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%) Assume you have free magnetic charge density ρ_m in certain material.

(a) (3%) What is the unit of ρ_m ?

(b) (6%) How would you modify the Maxwell's equations accordingly? State your theoretical/physical basis and identify all terms.

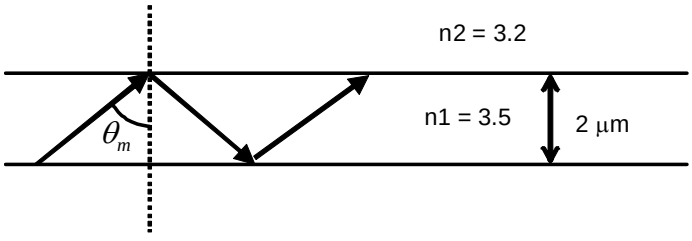
(c) (6%) Discuss the resulting boundary conditions.

2. (15%) Consider a plane wave propagating in an imperfect dielectric material.

(d) (5%) What does "imperfect dielectric" mean? Describe it verbally and mathematically.

(e) (10%) Discuss the wave propagation behavior in such material according to its degree of "imperfectness". (*Hint: find the resulting wave number*)

3. (25%) Consider a symmetric optical slab waveguide with a refractive index of 3.5 inside the guide and a refractive index of 3.2 outside the guide; the waveguide dimension is 2 μm, and assume the magnetic permeability is the same everywhere.



(a) (7%) For a light with a wavelength of 1.5 μm in free space, find the number of guided TE modes in this waveguide.

(b) (8%) Using the ray optics approach, find the angle θ_m of the guided TE_m mode bouncing back and forth between the two boundaries of the waveguide.

(c) (10%) Find the cutoff wavelength lm of the TE_m mode.

4. (25%) Consider a parallel plate capacitor. The two conducting plates are of area A (m^2) and separated by a distance d.

(a) (5%) If a battery of voltage V_0 is connected to the two plates ($V(0)=V_0, V(d)=0$), what is the surface charge density ρ_s (C/m^2) at $z=0$ (Fig. 1)?

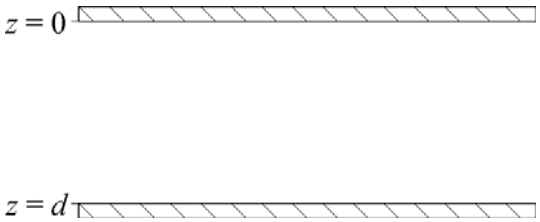


Fig. 1.

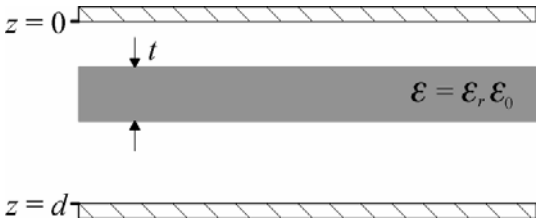


Fig. 2.

(b) (5%) A perfect dielectric slab with $\varepsilon=\varepsilon_r\varepsilon_0$ and thickness d is inserted somewhere between the plates (Fig. 2). Find the expressions for the electric field intensity ($\vec{E}$) in each region in terms of ρ_s, ε_r, and ε_0.

(c) (10%) Find the capacitance for the geometry of question (b) in terms of ε_r, ε_0, d, t, and A.

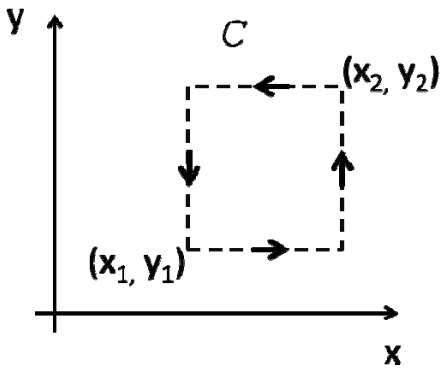
(d) (5%) What is the work done to insert the dielectric slab if each plate has constant charge Q? (*Hint*: The energy stored in a capacitor of capacitance C with deposited charge $\pm Q$ is $W_e=\frac{Q^2}{2C}$.)

5. (10%) TEM transmission line is characterized by the capacitance per unit length C, inductance per unit length L, Z_0 ($=\sqrt{L/C}$) and k ($=\omega\sqrt{LC}=\omega\sqrt{\mu\varepsilon}$). For a coaxial cable with inner radius a and outer radius b , the capacitance and inductance per unit length are given by $C=\frac{2\pi\varepsilon}{\ln(b/a)}$ and $L=\frac{\mu\ln(b/a)}{2\pi}$.

(a) (6%) Please design the dimensions of an air-filled coaxial cable such that the characteristic impedance is 50Ω.

(b) (4%) Would it be practical to have an air-filled coaxial cable with a characteristic impedance of 1Ω? Please explain.

6. (10%) An electric field is $\vec{E} = Ay\hat{a}_x$ where A is a constant.



(a) (5%) Please find $\oint_C \vec{E} \cdot d\vec{\ell}$ for the curve *C* shown in the figure.

(b) (5%) Assume there is a uniform magnetic field $\vec{B}(t) = B(t)\hat{a}_z$ in space. Please use the result in (a) and Faraday's law to find $B(t)$.