2010 春季光電所博士班資格考題 光電子學 I　總共十題，總分 100，總共三頁

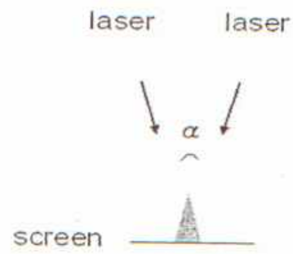
1. Graded-Index (GRIN) lens is made from a material showing radial refractive index distribution as $n(r) = n_0(1-\alpha r^2)$, where r is the radial distance from the optical axis, α is some design parameter. Now answer the following questions:

a. (6%) Draw a schematic figure and explain how a 0.25-pitch GRIN lens can be used to construct an optical fiber collimator?

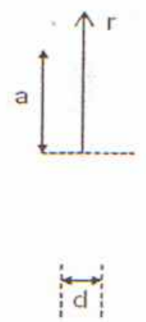
b. (4%) Discuss whether other pitch lengths can be used as fiber collimators? What are the pros and cons?

2. (4%) Does the standing wave $\vec{E} = \vec{E}_0 \sin(kz)\cos(\omega t)$ satisfy the wave equation? If yes, please show your calculation. If no, please explain your reason.

3. (6%) A laser beam emitting red light of 632nm is used with a beamsplitter to produce two coherent beams. Both are reflected from plane mirrors and brought together at the screen with an angle α=1° as depicted in the figure (the screen normal bisects the angle). Please show your derivation and find the period of the interference fringe observed on the screen.



4. (5%) A lens is made from a glass of constant thickness where there is an index of refraction variation in the radial direction n(r) and n(0)= n_0. Given a disk of radius a and thickness d as shown below, please find the radial variation of the index of refraction n(r) which will produce the equivalent of a conventional lens with a focal length f. You may assume f >> r and a thin lens (d<<a).



5. Consider a Gaussian beam with Rayleigh range z_o transmitting through an optical device whose ray-matrix is [ABCD]. If the beam waist is at a distance z from the front surface of the device, find the beam parameter q at the output surface. (10%)

6. (15%) Write down the transfer function of a coherent light wave propagating under water. Write down the Fresnel approximation of the transfer function. A laser beam (λ=500 nm) emitting from submarine located 300 m below the ocean surface propagates through a 10x10 (cm) window. The laser beam has a Guassian profile with the waist of 5 cm at the window. What's the laser intensity profile on the water surface assuming the ocean is completely calm?

7. (15%) Electromagnetic optics.
(a) What are the differences among ray optics, wave optics, and electromagnetic optics? (5 points)
(b) What is the meaning of dispersion? Why are nearly all the materials dispersive? (5 points)
(c) What happens when a short pulse passes through a dispersive medium? Justify your answer by simple mathematical modeling.

8. (10%) Polarization and crystal optics:
(a) If the Jones vector of a monochromatic plane wave is:

$$\frac{1}{\sqrt{2}}\begin{bmatrix} 1 \\ -j \end{bmatrix}$$

Plot the trajectory and denote the sense of rotation of the corresponding E-field. (5 points)
(b) What happens when this monochromatic plane wave passes through a quarter-wave retarder? Justify your answers. (5 points)

9. (a) Give the physical meanings of photon lifetime and Q factor of an optical

resonator. Explain how and why they are related. (7%)

(b) Give two applications for the Fabry-Perot resonator. Explain in details how they work. (8%)

10. (10%) 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***.