國 立 清 華 大 學 命 題 紙

一百零二學年度第一學期 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 2 頁第 1 頁 ＊請在試卷(答案卷)內作答

1. (a) What is Snell's law? (b) What is Fermat's principle? (c) Derive Snell's law using the Fermat's principle as the fundamental postulate. (10%)

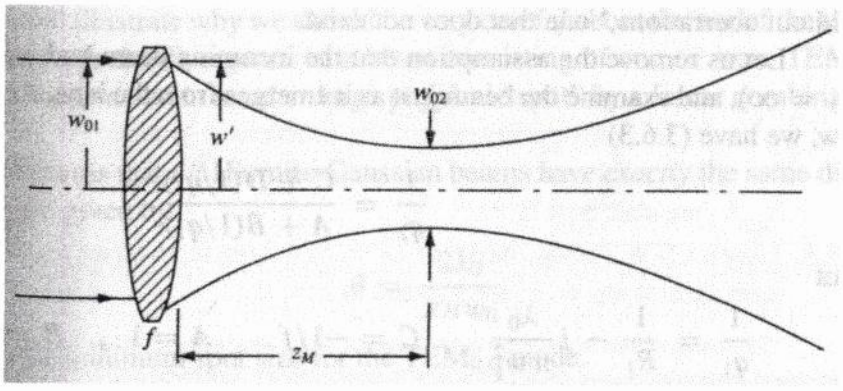
2. Consider the light passes through a plate with index n and thickness d, in which light experiences attenuation. The plate is in a medium of index n_0. Assume the reflectance at each n-n_0 interface is R and the attenuation coefficient is α.

(a) (5%) Please derive the transmittance T of light passing through the plate.

(b) (5%) If we neglect any loss in the glass plate (i.e. α=0), please express n/n_0 in terms of the transmittance T.

(c) (5%) If the plate is placed in air (n_0=1) and the transmittance has been measured to be 89.96%, what is its refractive index of the plate? Do your think this is a good way to measure the refractive index?

3. (10%) As shown in the figure, a thin lens with focal length f = 157 cm is used to focus a large-diameter Gaussian beam with a planar wave front with w_{01} = 1 mm and l_0 = 1 μm. Where after the focal point would the laser beam again diverge back to $w = w_{01}$? What would be the radius of curvature R there?



4. (a) (8%) Provide clear definition of spatial frequency. Also discuss in details, how the attributes of spatial frequencies affect an optical beam.

(b) (7%) Design an optical setup/system, so one can freely compress/broaden the spatial frequencies. You need to provide detailed explanations.

5. The Maxwell's equations in a linear, nondispersive, homogeneous, and isotropic medium can be written as

$$\nabla \cdot \mathbf{D} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t}$$

(a) How are the permittivity and permeability defined using **D**, **E**, **B**, and **H**? (4%)

(b) How is the susceptibility defined using **P** and **E** (or **P** and **D**)? **P** is the polarization density. (5%)

(c) Show that the wave equation can be written as

$$\nabla^2\mathbf{E} - \mu_0\varepsilon_0\frac{\partial^2\mathbf{E}}{\partial t^2} = \mu_0\frac{\partial^2\mathbf{P}}{\partial t^2}.$$

(6%)

6. （a） (5%) If the Jones vector of a monochromatic plane wave of wavelength (in vacuum) λ_0 is:

$$\begin{bmatrix}1\\ j\end{bmatrix},$$

Plot the trajectory and denote the sense of rotation of the corresponding E-field.

（b) (5%) What happens if the wave passes through a birefringence crystal of thickness L where $(n_x - n_y)\frac{2\pi L}{\lambda_0} = 2.5\pi$? Justify your answer.

7. (15%) Please give the density of modes at frequency f for

(a). (5%) 1D resonator (in terms of mode no. per unit frequency per unit length)

(b). (5%) 2D resonator (in terms of mode no. per unit frequency per unit area)

(c). (5%) 3D resonator (in terms of mode no. per unit frequency per unit volume)

8. (10%) Consider light of constant optical power P, the frequency v, in a time interval of duration T, find

(a) the detected mean photon number, and

(b) the corresponding variance.