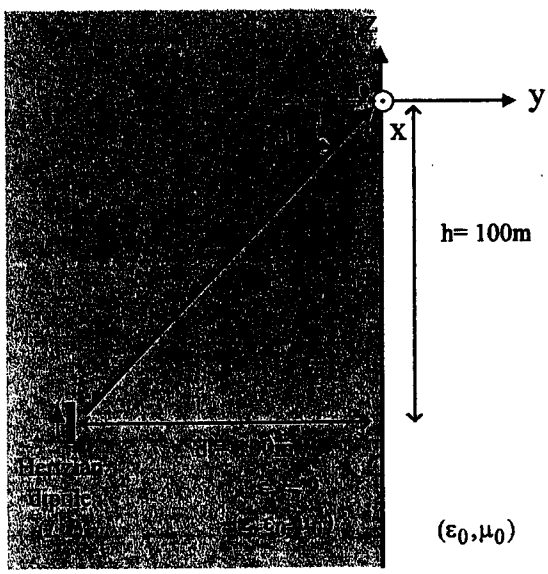
* Useful constants : $\varepsilon_0 = 10^{-9}/(36\pi)$ (F/m); $\mu_0 = 4\pi \times 10^{-7}$ (H/m); $C = 3 \times 10^8$ (m/s)

1. Explain what is the difference between the **displacement current** and the **free current** in the Maxwell's equations? (5%)

2. A z-directed Hertzian dipole antenna (I = 1A, l = 0.11cm, f = 10GHz) is located inside a dielectric space as shown in the figure.
   (a) What type of the EM wave (TE, TM, TEM) rom the Hertzian dipole at the point O? Why?. (5%)
   (b) Determine the **power density** $P_{av}(W/m^2)$ of the the incident wave at the point O from the Hertzian dipole. (5%)
   (c) Determine the **angle** of the **reflected** and **transmitted wave** (at the point O) for the incident wave radiated from the Hertzian dipole. (10%)



Hertzian dipole far-zone radiation fields

$$\begin{cases} \vec{E} = \hat{\theta}\, j\eta kIl \dfrac{e^{-jkr}}{4\pi r}\sin\theta \\ \vec{H} = \hat{\phi}\, jkIl \dfrac{e^{-jkr}}{4\pi r}\sin\theta \end{cases}$$

(背面仍有題目，請繼續作答)

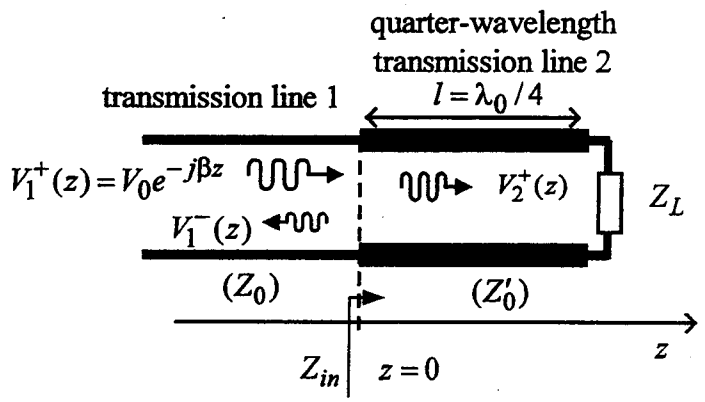
3. For a quarter-wavelength line transformer with a real lad impedance (Z_L), the following curve shows an approximate response of the reflection coefficient magnitude ($|\Gamma|$) near its design (central) frequency (f_o). It means $\Delta\theta << \pi/2$ and $\Delta f << f_0$. Γ_m can be derived as

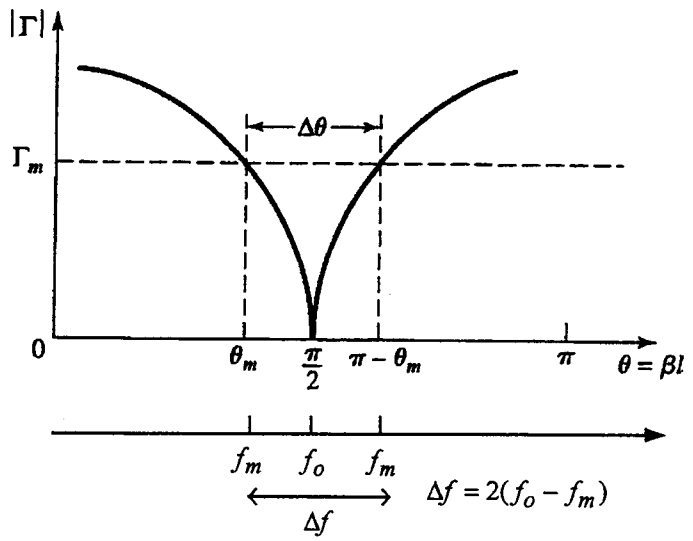
$$\frac{1}{\Gamma_m^2} = 1 + \left[\frac{2\sqrt{Z_0 Z_L}\sec\theta}{|Z_L - Z_0|}\right]^2$$

(a) Prove that $\dfrac{\Delta f}{f_o} = 2 - \dfrac{4}{\pi}\cos^{-1}\left[\dfrac{\Gamma_m}{\sqrt{1-\Gamma_m^2}}\dfrac{2\sqrt{Z_0 Z_L}}{|Z_L - Z_0|}\right]$ (10%)

(b) For $\Gamma_m = 0.5$ and $Z_L = 4Z_0$, determine Δf and reflected and transmitted voltage (to the load), $V_1^-(z)$ and $V_2^+(z)$, at $f = f_m$. (15%)

(c) For an input power $P_1 = 0dBm$, determine the reflected and transmitted power (to the load), $P_r(dBm)$ and $P_t(dBm)$, at $f = f_m$. (10%)





* For $l = \frac{\lambda_0}{4}$, $\theta = \beta l = \frac{2\pi}{\lambda_0}\frac{\lambda_0}{4} = \frac{\pi}{2}$ at $f = f_o$

4. (a) Briefly explain why a microstrip line can not support a pure TEM wave. (10%)
   (b) For a PCB substrate (d =1 mm, ε_r=4), determine the microstrip line width (W) and length (l) of a $\lambda/4$ microstrip line at f = 1 GHz.with a characteristic impedance of 50 Ω by using the parallel-plate line approximation (assuming a pure TEM wave propagating in the parallel-plate line) (10%)
   (c) As shown in the figure, a pulse signal is applied to a microstrip-line circuit on a PCB substrate of (b). Plot the **voltage waveform** at the midpoint of the line as a function of time up to 0.2 nS. (20%)