Tutor Marked Assignment
OPTICS

Course Code: PHE-09
Assignment Code: PHE-09/TMA/2021
Max. Marks: 100

Note: Attempt all questions. Symbols have their usual meanings. The marks for each question are indicated against it.

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1. i) State and explain Fermat's principle. Using this principle, derive Snell's law of refraction. (4+6)

   ii) A beam of light is propagating in vacuum and its frequency is constant. Show that the average energy carried by it per unit area is proportional to the associated electric field vector. (5)

   iii) Two plane polarised light waves are propagating along the positive z-direction such that their electric field vectors are mutually perpendicular. These waves are superposed. Obtain the condition under which the resultant wave will be circularly polarised. (5)

   iv) For a crystal, the refractive index n_o for the *o*-ray is 1.5442 for light of wavelength 6×10^{-7} m. The least thickness of the crystal used as a quarter wave plate is found to be 1.65×10^{-5} m. Determine the refractive index n_e for the *e*-ray in this crystal. (5)

2. i) The wavelength of light used in Young's double slit experiment is 6000 Å. The second and the fourth bright fringes from the centre of the fringe pattern are located respectively at 10.24 mm and 12.40 mm. If the observation screen is placed at a distance of 1 m from the slits, calculate the separation between the slits. (5)

   ii) A wedge shaped film is obtained by placing a thin wire between two plane glass plates at one end keeping them in contact with each other at the other end. When the film is illuminated by light of wavelength 6000 Å, 40 fringes are observed. Calculate the radius of the wire. (5)

   iii) Interference fringes are produced by a beam of monochromatic light incident normally on a wedge shaped film of refractive index 1.5. The angle of the wedge is 15 seconds of an arc and the two successive dark fringes are 0.4 cm apart. Calculate the wavelength of light. (5)

   iv) With the help of a diagram, explain the working of Michelson interferometer. Explain how Michelson interferometer can be used for determining the refractive index of a thin plate. (6+4)

3. i) Derive an expression for the intensity of the diffraction pattern obtained due to Fraunhofer diffraction from a single slit. (10)

   ii) A grating has 10,000 lines per cm. What is the maximum number of principal maxima that can be formed for light of wavelength 5×10^{-5} cm? (5)

   iii) 6 principal maxima are observed in the diffraction pattern due to a diffraction grating. Calculate the number of lines per cm in the grating if the wavelength of the light is 5000 Å. (5)

iv) A beam of parallel light of wavelength 6000 Å is incident normally on a 1 rupee coin of diameter 3 cm. If an observation screen is placed at a distance of 1 m from the coin, how many Fresnel zones would be obstructed by it (the coin)? For what separation between the coin and the screen, only 5 zones would be cut off? (5)

4. i) An atomic system consisting of two energy levels with population of higher energy level less than that of the lower level, is in thermal equilibrium. Show that the absorption of radiation dominates stimulated emission if radiation of appropriate frequency is introduced into the system. Comment on the consequences of this fact for laser action. (10)

ii) Why pumping is necessary for laser action? Compare and contrast three level and four level pumping schemes for lasers. (5)

iii) Two energy levels of an atomic system are separated by energy corresponding to frequency 5.0×10^{14} Hz. Assume that all atoms are in one or the other of these two energy levels. Compute the fraction of atoms in the upper energy level at temperature 600 K. Take $k_B = 1.38 \times 10^{-23}$ JK^{-1} and $h = 6.6 \times 10^{-34}$ Js. (5)

iv) The refractive indices of the core and cladding materials of an optical fibre are 1.64 and 1.53 respectively. Calculate the numerical aperture and light gathering capacity of the fibre. (5)

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