國 立 清 華 大 學 命 題 紙

九十九學年度第一學期 光電工程研究所 博士班研究生資格考試

科目 電磁理論 共 頁第 頁 ＊請在試卷(答案卷)內作答

1. (15%) You have a plane electro-magnetic wave propagating along the z-direction in vacuum. Start from the Maxwell's equations, explicitly show why such wave needs to be transverse. State all your assumptions and reasons.

2. (15 %) When there is a relative motion between a time-harmonic source and a receiver, the frequency of the wave detected by the receiver tends to be different from that emitted by the source. This phenomenon is known as the Doppler effect. Let us assume that a light transmitter of a time-harmonic wave of a frequency f moves with a velocity u at an angle θ relative to the direct line to a stationary receiver.

   (a) Please derive and show that the frequency of the received wave is $f' = \dfrac{f}{1 - \dfrac{u}{c}\cos\theta}$

   (b) If the transmitted signal has a spectral linewidth of $\Delta\nu$, what would be the linewidth of the received signal after the Doppler effect?

   (c) How would the linewidth of the received signal change if the target has a rough surface?

3. (15 %) A symmetric planar waveguide has a core thickness of 3 μm. Ignoring the dispersion of the waveguide material, we find the indices to be n1(core) = 1.50 and n2(cladding) = 1.46.

   (a) Is the waveguide single-mode or multimoded at λ = 1.5 and 1.3 μm? (5 pts)

   (b) What is the range of wavelength in which this waveguide is single-mode? (10 pts)

4. (10 %) Can you explain why dielectric waveguides can't support TEM modes whereas metallic waveguides can?

5. (25%) Consider a parallel-plate capacitor biased by a constant voltage V_0. Assume $w, L >> d$ (L is the linear dimension along the z-direction). Neglect the fringing effect near the edges.

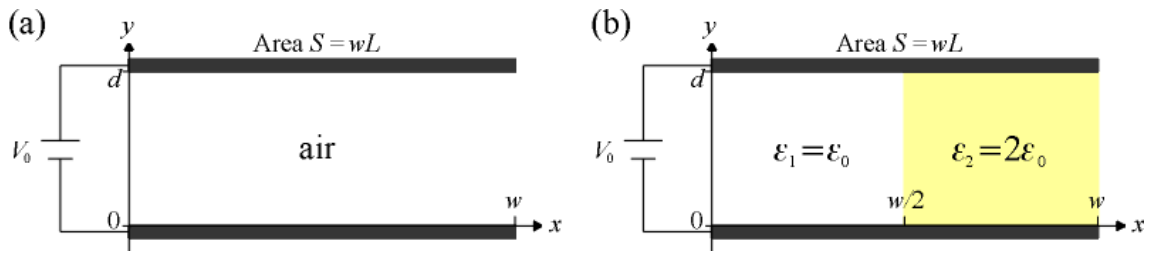

Figure 1.

1a. If the insulating region ($0 < y < d$) is filled with air (Fig. 1a), evaluate and plot the electric field intensity $\vec{E}$, the electric flux density $\vec{D}$ everywhere in the insulating region. Also evaluate the free surface charge density ρ_s on the two conducting plates and the capacitance C. Justify your answers. (10 pts)

1b. Repeat problem 1a if the insulating region is filled with two dielectric materials in parallel (Fig. 1b). (7 pts)

1c. Refer to problem 1a, will the capacitance C be larger or smaller if the fringing effect at the conducting edges are taken into account? Justify your answer. (8 pts)

6. (10%) A time-harmonic wave of rms voltage V_0 propagates with phase constant β along a lossless transmission line terminated by an unmatched load. Given the transmission coefficient at the termination as τ and reflection coefficient as Γ, please derive the total voltage along the transmission line as a sum of traveling and standing waves. Express your answer both the complex V(z) and the instantaneous form v(z,t). (Please express your answer in terms of V_0 , β, z, τ, and Γ).

7. (10%) (a) Do the boundary conditions derived for electrostatics and magnetostatics remain valid for time-varying fields? Please explain your reasoning. (b) Deduce the boundary conditions for $\vec{H}$ from Maxwell's equations, assuming $\vec{J}_s$ is the surface current density at the boundary. (No credit is given to a correct answer without any explanation or derivation.)