國立台灣科技大學九十七學年度碩士班招生試題

系所組別： 光電工程研究所碩士班

科　　目： 電磁學

總分 100 分

1. (a) Derive the general boundary conditions for the electric field intensity ($\vec{E}$) and electric flux density ($\vec{D}$) at an interface between two different dielectric media with dielectric constants ε_{r1} and ε_{r2}. (10%)

   (b) A plane defined by $6x + 3y + 2z = 5$ separates two dielectrics. The first dielectric, on the side of the plane containing the origin (0, 0, 0), has $\varepsilon_{r1} = 2.5$ and $\vec{E}_1 = 7.0\,\hat{a}_z$ V/m. The other dielectric has $\varepsilon_{r2} = 5.0$. Find $\vec{E}_2$. (10%)

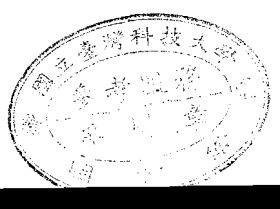
2. A long cylindrical conductor of radius a, with axis along the z-axis, carrying a current density $\vec{J} = \frac{1}{2} J_0 e^{-2r}\,\hat{a}_z$, is situated in empty space. Determine the magnetic field intensity $\vec{H}$ for

   (a) $0 \le r \le a$ (10%)

   (b) $r > a$. (10%)

   (J_0 is a constant and r is the radial distance from the z-axis.)

3. Please describe the Hall Effect. How is it useful? (10%)



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4. Write down Maxwell's equations in the differential form (time-varying) and integral form, and also give the constitutive relations. (10%)

5. As shown in Fig. 5, a dielectric fiber of a transparent material can be used to guide light or an electromagnetic wave under the conditions of total internal reflection. Determine the minimum dielectric constant (ε_{r1}) of the guiding medium so that a wave incident on one end at any angle will be confined within the fiber until it emerges from the other end. (10%)

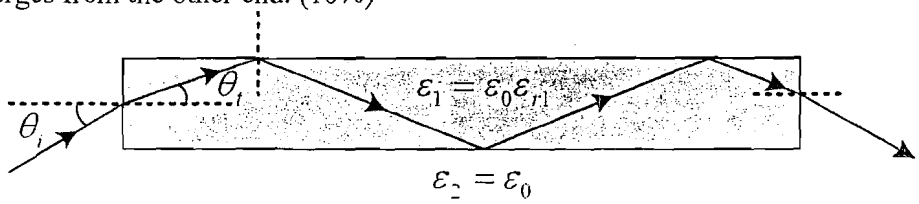

Fig. 5

6. The equivalent circuit of a differential length Δz of a transmission line is shown in Fig. 6. Derive the **time-harmonic** transmission line equations, (6%) and give the formulas for calculating the propagation constant γ (2%) and the characteristic impedance Z_0.(2%)

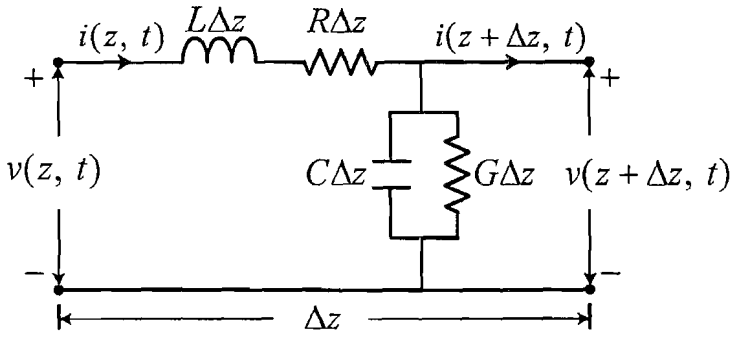

Fig. 6

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7. A *RLC* circuit with component values R=50Ω, L=1 nH, and C=1 pF is illustrated as Fig. 7. The impedance of this circuit is denoted by Z. As Z is normalized to the characteristic impedance 50 Ω and graphically represent on the impedance Smith Chart, determine the rough locations of the normalized Z at the following operating frequencies. (a) 0 Hz, (b) 2×10^9 Hz, (c) 5×10^9 Hz, (d) 10×10^9 Hz, and (e) 1×10^{100} Hz. (10%)
{hint: Only location symbol (A, B, C, …) on the Smith Chart is required to write down on the answer sheet. In addition, please clearly note the question number [(a), (b), (c)]….}

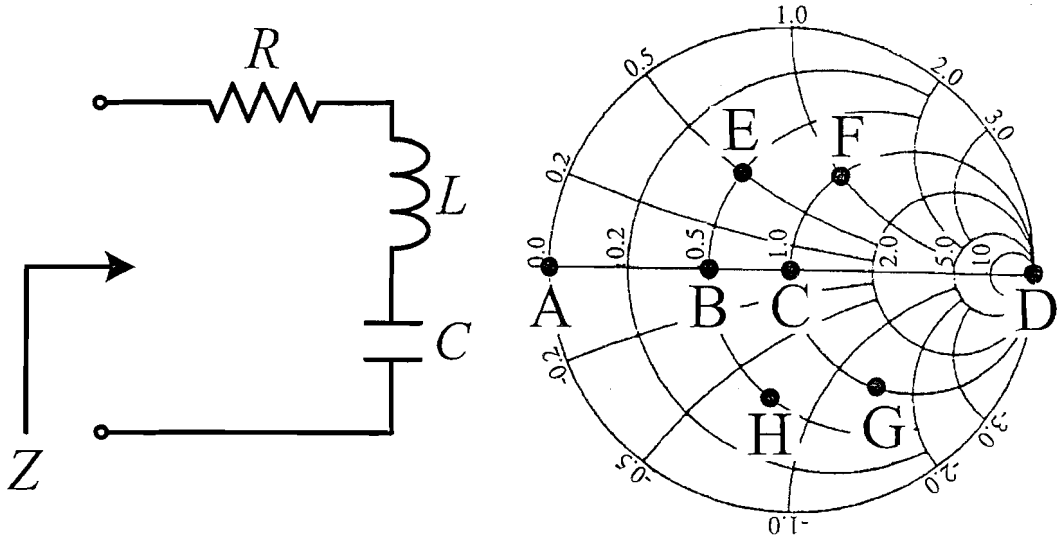

Fig. 7

8. A metallic rectangular waveguide filled with the non-magnetic material having the relative permittivity $\varepsilon_r = 9$ is shown in Fig. 8. The cross-section dimensions of the waveguide are a=4 cm and b=2 cm.
(a) Show that the TEM mode can not exist in the waveguide structure. (4%)
(b) List the lowest 3 propagation modes (3%) and calculate the corresponding cutoff frequencies. (3%)

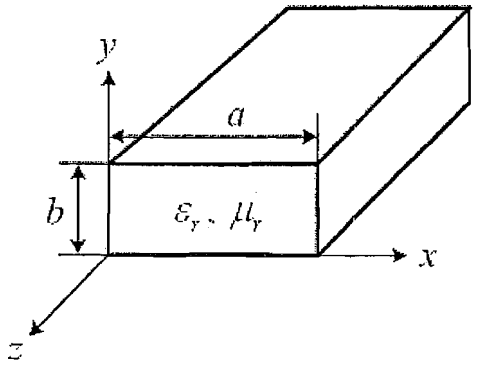

Figure 8