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. A uniform plane wave traveling in vacuum has only y and z components of electric field strength of the form
$\begin{cases} E_y(x,t) = 3\sin(\omega t - k_0 x - \pi/6) \ \ (\mathbf{V/m}) \\ E_z(x,t) = 6\sin(\omega t - k_0 x + \pi/6) \ \ (\mathbf{V/m}) \end{cases}$, where ω and k_0 are the angular frequency of the wave and wave number in vacuum, respectively.
(1) What is the polarization state of this uniform plane wave? **(4 points)**
[*Note that the polarization state must be one of the following:* *linear polarization*, *right-handed elliptical polarization*, *left-handed elliptical polarization*, *right-handed circular polarization*, *or* *left-handed circular polarization*.]
(2) Find the time-averaged power density of the wave in W/m^2. **(6 points)**

2. Consider a transmission line resonator as shown in Fig. 1(a), in which Z_c and θ_1 denote the characteristic impedance and electrical length of the transmission line section, respectively. Assume that the constituent transmission line is lossless and terminated by an ideal short circuit. To shorten the length of the resonator while keeping the same resonating behavior (Z_{in}) at its input, one could simply reduce the electrical length of the line to be θ_2 ($\theta_2 < \theta_1$) and replace the short circuit by some reactive termination, as shown in Fig. 1(b).
(1) Write down the general expression for the impedance of the reactive termination needed. **(4 points)**
(2) For $\pi > (\theta_1 - \theta_2) > \pi/2$, which kind of reactive element should be used, inductor or capacitor? **(2 points)**
(3) What is the value of the inductance or capacitance? (Given the angular frequency ω.) **(4 points)**

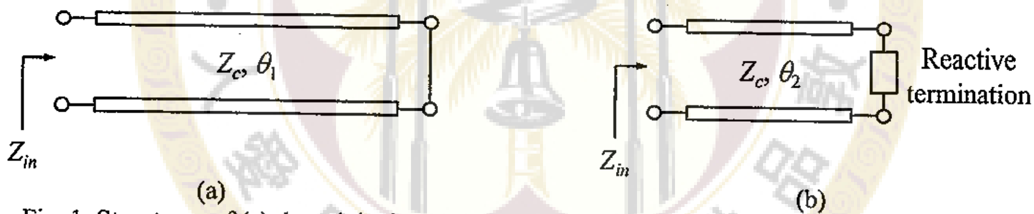

Fig. 1. Structures of (a) the original and (b) the length-reduced transmission line resonators.

3. Consider an impedance matching problem as shown in Fig. 2(a), in which a load impedance Z_L is matched to the desired system impedance Z_0 using a passive impedance matching circuit. Given the impedance locus (thick line) shown in Fig. 2(b), please find the schematic of the matching circuit. **(6 points)**

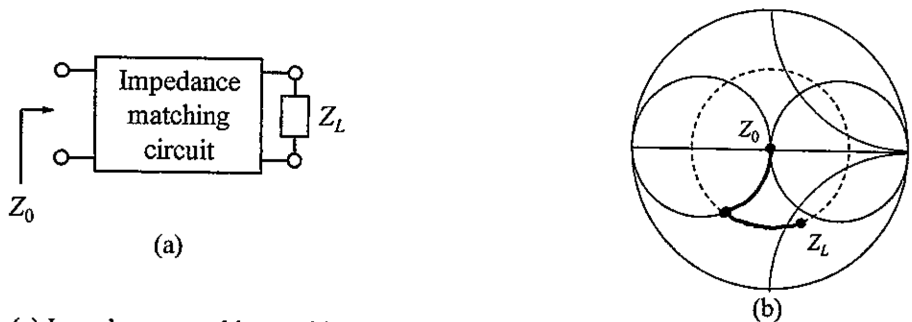

Fig. 2. (a) Impedance matching problem and (b) the associated impedance locus on the Smith chart.

4. An antenna radiates a total power of 2 W. In the direction of maximum radiation, the field strength at a distance of 1 km was measured to be $H = 10^{-4}$ A/m (rms value). What is the directivity D of the antenna, assuming free-space propagation to the measurement point? **(6 points)**

見背面

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5. A lossless transmission line is terminated with a normalized load of $0.8 + j1.0$. Please calculate
   (1) the VSWR. **(3 points)**
   (2) the distance between the first voltage minimum and the load. **(6 points)**
   (3) the percentage of the incident power that is transferred to the load. **(3 points)**

6. Design a dielectric-filled rectangular waveguide to transmit 6-GHz electromagnetic waves and satisfy the following specifications simultaneously: (a) the relative permittivity of the filling material (non-magnetic) is 4, (b) the 6-GHz frequency is at the middle of the operating frequency band of the waveguide, and (c) $b = a/2$. **(6 points)**

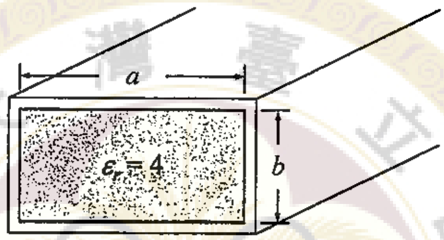
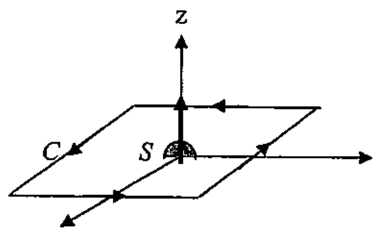


Fig. 3. Configuration of the dielectric-filled rectangular waveguide to be designed.

7. Current I flows along a straight wire from a point charge $Q_1(t)$ located at the origin to a point charge $Q_2(t)$ located at (0, 0, 2).
   (1) Find the line integral of $\bar{H}$ along the square closed path C having the vertices at (2, 2, 0), (-2, 2, 0), (-2, -2, 0), and (2, -2, 0) and traversed in that order. Please solve it by using Ampere's law and considering the **plane** surface S bounded by C except for a slight **upward** bulge at the origin to avoid $Q_1(t)$ as shown in Fig. 4. (Express the answer in terms of I.) **(5 points)**
   (2) Redo (1) by considering the **plane** surface S bounded by C except for a slight **downward** bulge at the origin to avoid $Q_1(t)$. **(5 points)**
   (3) If $Q_2(t)$ is moved to infinity along z-axis, how does the answer in (1) change? **(5 points)**
   (4) If $Q_2(t)$ is slowly moved to the origin (keeping I constant) along z-axis, how does the answer in (1) gradually change? **(5 points)**

Fig. 4 for Problem 7



8. The space between two parallel conducting plates each having an area S is filled with two different lossy dielectrics as shown in Fig. 5, where the thicknesses d_1, $d_2 \ll S^{1/2}$=L (the length) so that the fringe effect can be neglected. A battery of dc voltage V is applied across the plates. Please determine
   (1) The steady current densities in both dielectrics **(5 points)**
   (2) The electric field intensities in both dielectrics. **(5 points)**
   (3) The surface charge densities on the plates and the interface. Please explain briefly the origin of the surface charge density on the interface. **(10 points)**

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(4) If the steady magnetic field is neglected, please draw the equivalent circuit of this system and show the circuit parameters. **(10 points)**

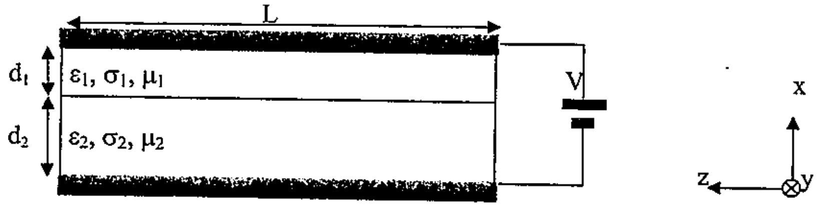

Fig. 5 for Problem 8