1. In the system shown in Fig. 1, Line 1 and Line 2 are quarter-wavelength transmission lines with a characteristic impedance of Z_0. Find Z_0 for which there is no reflected wave to the signal source. **(10 points)**
2. A parallel-plate transmission line consists of an arrangement of two perfect dielectrics, and the transverse cross section is shown in Fig. 2. Answer the following problems by neglecting fringing of field.
   (a) Are the TEM waves propagating in both dielectrics in phase? Explain the reason. **(3 points)**
   (b) Compute the circuit parameters, inductance (H/m), capacitance (F/m) per unit length and characteristic impedance Z_0 (Ω) of the transmission line. **(9 points)**
3. In a system shown in Fig. 3(a), the system is initially uncharged, and the switch S is closed at $t = 0$. The component N is a lumped element (R, L, or C). The line voltage at $z = 0$ is shown in Fig. 3(b).
   (a) What is the component N? Explain the reason. **(6 points)**
   (b) Find the characteristic impedance of Line 2 (Z_{02}). **(6 points)**
4. In a transmission line system as shown in Fig. 4(a), standing-wave measurements indicate that the voltage maximum and minimum are 2 mV and 1 mV, respectively, and a voltage minimum locates at a distance of $0.125\lambda_g$ from the load, where λ_g is the wavelength of the transmission line.
   (a) Derive the reflection coefficient (Γ_L). **(6 points)**
   (b) Derive the load impedance (Z_L). **(4 points)**
   (c) As shown in Fig. 4(b), a transmission-line matching network which consists of a series transmission line and a shunt short stub is used to transform Z_L to 50 Ω, and the length of transmission lines are both smaller than $0.25\lambda_g$. Use Smith chart to explain the impedance trace movement of the transmission-line matching circuit. (Note: Calculating the exact transmission line length is not necessary.) **(6 points)**
5. Two semi-infinite conducting plates are arranged at an angle ϕ_0, as shown in Fig. 5. One plate is charged to 0 volts and the other is charged to V_0 volts. A gap at the tip insulates one plate from the other. Find the electrostatic potential Φ and electric field $\boldsymbol{E}$ in the region $0 < \phi < \phi_0$. **(12 points, 6 points each)**
6. A point charge ($+q$) is located in the middle between two infinitely-extended conducting plates separated by a distance d, as shown in Fig. 6. Find the electrostatic potential Φ at P, which is also located in the middle between the two plates and away from the point charge by d. **(10 points)**
7. A uniform plane wave traveling in vacuum has only x and y components of electric field strength of the form $\begin{cases} E_x = 5sin\left[\omega\left(t-\frac{z}{c}\right)\right] \ \text{(V/m)} \\ E_y = 10sin\left[\omega\left(t-\frac{z}{c}\right)\right] \ \text{(V/m)} \end{cases}$, where ω and c are the angular frequency of the wave and the speed of light in vacuum, respectively.

   (1) What is the polarization state of this uniform plane wave? **(4 points)**

   (2) If a dissipative medium that is homogeneous and anisotropic with $\varepsilon_x = \varepsilon_0$, $\varepsilon_y = \varepsilon_0(1-ja)$, $\mu_x = \mu_0(1-ja)$, and $\mu_y = \mu_0$ occupies the half space $z > 0$, what is the reflection coefficient at the interface $z = 0$ for the above uniform plane wave? **(4 points)**

   (3) Following (2) and given that $a = 2ln(2)/\pi$, what would be the polarization state of the plane wave at $z = \lambda/4$, where λ is the wavelength in vacuum? **(4 points)**

   (4) Find the time-averaged Poynting vector of the wave in W/m^2 at $z = \lambda/4$. **(6 points)**

   [Hint: The polarization states for (1) and (3) must be one of the following: linear, right-handed elliptical,

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left-handed elliptical, right-handed circular, or left-handed circular polarization.]

8. **True or false** (If it is false, explain briefly why it isn't true)
Consider a uniform plane wave incident on an infinitely-extended planar boundary separating two media with refractive indexes n_1 (medium 1) and n_2 (medium 2). The wave impinges obliquely onto the boundary from medium 1. By defining the plane of incidence as the plane including the direction of the wave propagation and the normal to the boundary, there are two sets of plane waves to be considered: perpendicular polarization (electric field perpendicular to the plane of incidence) and parallel polarization (electric field parallel to the plane of incidence). Besides, θ_i and θ_t stand for the angle of incidence and angle of refraction, respectively.
   (1) The Brewster's angle is the incident angle, at which the reflection coefficient for parallel polarization becomes zero. **(3 points)**
   (2) The Brewster's angle exists only when $n_1 < n_2$. **(3 points)**
   (3) At Brewster's angle, $\theta_i + \theta_t = \pi$. **(2 points)**
   As for $n_1 > n_2$, there is a critical incident angle $\theta_i = \theta_c$, at which θ_t becomes $\pi/2$, and the incident wave is totally reflected when $\theta_i > \theta_c$.
   (4) For $\theta_i > \theta_c$, there is no real power transmitted through the boundary. As a result, there is no field in medium 2. **(2 points)**

[In cylindrical coordinates, $\nabla A = \hat{\rho}\frac{\partial A}{\partial \rho} + \hat{\varphi}\frac{1}{\rho}\frac{\partial A}{\partial \varphi} + \hat{z}\frac{\partial A}{\partial z}$ and $\nabla^2 A = \frac{1}{\rho}\frac{\partial}{\partial \rho}\left(\rho\frac{\partial A}{\partial \rho}\right) + \frac{1}{\rho^2}\frac{\partial^2 A}{\partial \varphi^2} + \frac{\partial^2 A}{\partial z^2}$]

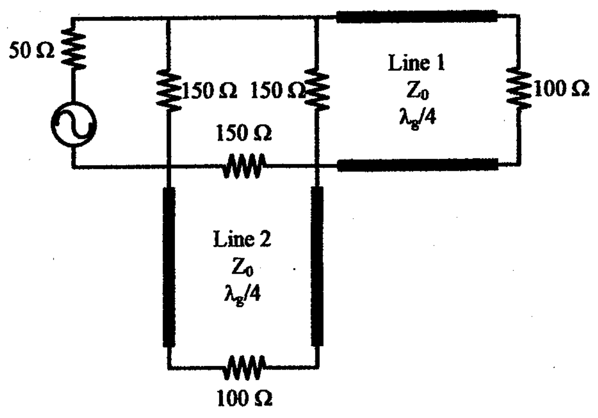


Fig. 1

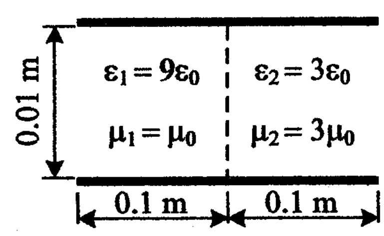
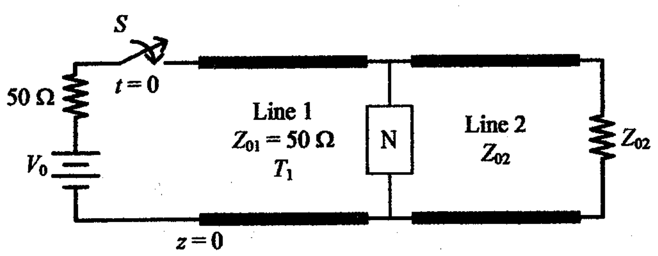
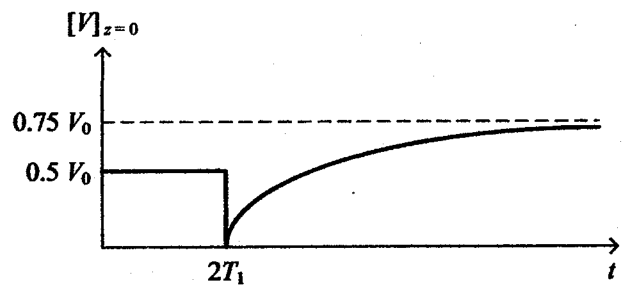


Fig. 2



(a)



(b)

Fig. 3

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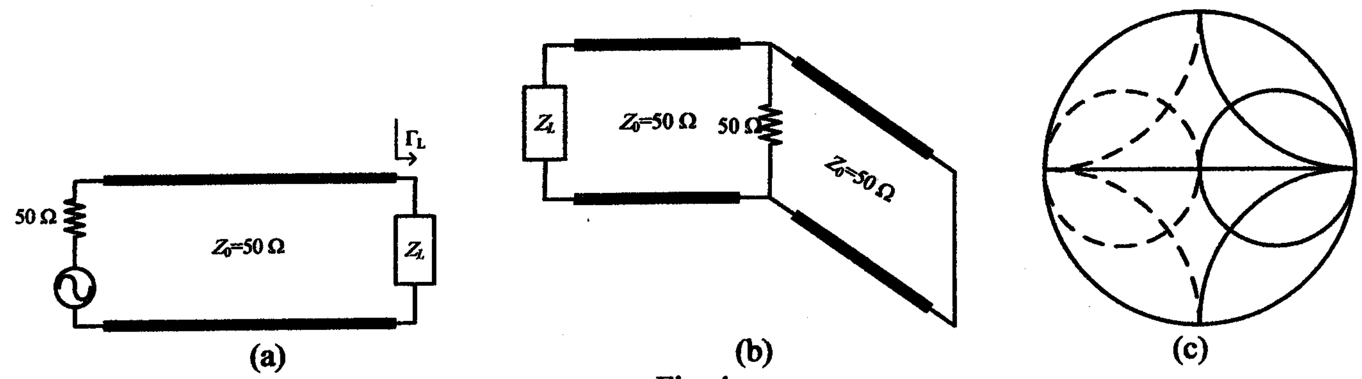

Fig. 4

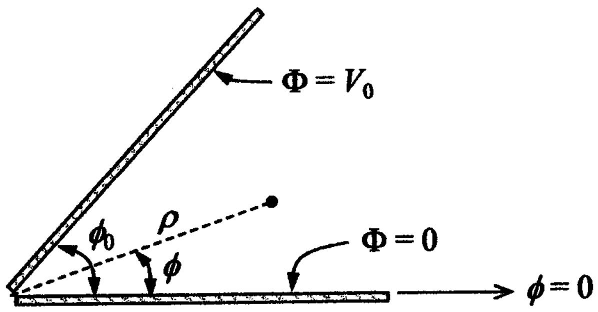

Fig. 5

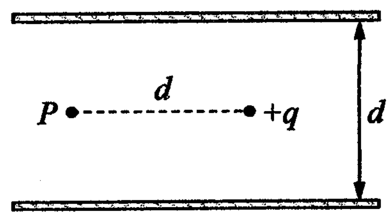

Fig. 6

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