本試題是否可以使用計算機：☑可使用　，　☐不可使用　（請命題老師勾選）

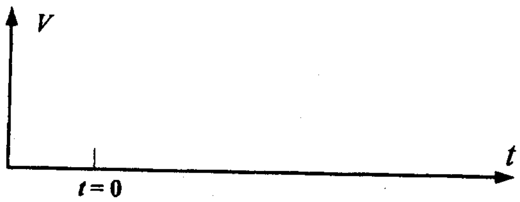
* Useful constants : $\varepsilon_0 = 10^{-9}/36\pi$; $\mu_0 = 4\pi \times 10^{-7}$; $\eta_0 = 120\pi$

1. (a) For a **perfectly-matched two-port microwave 3-dB attenuator (3-dB 衰減器)**, determine its S- parameter matrix. (5%)

   (b) If the **input and output VSWR** of a two-port 3-dB microwave attenuator are all equal to **1.5** (and assuming the input and output impedance are all **real**), determine its S-parameter matrix. (5%)

$$\text{S-parameter matrix: } \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}$$

2. At $t = 0$ for an **unit step signal** incident to a **short-circuited** microstrip transmission line with **a length L** on a substrate of **thickness d** and **diectric constant ε_r**, draw the **reflected** and **total signal voltage as a function of time.** (Note: assuming a pure TEM wave propagating in the microstrip transmission line) (10%)



3. Determine the length l (in term of wavelength λ) of a **short-circuited** transmission line ($Z_0 = 50\,\Omega$) to have an equivalent inductance **L = 5 nH** at **f = 1 GHz.** (10%)

   Note: assuming the transmission line is lossless with a propagation constant β.

   * General input impedance formula of a lossless transmission line with a length l and load Z_L :
   $$Z_i = Z_0 \frac{Z_L + jZ_0 \tan(\beta l)}{Z_0 + jZ_L \tan(\beta l)}$$

4. For an air-filled rectangular waveguide (a x b), it can be proven that the normalized frequency at which the TE_{10} mode exhibits its minimum attenuation is

$$f/f_c = \left[g + \sqrt{g^2 - (2b/a)}\right]^{1/2} \qquad g = \tfrac{3}{2} + \tfrac{3b}{a}$$

If a waveguide is with (a = 6 mm, b= 3 mm), determine the operating frequency of the TE_{10} mode which exhibits its minimum attenuation. (10%)

Waveguide TE_{10} mode attenuation constant :

$$\alpha_{c_{TE10}} = \frac{1}{\eta_0 b}\sqrt{\frac{\pi f \mu_0}{\sigma_c[1-(f_c/f)^2]}}\left[1 + 2\frac{b}{a}(f_c/f)^2\right]$$

（背面仍有題目,請繼續作答）

5. The Helmholtz's equation in a **source-free lossy medium** $(\varepsilon, \mu, \sigma)$ is as follows.

$$\nabla^2 \vec{E} + k_c^2 \vec{E} = 0$$
$$k_c = \sqrt{-j\omega\mu(\sigma + j\omega\varepsilon)} = \omega\sqrt{\mu\varepsilon(1+\tfrac{\sigma}{j\varepsilon\omega})} = \omega\sqrt{\mu\varepsilon_c},$$
$$\varepsilon_c = \text{equivalent complex - permittivity}$$

(a) Determine the approximated **intrinsic (wave) impedance** η_c of a TEM wave in a **good conductor** ($\sigma/\varepsilon\omega >> 1$).(10%)

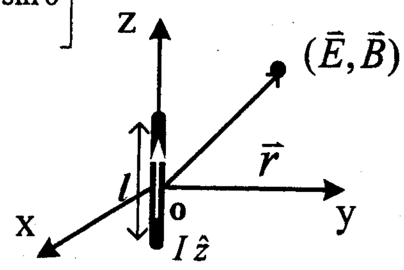
Note: Use the condition $\sigma/\varepsilon\omega >> 1$ and $\sqrt{j} = \frac{(1+j)}{\sqrt{2}}$

(b) From (a) explain that E- and H-field of a TEM wave in a good conductor have **a phase difference of 45°**.(5%)

6. For a **z-directed Hertzian dipole antenna** with **an uniform current distribution** ***I*** in a free space, the **radiated E- and B-filed** can be derived as follows.

$$\vec{E} = \frac{-j\eta_0 Il}{4\pi k}\left[\hat{r}\left(\frac{2}{r^3} + \frac{j2k_0}{r^2}\right)e^{-jk_0 r}\cos\theta + \hat{\theta}\left(\frac{1}{r^3} + \frac{jk_0}{r^2} - \frac{k_0^{\,2}}{r}\right)e^{-jk_0 r}\sin\theta\right]$$

$$\vec{B} = \hat{\phi}\frac{\mu_0 Il(1+jk_0 r)}{4\pi\ \ r^2}e^{-jk_0 r}\sin\theta$$



$l << \lambda$

(a) Derive the **near-zone and far-zone** radiated **E- and H-field**. (10%)
(b) From (a) Express the relation between the **far-zone E- and H-field** . (5%)
(c) Draw an approximated **E-plane** (at $\phi = 0^0$) antenna pattern in <u>linear scale</u>. (5%)
(d) Determine the far-zone **radiation power density** P_{av} and the **total radition power** P_{rad}. (15%)
Note: $\left(\int_0^{\pi}(\sin\theta)^3 d\theta = 4/3\right)$

(e) Explain the meaning of the **antenna radiation resistance** R_{rad}. Determine the R_{rad} of a Hertzian dipole. (10%)