請於答案卷上非選擇題作答區標明題號作答。計算題請詳列過程。 $\varepsilon_0 = 10^{-9}/(36\pi)$ [F/m], $\mu_0 = 4\pi\times10^{-7}$ [H/m]

1. (填充題) (6%) A transmission line is 30 cm long. It is short-circuited at left end and open-circuited at right end. The lowest two frequencies of its natural oscillation are _____ MHz and _____ MHz.

2. (填充題) (10%) The directivity of a rectangular aperture antenna is $D = 4\pi wh/\lambda^2$, where w and h are the width and height of the aperture, respectively.

   (a) (3%) If D of an antenna is 4.0 at 900 MHz, D will be about **(1.0, 2.0, 4.0, 8.0, 16.0)** at 1800 MHz.
   (b) (2%) From the equation, you can find that D will be **(smaller, the same, larger)** for larger w.
   (c) (2%) From the equation, you can find that D will be **(smaller, the same, larger)** for smaller h.
   (d) (3%) The width and height of an edge-emitting laser facet are w = 10 μm and h = 5 μm, respectively. The facet looks like ☐ . From (b) and (c), you can deduce that the shape of far field spot from the laser will be

   a. ◯　b. ⬭　c. ⬭　d. ▭　e. ▭

3. (計算題) (12%) Let us consider a uniform plane wave incident from space ($z < 0$) normally onto an anisotropic perfect dielectric medium ($z > 0$), characterized by the permittivity matrix $[\varepsilon] = \varepsilon_0 \begin{bmatrix} 9 & 0 & 0 \\ 0 & 4 & 0 \\ 0 & 0 & 4 \end{bmatrix}$ and $\mu = \mu_0$. The electric field of the incident wave is expressed by $\boldsymbol{E}_i = E_0\cos(\omega t - k_0 z)(\boldsymbol{a}_x + j\boldsymbol{a}_y)$

   (a) (8%) Please write the electric-field expressions for the reflected and transmitted waves. (Hint: Consider x-component first, then y-component.)
   (b) (4%) If the wavelength is λ_0 = 1.5 μm, please find the shortest distance that the transmitted wave becomes a linearly polarized wave.

4. (計算題) (10%) A transmission line of characteristic impedance Z_0 = 50 Ω provided the following data. First, the voltage minima were found to be 30 cm apart as it is short-circuited. As the short circuit was replaced by a load Z_R, the SWR was found to be 4 and a voltage minimum was found to be 6 cm from the reference point on the side toward the load. Please find the $|\bar{\Gamma}_R|$ and θ of the reflection coefficient $\bar{\Gamma}_R = |\bar{\Gamma}_R|e^{j\theta}$.

5. (計算題) (12%) The ω-β curve for a dispersive channel can be approximated by $\beta = \beta_0 + \beta_1\left(\omega - \frac{2\pi c}{\lambda_0}\right) + \frac{\beta_2}{2}\left(\omega - \frac{2\pi c}{\lambda_0}\right)^2$ in the vicinity of wavelength λ_0, where c is the light speed in free space.

   (a) (4%) Please find the phase velocity $v_{p,A}$ and group velocity $v_{g,A}$ for signal A at $\lambda_A = \lambda_0$.
   (b) (4%) Please find the group velocity $v_{g,B}$ for signal B at $\lambda_B = \lambda_0 + \Delta\lambda$, where $\left|\frac{\Delta\lambda}{\lambda_0}\right| \ll 1$. (Hint: Use $\frac{1}{1+x} \approx 1 - x$ for small x.)
   (c) (4%) It takes t_A and t_B for pulses centered at λ_A and λ_B, respectively, to travel a distance L. If the time difference is $\Delta t \equiv (t_B - t_A)$, please find the parameter $D \equiv \frac{\Delta t}{\Delta\lambda\, L}$.

6. (計算題) Consider a coaxial cable formed by two perfectly conducting cylinders of radii a = 0.5 mm and b = 2.5 mm with a perfect dielectric ($\mu_r = 1, \varepsilon_r > 1$) filled in between them and the axis of the cylinders is the z-axis. The electromagnetic waves which propagate in the coaxial cable are given by $\mathbf{E} = \{V_0/[r\ln(b/a)]\}\cos(6\pi\times10^9 t - 30\pi z)\boldsymbol{a}_r$ [V/m] and $\mathbf{H} = (I_0/2\pi r)\cos(6\pi\times10^9 t - 30\pi z)\boldsymbol{a}_\phi$ [A/m] for $a < r < b$, where V_0 and I_0 are constants.

   (a) (4%) What is the frequency f of the electromagnetic waves in the coaxial cable?
   (b) (4%) What is the phase velocity v_p of the electromagnetic waves in the coaxial cable?
   (c) (4%) According to (b), what is the relative permittivity ε_r of the dielectric filled in between the two conducting cylinders?
   (d) (4%) Based on (c), what is the capacitance per unit length C of the coaxial cable for static fields?
   (e) (4%) Based on (d), what is the characteristic impedance Z_0 of the coaxial cable as a transmission line?
   (f) (4%) Based on (e), if one end of the coaxial cable is open-circuited, what is the voltage reflection coefficient Γ?
   (g) (4%) Based on (e), if the coaxial cable is terminated with a resistive load without reflection, what is the load reistance R_L?
   (h) (4%) Please find the instantaneous Poynting vector $\mathbf{P}$ associated with the electromagnetic waves.
   (i) (4%) Please find the time-average Poynting vector $\langle\mathbf{P}\rangle$ associated with the electromagnetic waves.
   (j) (4%) Please find the time-average power flow $\oint\langle\mathbf{P}\rangle\cdot d\boldsymbol{s}$ along the coaxial cable.

7. (計算題) A toroid with magnetic core (permeability μ) of circular cross section (radius = r) as shown in Fig 1. The mean radius of the toroidal core is a and the number of turns per unit length along the mean circumference of the toroid is N.

   (a) (5%) Please find the magnetic flux ψ inside the magnetic core when the electric current is I.
   (b) (5%) Please find the inductance L of the toroid.

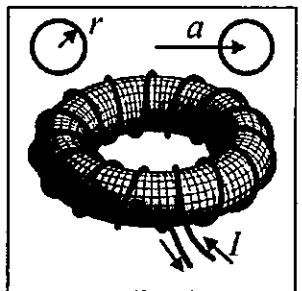

Fig. 1