系所組別： 電腦與通信工程研究所丙組

考試科目： 電磁學及電磁波

考試日期：0307，節次：2

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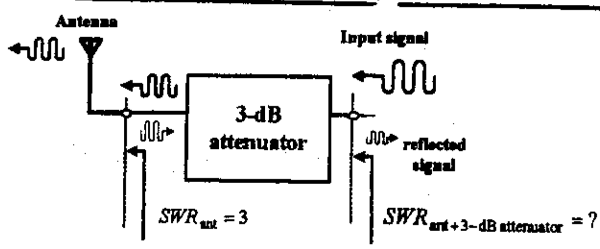
* Useful constants: $\varepsilon_0 = 10^{-9}/36\pi$; $\mu_0 = 4\pi \times 10^{-7}$; $\eta_0 = 120\pi$

1. If a charge of 1 [*C*] is applied to a **perfectly conducting sphere** with the radius a = **1** *cm*, determine the $\bar{E}$ field [*V/m*] (including the vector of the field) **on the surface** of the sphere. (10%)

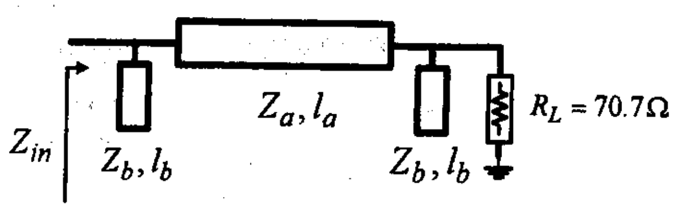
2. **Maxwell's Equations**
   (a) Write down the **time-variant equation of Ampere's Law** with **the displacement current** in differential form. (10%)
   (b) Explain the difference between the **displacement current** and **free current**. (10%)

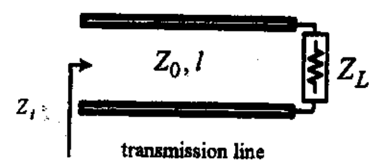
3. If the input SWR of an antenna is SWR_{ant}=3, what is the $SWR_{ant+3\text{-}dB\ attenuator}$ when the antenna is connected to a 3-dB attenuator (assuming the attenuator is perfectly matched).

   ***You must solve the problem from the basic definition of SWR, reflection coefficient Γ, and 3-dB attenuation. (10%)**



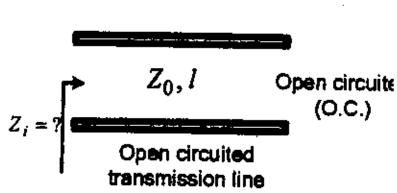
4. A **microstrip** transmission line is connected with with two ***shunt open-circuited*** transmission line (left figure). If $\theta_a(=\beta l_a) = 45^o$, $\theta_b(=\beta l_b) = 20^o$, the transmission-line characteristic impedance Z_a= 100 (Ω), Z_b= 36.4 (Ω), determine the **input impedance** Z_{in}. (15%)



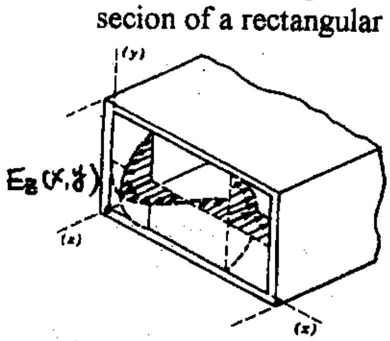


$$Z_i = Z_0 \frac{Z_L + jZ_0 \tan(\beta l)}{Z_0 + jZ_L \tan(\beta l)}$$

You will use the **input admittance**(Y_i) **formula** of the shunt open-circuited short transmission line.



5. The following figure shows the **E_z-filed distribution** of a *waveguide mode* on the cross-secion of a rectangular waveguide (a x b).



What is this waveguide mode (***TE_{mn}*** or ***TM_{mn}***, m =? n= ?) and write down the formula of **E_z filed** $E_{0z}(x, y) = E_0[?]$ (10%)

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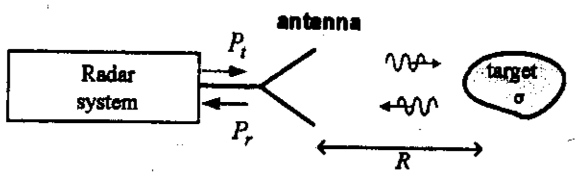
6. In a **60-GHz** radar system, let the radar **antenna gain** G **= 20 dB** and the target **radar cross section (RCS)** $\sigma = 10^{-2}\,(\mathrm{m}^2)$. If the **transmitting power** P_t **= 0 dBm** and the ***required radar minimum receiving power*** P_r **= -60 dBm,** determine the radar maximum detectable distance R **(m). (10%)**



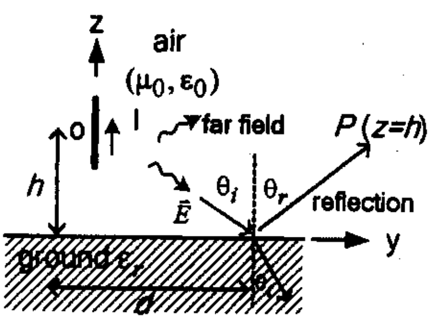
Radra equation:

$$P_r = \frac{P_t G^2 \lambda^2 \sigma}{(4\pi)^3 R^4}$$

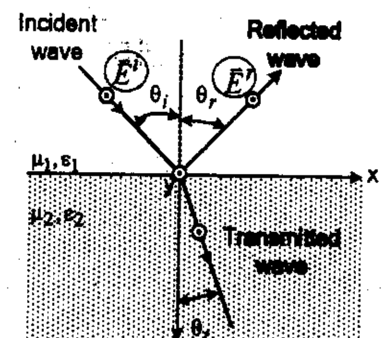
7. A Hertzian antenna with a length l and a current I is located above a dielectric ground plane (ε_r=4) with a height of h. Let the origin O of this radiating system is at the center of the Hertzian antenna and the far-zone E field is as follows. (see figure (a))

$$\vec{E} = \hat{\theta} j\eta_0 k l I \frac{e^{-jkr}}{4\pi r} \sin\theta \qquad \frac{\sin\theta_t}{\sin\theta_i} = \frac{\sqrt{\varepsilon_{r1}}}{\sqrt{\varepsilon_{r2}}}$$

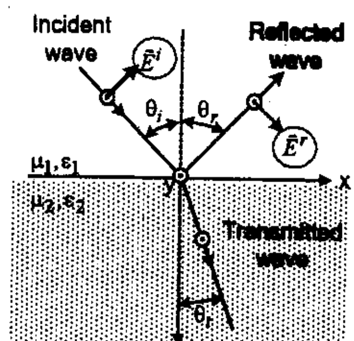
The illustration and formulas of the reflected coefficient ($\Gamma_\perp$ and $\Gamma_{//}$) for the perpendicular and parallel polarization are shown in the (b)(c) figures. If h **= 1m** and d **= 10 m,** determine the **reflected** E **filed at the point** P**. (15%)**



(a)



(b)
perpendicular polarization
($\vec{E} \perp$ **xz - plane**)



(c)
parallel polarization
($\vec{E}$ // **xz - plane**)

$$\Gamma_\perp = \frac{\eta_2\cos\theta_i - \eta_1\cos\theta_t}{\eta_2\cos\theta_i + \eta_1\cos\theta_t} \qquad \Gamma_\parallel = \frac{\eta_2\cos\theta_t - \eta_1\cos\theta_i}{\eta_2\cos\theta_t + \eta_1\cos\theta_i}$$

8. In a conductive medium, the propagating constant $\gamma (= \alpha + j\beta = j\omega\sqrt{\mu\varepsilon(1+\frac{\sigma}{j\varepsilon\omega})})$ can be approximated for a good conductor or dielectrics as follows.

$(\sigma/\omega\varepsilon) >> 1 \Rightarrow \alpha = \beta \approx \sqrt{\pi f \mu\sigma}$; $(\sigma/\omega\varepsilon) << 1 \Rightarrow \alpha \approx \frac{\sigma}{2}\sqrt{\mu/\varepsilon}$, $\beta \approx \omega\sqrt{\mu\varepsilon}\,[1+\frac{1}{8}(\frac{\sigma}{\omega\varepsilon})^2]$

For a 30-Hz plane wave incidents from free space to seawater ($\sigma = 4[S/m]$, $\varepsilon_r = 80$ @30 Hz), calculate the **distance** d *below the seawater surface* where **E-field is 10%** of its value at nthe surface. **(10%)**