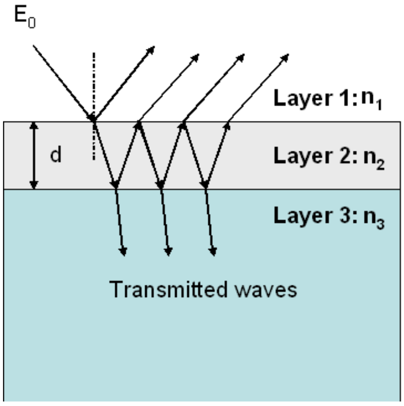
國 立 清 華 大 學 命 題 紙

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__光電子學一__共____頁第____頁 ＊請在試卷(答案卷)內作答

1. (4%) ABCD matrices are often used in ray optics to calculate the transfer function of certain optical element or even optical system. Can the ABCD matrices be used all the time? (6%) Show the step-by-step derivations for the ABCD matrix of a thin lens.

2. (15%) Consider a thin film coating on a substrate as shown below. The incident wave has an amplitude of E_0 and there are various transmitted and reflected waves. Assume $n_1<n_2<n_3$ and the thickness of the coating is d.



(1) Please derive the transmission coefficient from layer 1 to layer 3 (i.e. the ratio of total transmitted waves to E_0). For simplicity, you may assume normal incidence for your derivation. The phase change in traversing the coating thickness d is $\phi=(2\pi/\lambda)n_2d$ where λ is the free space wavelength. This phase change needs to be included in your calculation.

(2) Please derive the conditions for the thickness d and the refractive indices of layers such that a normally incident light beam has maximum transmission into medium 3.

3. (5%) Show explicitly what is the so-called paraxial approximation. (5%) If your classmate tells you that Gaussian beams do not exist in the real world, what is your reply?

4. (10%) A plane wave of wavelength 532 nm is propagating along the z axis through an amplitude modulator, $\cos^2(4\pi \times 10^{-7} x - 8\pi \times 10^{-6} y)$. Write down the mathematic expression of the transmitted wave and the diffracted angle.

5. (10%) Electromagnetic optics.

(1) Roughly plot the wavelength-dependent absorption coefficient and index of refraction of a typical dielectric material. (5%)

(2) If a white light beam impinges on a prism made by anomalously dispersive medium, draw the output R(ed), G(reen), B(lue) rays. (5%)

6. (10%) Consider a time-harmonic plane wave. The corresponding vector phasors of EM fields $\vec{E}$, $\vec{D}$, $\vec{H}$, $\vec{B}$ are proportional to $\exp\left(-j\vec{k}\cdot\vec{r}\right)$, where $\vec{k}$ and $\vec{r}$ represent wave vector and position vector, respectively.

(1) If the wave propagates in an electrically anisotrpic medium, show that the power density vector (Poynting vector $\vec{S}$) is NOT in parallel with $\vec{k}$ (Hint: Use Maxwell's curl equations). (6 %)

(2) According to the fact in (1), sketch $\vec{S}$ and the corresponding phase fronts conceptually. (4%)

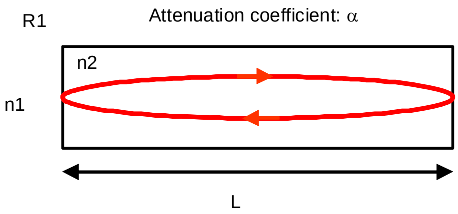
註解 [SY1]: Please modify this number accordingly.

7. (15%) Consider electromagnetic waves resonating inside a Fabry-Perot cavity as shown in the figure below. R1 and R2 are the reflectivity at the two end of the cavity. a is the attenuation coefficient and n1, n2 are the refractive indices.

(1) What is the free spectrum range, if we don't consider the waveguide dispersion?

(2) If light pass through this Fabry-Perot cavity (for example, from left to right), please sketch the transmittance spectrum.

(3) Continue in (2), what is the dynamic range of transmittance (T_{max}/T_{min}) ?



8. (10%) Plot the photon number distribution, P(n) = $|\langle n|\phi\rangle|^2$, as a function of photon numbers for the state, $|\phi\rangle$

(1) (2%) Number state, $|\phi\rangle = |n = 3\rangle$;

(2) (5%) Coherent state, $|\phi\rangle = |\alpha = 3\rangle$;

(3) (3%) Squeezed Coherent state, $|\phi\rangle = |\xi=3, \alpha= 3\rangle$

9. (10%) A lasing transition is occurred between upper energy level and lower energy level with lifetimes τ_u and τ_l, respectively. The lasing photon energy is ΔE. Write down the likely line shape function and elaborating the relationship between the lifetimes and the broadening line profile assuming that the lasing gain medium is a single crystal.