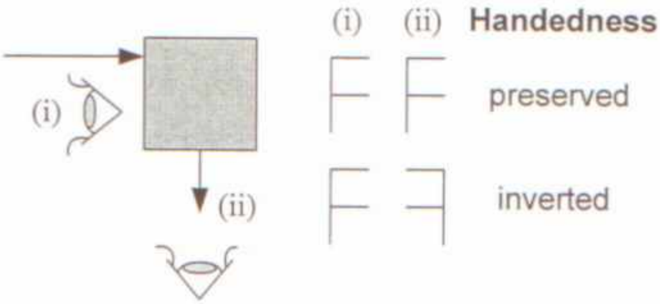
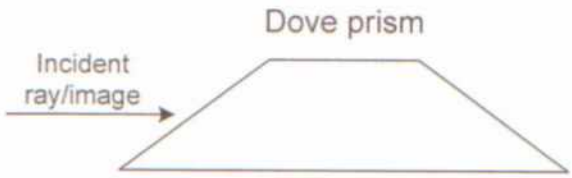
光電所 98 學年度第二學期博士班資格考 光電子學 I 考題
總共四頁 十題 一百分

1. (4%) In various applications it is desired to redirect the image/beam propagation by 90 degrees but without inverting it's handedness (see below for demonstration of preserved and inverted handedness when looking into the beam). Come up with a simple design.



(6%) A dove prism is a common device. Discuss the unique properties of an incident ray/image through the dove prism as shown below.



2.

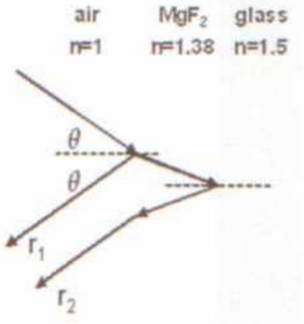
(1) (4%) Please list two types of interferometers (please write down the name and draw the configuration).

(2) (a) (2%) We use the term "plane wave" where plane is used to describe the characteristic of the wave. What is actually plane of a plane wave?

(b) (4%) Consider two plane waves, each of intensity I_0 and wavelength λ, propagating in the same direction, and assume that one wave is delayed by a distance d with respect to the other. Please derive the intensity of the superposition these two plane waves to be

$$I = 2I_0(1+\cos(2\pi\frac{d}{\lambda}))$$

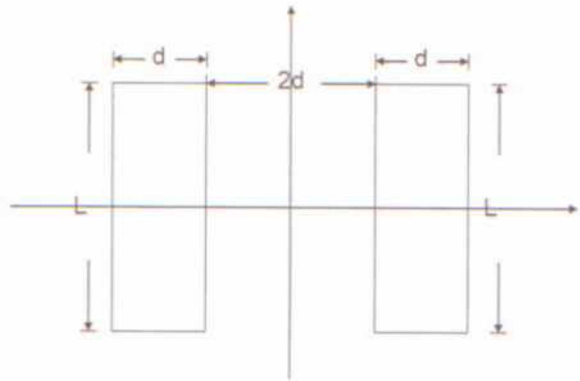
(3) (5%) To build a glass (n=1.5) with the least reflection, we can apply a material with a proper thickness, such that the reflection is minimized by interference. Assume that we apply MgF_2(=1.38) for such anti-reflection coating as shown below. Please calculate the thickness of MgF_2 in order to minimize the reflection at 550nm (assuming normal incidence θ=0).



3. A Gaussian beam in free space with wavelength **l** = 1 μm has beam waist $\mathbf{w_0}$ = 10 μm.
   (1) Find its divergence angle θ and Rayleigh range $\mathbf{z_R}$. (4%)
   (2) A thin lens with ray matrix [A, B; C, D] is located at distance **s** away from the beam waist. Derive the beam parameter **q** just passing the lens. (4%)

4. Explain the property and physical origin for the atomic spectral line shape of
   (1) homogeneous broadening (4%)
   (2) Doppler broadening (3%)

5. (15%) A uniform plane wave of wavelength λ normally incidents on the double slits as shown below. Write down the diffracted fields in the Fresnel and Fraunhofer region and the sufficient distances, respectively.



6. (10%) In a simple (linear, homogeneous, isotropic) nondispersive medium, the polarization density $\bar{P}$ (i.e. volume density of the induced electric dipole moment) is related to the external e-field $\bar{E}$ via:

$$\bar{P} = \varepsilon_0 \chi \bar{E} \tag{1}$$

where ε_0 is the permittivity of vacuum, and $\chi (= \chi' + j\chi'')$ is the "constant" susceptibility of the medium. This means the bound electrons of the material can react to the external e-field instantaneously.

(a) How to modify eq. (1) and χ in the "frequency" domain (i.e. phasor relation) if the medium is simple but dispersive? (3 pts)

(b) How to modify eq. (1) and χ in the "time" domain if the medium is simple but dispersive? The result should show that the response of $\bar{P}$ to $\bar{E}$ is not instantaneous. (4 pts)

(c) Why one can determine the spectral dependence of refractive index ($\sim \chi'$) by measuring the absorption ($\sim \chi''$)? No formula is required. (3 pts)

7. (10%) Consider the vector phasor of the e-field of a time-harmonic uniform plane wave propagating in the +z direction:

$$\bar{E}(z)=E_0\left(2\bar{a}_x + j\bar{a}_y\right)e^{-jkz}\text{, where } E_0=\left|E_0\right|e^{j\phi}$$

(a) Write down the time-dependent e-field components in the x, y directions at $z=0$, i.e. $E_x(t)$, $E_y(t)$, respectively. (3 pts)

(b) Describe the corresponding polarization state, including the trajectory and sense of rotation of the e-field. (4 pts)

(c) Whether the polarization state can generally be described by a "tilted ellipse" if the e-field consists of a multiple of frequency components? Why? (3 pts)

8. (15%) A confocal/planar resonator with mirror spacing d = 16 cm, mirror reflectance 0.995, and n = 1 is used in a laser operating at λ_0 = 1 μm.

(1) (5%) Find the radius of the curvature of the spherical mirror.

(2) (5%) Find the waist of the (0,0) (Gaussian) mode.

(3) (5%) What is the free spectrum range?

9. (6%) 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 $g(x_1,x_2)$ (2%) and sketch it as a function of $x_1 - x_2$ (2%).

(b) What is the physical meaning of the parameters I_0, W_0, and ρ_C ? (2%)

10. (4%) 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***.