國立清華大學命題紙

八十九學年度第二學期 電機工程 學系 博士班研究生資格考試

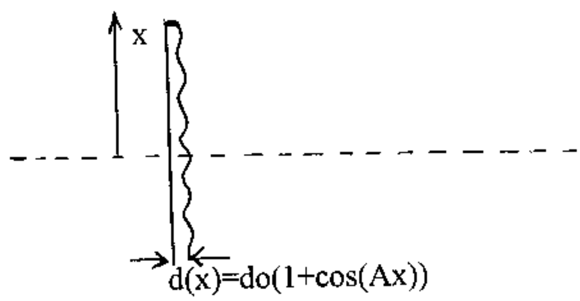
科目 光電子學 科號 共 3 頁第 1 頁 *請在試卷(答案卷)內作答

1. For the case of plane wave incidence upon a thin lens, we may express the complex amplitude transmittance of the lens as

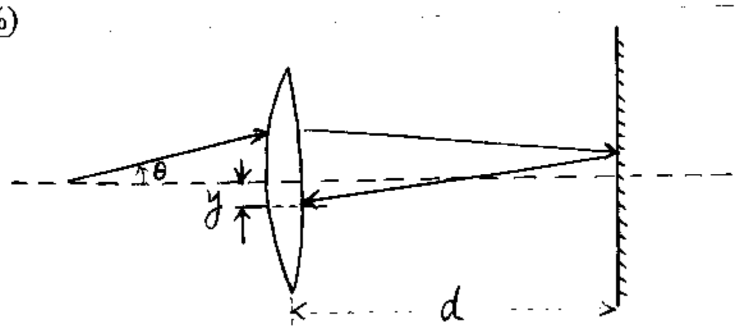
$t(x,y)=h_o\exp[j\,k_o(x^2+y^2)/2f]$, where h_o is a constant, k_o the propagation constant and f the focal length.

(a) Now consider a thin transparent plate whose thickness varies sinusoidally in the x didection (see the figure below). Write the complex amplitude transmittance of the plate. (7%)

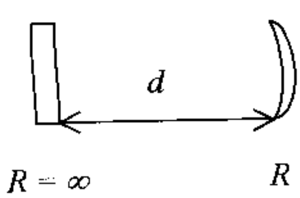
(b) What would you expect to see after a plane wave passes through the plate? (6%)



2. Use ray (ray transfer) matrix to compute y of the optical scheme shown below, where an optical beam is incident upon a thin lens and then directed to a reflective mirror. (12%)



3. A laser resonator consists of a flat mirror and a concave mirror with a radius of curvature *R*. The two mirrors are separated by a distance *d*. Assume the resonator is in a vacuum and the thickness of the two mirrors is negligible.



a. What is the stability condition of this laser resonator? (2%)

b. If a laser field oscillates in this resonator, where is the laser waist? (2%)

c. What is the Rayleigh range of the laser z_R? (2%)

d. What are the laser radii on the two mirrors? (4%)

e. If you would like to have the largest laser spot size on the flat mirror, what is the resonator length *d* for a given *R*? Under this condition what is the laser waist radius? (4%)

f. What is the diverging angle of the laser in the far field (full angle)? (2%)

4. The susceptibility of a resonant system, modeled by a classic harmonic oscillator, is give by

$\chi(\nu) = \chi_0 \dfrac{\nu_0^2}{\nu_0^2 - \nu^2 + j\nu\Delta\nu}$, where χ_0 is the DC susceptibility, ν_0 is the resonant frequency of the oscillator, ν is the driving frequency, and $\Delta\nu$ is the absorption bandwidth.

a. If the resonant system has a negligible damping, how would it affect the absorption bandwidth? Explain the physics or no credit will be given. (2%)

b. Without damping, the susceptibility has a π phase shift near the resonance. Explain the physics for what happens to the harmonic oscillator with the π phase shift near the resonance, including the cause of it and the behavior of the harmonic oscillator before the after the driving frequency is tuned before and after the resonance. (3%)

c. With the damping in place, calculate the refractive index and the absorption coefficient at the resonance. Assume the susceptibility is much less than 1. (4%)

5. Use Jone's matrix to show that two cascaded quarter-wave retarders with parallel fast axes are equivalent to a half-wave retarder. What if the fast axes are orthogonal? (10%)

6. Can you make a fast and rough estimation about how much percentage of light will transmit through a piece of flat glass with refractive index of 1.5 on normal incidence. Describe how do you do the estimation. (5%)

7. Given the normal surface (i.e. the **k** surface) of a uniaxial crystal, show that, schematically, how do you determine the energy transport direction of the ordinary and extraordinary waves with respect to the direction of the k vectors. (10%)

8. A Fabry-Perot formed by two mirrors of reflectance $R_1=R_2=90\%$ is operated at wavelength of 1 μm.

(1) If there is no loss, find the finesse F, the maximum of transmittance T_{max}, the minimum of reflectance R_{min} and the width of transmittance $\Delta\nu_{FWHM}$. (10%)

(2) List the possible sources of resonator loss. What is the effect of those losses to the performance of Fabry-Perot? (5%)

9. An atomic transition at wavelength $\lambda=0.5$ μm was measured to have a spontaneous lifetime of 2 ns and a homogeneous broadened linewidth (Lorentzian lineshape) $\Delta\nu_{FWHM}=100$ MHz. Find the transition cross-section at line center, $\sigma(\nu_o)$. (10%)