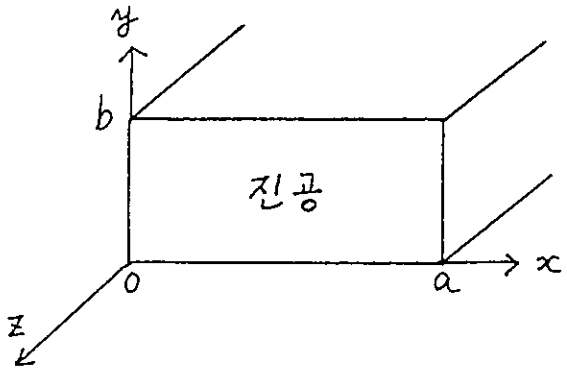
2. A spherical cloud of charge is shown in the figure with uniform charge density ρ_0. Find the work required to assemble the charge cloud.



EM (기초문제)

문제 1. 내부가 진공인 rectangular waveguide에 TE_{10} mode의 전자파가 +z 방향으로 전파하고 있다.

이 mode의 phasor 전자계와 waveguide의 제원은 다음과 같다.



$$H_z = A \cos k_x x \; e^{-j\beta z}$$

$$E_y = -\frac{j\omega\mu A}{k_x} \sin k_x x \; e^{-j\beta z}$$

$$H_x = \frac{j\beta A}{k_x} \sin k_x x \; e^{-j\beta z}$$

$$E_z = E_x = H_y = 0 ,$$

$$k_x = \frac{\pi}{a} ,$$

a= 22.86 mm,

b= 10.16 mm,

$\omega = 2\pi(10^{10})$ rad/sec.

a) 이 전자파의 guided wavelength를 구하라.

b) 이 waveguide를 통해서 20milliwatt의 average power를 전송할 때, A의 magnitude를 구하라.

EM (기초문제)

(문제2) i) 시변(time varying) 전자장 $\bar{E}$와 $\bar{H}$에 대한 4개의 Maxwell 방정식에서 2개만 독립된 방정식임을 밝혀라.

ii) 서로 다른 매질 I,II가 경계면을 이루었을때 시변 전자장 $\bar{E}$와 $\bar{H}$에 대한 접선 성분의 경계조건으로부터 법선 성분의 경계조건을 유도하라.

전자기학

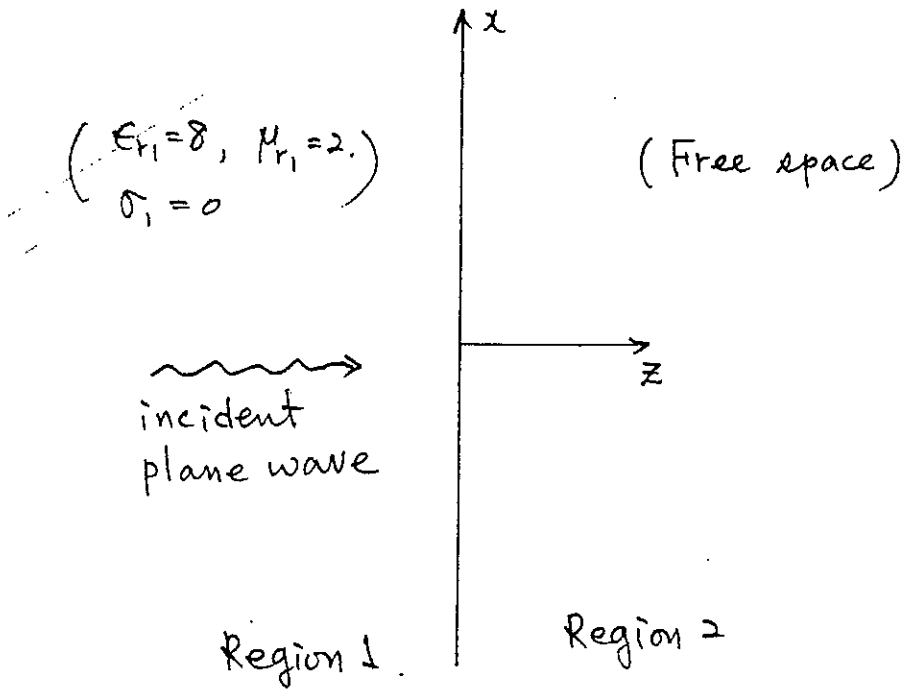
[1] A plane wave $\bar{E}^i = \hat{x} E_0 e^{-jk_1 z}$ is incident on the interface shown in Figure. Assuming the normal incidence,

1) find k_1 in terms of k_0

2) find the incident magnetic field $\bar{H}^i$ in region 1.

3) find the reflected field $\bar{E}^r$ and $\bar{H}^r$ in region 1.

4) find the transmitted field $\bar{E}^t$ and $\bar{H}^t$ in region 2.



(Figure)

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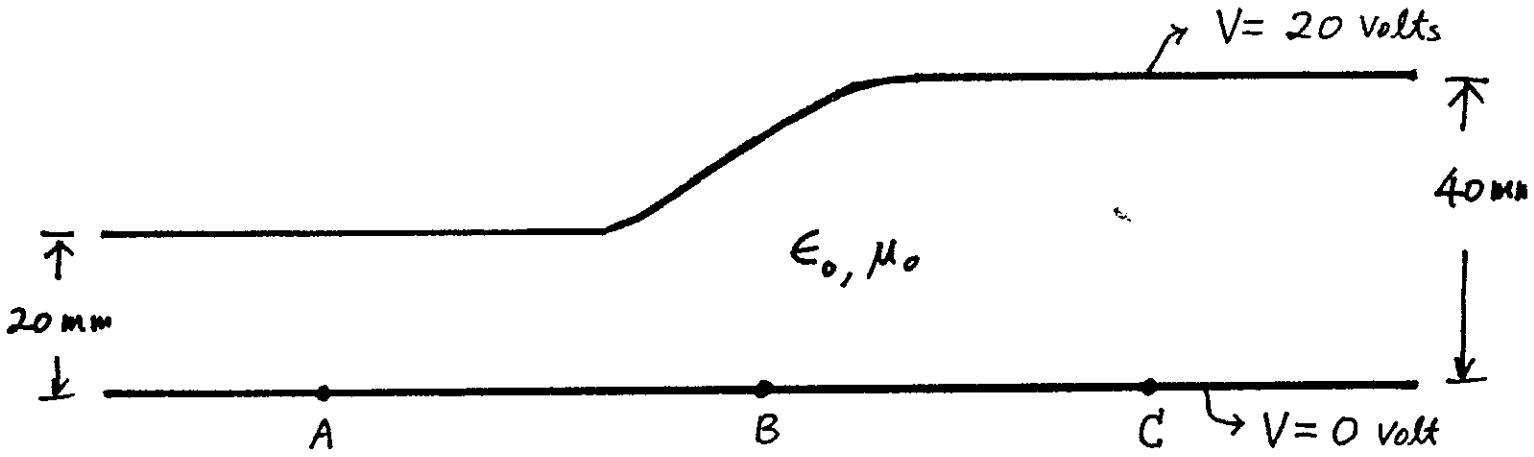
2. Find (a) the phase (in radians) and (b) amplitude of the E field at a depth of 0.1 mm into a copper sheet relative to that entering the surface for a 1 GHz wave directed normal to the sheet. Use σ=5.8E7, ϵ' =8.854E-12, μ =4πE-7. (c) Find the intrinsic impedance of the copper medium to the wave, and explain if the result has any contrast to the impedance of the circuit elements.

the

(2) Given a cross-section of a capacitor made of two sheet conductors as shown
a) Map the equipotential lines having voltages of 5, 10, 15 volts and the electric field lines making curvilinear squares.
b) Find the approximate value of the capacitance of the capacitor per unit length.
c) Find the approximate values of the surface charge density at the points A, B, and C.



전자장, 전자기학

1. 아래의 전송선 모델은 그 특성 impedance가 50Ω이고, AB 면에 100Ω의 저항 R과 4 pF의 capacitor C가 shunt로 연결되어 있다. 이 전송선에 1 GHz의 전자파가 port 1으로부터 port 2로 전파할 때 (port 1과 port 2는 50Ω으로 terminate 되어 있음.)

a) AB 면에서의 반사계수를 구하라.

b) AB 면에서의 투과계수를 구하라.

c) AB 면 좌측에 생기는 standing wave의 VSWR을 구하라.