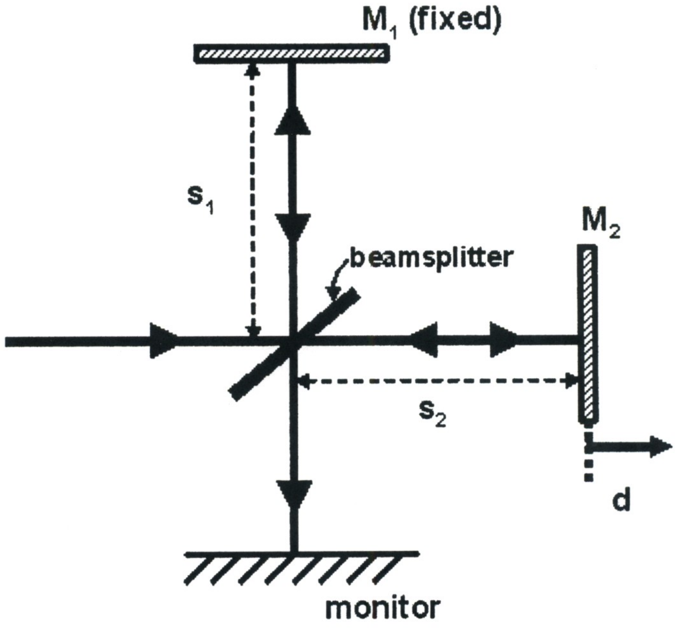
國立清華大學命題紙

九十六 學年度第二學期 光電工程研究所 博士班研究生資格考試

科目 光電子學 一 科號 ____ 共 三 頁第 ____ 頁 ＊請在試卷(答案卷)內作答

1. An interferometer is an optical instrument that splits a wave into two waves, which travel different paths, and then recombine to create interference. The following diagram is an example of an interferometer.



(a) (4%) What is the name of this type of interferometer? Name another type of interferometer and draw the corresponding interferometer setup.

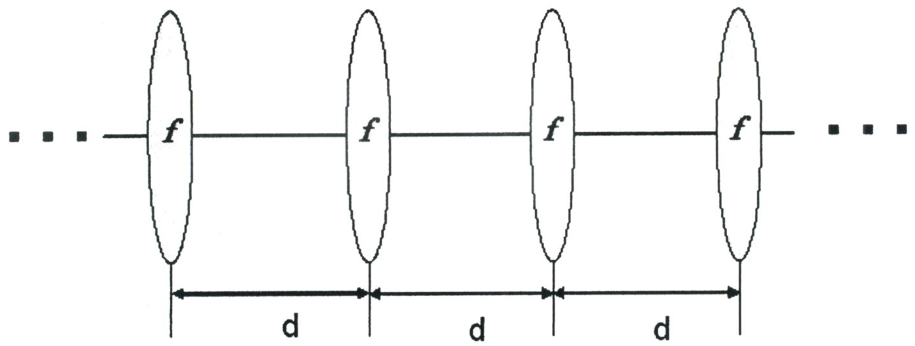
(b) (4%)A monochromatic wave with wavelength λ and intensity I is utilized in this interferometer. Assume the initial position $s_1 = s_2$. Draw the intensity variation with respect to the moving distance d of M_2. (Please denote both axes and draw a few periods of interference patterns. Specify the pattern period in terms of λ clearly.)

(c) (4%) We can utilize this interferometer to evaluate the refractive index of a material. A piece of glass with thickness L and refractive index n is placed between the beamsplitter and M_2. It introduces a path difference that results in a shift in the interference pattern. Assume we observe m periods shift in the interference pattern at the monitor. Please express the refractive index of glass in terms of L, λ, and m.

2. A periodic system is a cascaded of identical unit system. The following diagram is an example of a periodic system where a set of identical lenses of focal length f separated by distance d. The ABCD matrix for distance z in free space is $\begin{bmatrix} 1 & z \\ 0 & 1 \end{bmatrix}$. The ABCD matrix for a thin lens with focal length f is $\begin{bmatrix} 1 & 0 \\ -\frac{1}{f} & 1 \end{bmatrix}$.

(a) (4%)Please identify a unit cell directly on the diagram and calculate the corresponding ABCD matrix.

(b) (4%)What is the condition for d and f such that the ray trajectory is bounded(stable) in this system?



3. The absorption cross-section for the transition of atoms between energy states E_1 = 1 eV and E_2 = 2 eV is $\sigma(\nu)$.
   (1) Determine the wavelength λ_o of the absorption center. (2%)
   (2) Explain the physical effects that result in the line shape of $\sigma(\nu)$. (7%)
   (3) Find the population ratio N_2/N_1 for thermal equilibrium at room temperature. (3%)
   (4) If $N_2 > N_1$, sketch firefly the absorption coefficient $\alpha(\nu)$. (3%)

4. (10%) Write down the transfer function of free space propagation without assumption. A 632.8 nm HeNe laser is propagating through an amplitude modulator, $\sin(8\pi 10^6 x)$. What's behavior of the transmitted wave (explain by the transfer function)?

5. (5%) How do you design a filter to perform the edge enhancement of a 4-f system? Draw the system layout.

6. (8%) The scalar wave equation is of the form:

$$\nabla^2 E + k^2 E = 0$$

where E represents the scalar phasor of time-harmonic E-field, k is wave number. How to modify the equation if we are interested in the behavior of visible light pulse (of femtosecond duration) impinging on a thin (nanometer-scale) dielectric layer? Justify your answer.

7. (6%) Plot a setup to measure the dispersion of material. Describe the working principles.

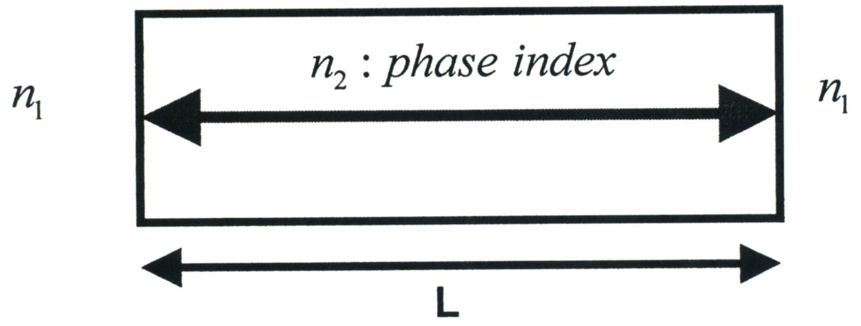
8. (6%) Design an amplitude modulator based on controlling and selecting polarization state. Discuss the limitations of performances (such as modulation speed, extinction ratio, insertion loss) of your design.

9. (15%) Consider electromagnetic waves resonating inside a Fabry-Perot cavity as

shown in the figure below. Apparently, there are multiple resonant frequencies (or wavelengths) ν_1, ν_2, ν_3, ... The free spectrum range is $\Delta\nu = \left(\frac{2L}{c} n_g\right)^{-1}$, where n_g is the group velocity index and c is the speed of light. Please answer the following questions:

(1)(10%) Please derive the equation $\Delta\nu = \left(\frac{2L}{c} n_g\right)^{-1}$

(2)(5%) Please give an intuitive explaining why the group velocity index is used instead of the phase velocity index.



10. (9%) The ***mutual intensity*** of an optical wave at points on the x axis is given by

$$G(x_1,x_2) = I_0 \exp[-\frac{(x_1^2 + x_2^2)}{W_0^2}]\exp[-\frac{(x_1 - x_2)^2}{\rho_c^2}],$$

where I_0, W_0, and ρ_C are constants.

(a) Derive an expression for the normalized mutual intensity $g(x_1,x_2)$ (3%) and sketch it as a function of $x_1 - x_2$ (3%).

(b) What is the physical meaning of the parameters I_0, W_0, and ρ_C? (3%)

11. (6%) Consider the following three basic hypotheses:

(a) For sufficiently small Δt, the probability of a single impulse occurring in the time interval t to $t + \Delta t$ is equal to the product of Δt and a real nonnegative function $\lambda(t)$; thus $P(1;t,t+\Delta t) = \lambda(t)\Delta t$.

(b) For sufficiently small Δt, the probability that more than one impulse occurs in Δt is negligibly small (i.e. there are no "multiple" events); hence $P(0;t,t+\Delta t) = 1 - \lambda(t)\Delta t$.

(c) The numbers of impulses in nonoverlappling time intervals are statistically independent.

Then by using the three fundamental hypotheses above show that the photocount statistics for light from a single-mode, amplitude-stabilized laser radiations obeys the ***Poisson process***.