國立清華大學命題紙

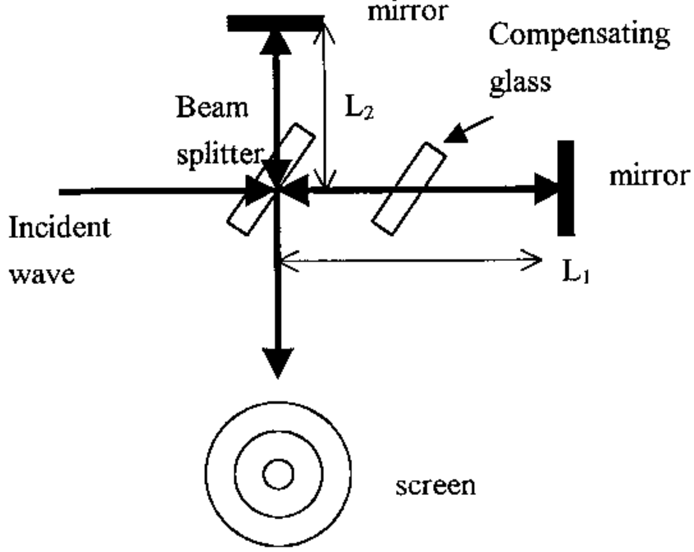
八十九學年度第一學期 電機工程 學系所 博士班研究生資格考試

科目 光電子學 科號 ＿＿＿ 共 2 頁第 1 頁 ＊請在試卷(答案卷)內作答

1. Snell's law of refraction at a material boundary is a fairly general result in any kind of waves. Prove Snell's law of refraction by using at least three methods. (10%)

   Hint: a. Fermat's principle. b. Eikonal equation. c. Construction of wavefronts. d. Conservation of tangential k vector. e. Brutally solve the electromagnetic wave solution at two boundaries. or anything creative and yet reasonable.

2.



A Michelson interferometer is shown above, wherein the compensating glass compensates the optical path difference resulted in the beam splitter.

(a) The incident wave is a superposition of two harmonic waves polarized in the same direction, given by
$E = E_0 \cos(\omega_1 t - k_1 z) + E_0 \cos(\omega_2 t - k_2 z)$, where $\omega_1 - \omega_2 = 2\pi \times 100$ GHz.
Plot the interference intensity versus $|L_1 - L_2|$, the optical path difference, at the screen. (5%)

(b) If the incident wave now is not a harmonic wave but has a bandwidth of 100 GHz, what is the interference intensity versus $|L_1 - L_2|$ that you expect to see at the screen? Explain thoroughly the physics behind your answer. (5%)

3. The ray matrix for a thin lens can be written as $\begin{bmatrix} 1 & 0 \\ -1/f & 1 \end{bmatrix}$, where f is the focal length of the lens. Consider the derivation for this ray matrix carefully, and think the problem:

   What would the ray matrix be if the lens is a thick lens? Or, does the idea of such a ray matrix exist for a thick lens? Explain. (10%)

4. The reflected and transmitted light intensities of a Fabry Perot etalon are, respectively, $I_r/I_o=4R\sin^2(\delta/2)/((1-R)^2+4R\sin^2(\delta/2))$ and $I_t/I_o=(1-R)^2/((1-R)^2+4R\sin^2(\delta/2))$, where δ is the round trip phase delay and R the product of the reflectivities of the two mirrors.

(a) From this, derive the shift of a spectral peak for the transmitted light as the length of the cavity is changed by ΔL. (7%)

(b) Explain how you would use a Fabry Perot etalon to measure an unknown spectrum of a light source. (8%)

5. A polarizing beam splitter followed by a quarter-wave plate can be used as an optical isolator. Light beam travel through the device is linearly polarized by the beam splitter then circularly polarized by the quarter-wave plate. Upon reflection from a mirror that is located beyond the quarter-wave plate, the sense of polarization is reversed, so that upon transmission back through the quarter-wave plate it becomes linearly polarized in the orthogonal direction and is blocked by the beam splitter. Use Jones calculus to show the optical isolation effect of such a device. (10%)

6. A randomly polarized beam is incident upon an uniaxial crystal at an oblique angle from the air, how to determine the polarization and wave-vector of the refracted beams. The optical axis of the crystal is oriented at an oblique angle with respect to the crystal surface. (15%)

7. An optical radiation with wavelength λ propagates through a solid medium of thickness L. If the temperature dependence of refractive index n and thickness L of the medium are dn/dT and dL/LdT, respectively, find the phase change per degree C, $\Delta f/\Delta T$, for the passed radiation. (10%)

8. Plot the typical graphs for the refractive index $n(\nu)$ and absorption coefficient $\alpha(\nu)$ near the absorption resonance frequency ν_o of a medium having an absorption linewidth of Δn. (8%)

9. A gas medium composed of N_o atoms per cm^3 is kept at temperature T. The atoms are assumed as two level systems having energy states E_1 and E_2 with transition cross section $\sigma(\nu)$ between them. Find the absorption coefficient $\alpha(\nu)$ of the medium. (12%)