PYL 115: APPLIED OPTICS

(Ist Semester, 2015-2016)

Major Test

Duration: 2 hours **Max. Marks: 40**

Attempt Q.1 AND
any SEVEN questions of the remaining questions (Q. 2-10).

Compulsory Question (12 marks)

1. (i) Electric field of a plane wave is given by (3)

$$\vec{E}(x, y, z, t) = E_0(\vec{x} + a\vec{z})\exp[ik_0\{ct + (x + \sqrt{3}\,z)\}]$$

where c = speed of light in vacuum. Obtain the index of medium and the value of a.

(ii) Identify whether each of the following is based on wavefront division or amplitude division: Newton's rings, Fresnel biprism, Michelson Interferometer, Young's double slits, Fabry-Perot Interferometer and Soap film colours. (3)

(iii) Why does the beam emerging from a He-Ne laser have a Gaussian intensity profile? (2)

(iv) Discuss the basic differences between the Fresnel diffraction and Fraunhofer diffraction. (2)

(v) A left circularly polarized wave (λ_0=656nm) is to be converted into a right circularly polarized wave. What should be the minimum thickness of a quartz plate (n_e=1.551, n_o=1.542) to achieve this aim and what should be the orientation of the plate? (2)

Attempt any SEVEN out of the following questions (2-10):

2. If a zone-plate has to have a principal focal length of 50 cm corresponding to λ = 600 nm, obtain an expression for the radii of different zones. What would be its principal focal length for λ = 500 nm? (4)

3. Using the example of the formation of the image of a point by an ellipsoidal mirror, discuss the image formation when the path is (i) minimum, (ii) maximum and (iii) stationary. (4)

4. In the Phase Contrast Microscope set-up the lens used for Fourier transforming has a diameter of 4cm and the wavelength used is 580 nm. What should be the size and thickness of the circular patch on a glass plate to be used as the filter, if the material used is MgF_2 with an index of 1.38? (4)

5. (a) What is the mechanism used for obtaining a linearly polarized output from a laser? Explain briefly. (2)

(b) Consider a four level laser. What are relative spontaneous life-times (t_{sp}) of the three upper levels one should have for an efficient laser operation and why? (2)

6. What is the significance of spectral windows at 850 nm, 1300 nm and 1550 nm in the context of optical communication? Why have the fiber-optic communication systems shifted from 850 nm to 1300 nm and then to 1550 nm? (4)

7. What is pulse dispersion and how is it related to the information carrying capacity of a fiber? Show that for a step-index fiber, the intermodal dispersion is given by (4)

$$\frac{\Delta t}{L} = \frac{n_{co}}{c}\left(\frac{n_{co} - n_{cl}}{n_{cl}}\right).$$

Hence calculate the intermodal dispersion (in ns/km) of a fiber with $n_{co} = 1.45$ and $n_{cl} = 1.44$.

8. What are the main advantages of fiber optic sensors? What are different types of fiber optic sensors? Discuss briefly giving an example of each type. (4)

9. Consider the composite prism shown in Fig 1. Both sections are made of calcite (n_o = 1.66 and n_e = 1.49). The optic axis of the first prism is parallel to the face of the prism and the optic axis of the second prism is normal to the face of the prism as shown in the figure. There is a polarizer at position P shown in the figure. An unpolarized light beam of intensity I_0 is incident normally as shown. The polarizer at P is rotating in its plane at a fixed speed. Plot the intensity as a function of time over one period of rotation for (i) the beam incident on the prism, and (ii) the beam shown at the output. (4)

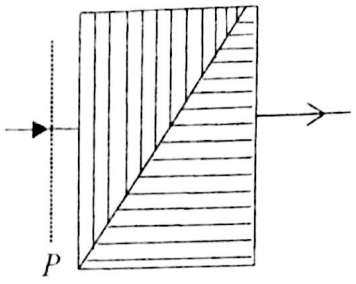

Fig. 1

10. A hologram of a point object is formed with a plane wave as a reference wave (Fig 2). Where would the images be formed if the hologram is illuminated with a plane wave propagating in the opposite direction as shown in Fig 3? What would happen if this hologram is illuminated with the object wave? (4)

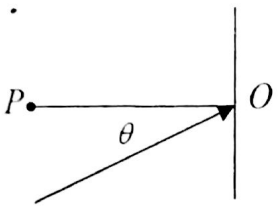

Fig. 2

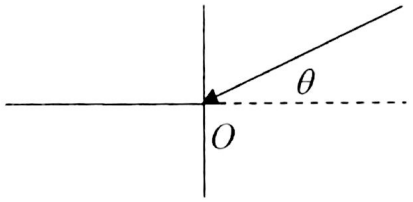

Fig. 3