POLARIZATION

Questions:

1. What is plane of polarisation and plane of vibration?
2. “Ordinary light is unpolarized”. Explain.
3. Why do we select electric field vector as light vector?
4. Distinguish between circularly polarized light and unpolarized light
5. How can we produce a linearly polarised light from an unpolarised beam of light using reflection?
6. State and explain Brewster’s law.
7. State and explain Malus’ law.
8. How can we produce a linearly polarised light from an unpolarised beam of light using refraction?
9. Write a brief note on double refraction.
10. Define optic axis and principal section of a calcite crystal.
11. Write down the differences between uniaxial and biaxial crystal?
12. Differentiate between positive and negative crystal.
13. Draw the Huygen’s wave surfaces for the E-ray and O-ray for positive and negative crystals.
14. What do you mean by optically anisotropic crystals?
15. Briefly describe the constrauction of Nicol Prism.
16. Explain how the state of polarisation of a given beam of light can be determined with the help of a Nicol prism and a quarter wave plate?
17. How can you convert plane-polarized light into circularly polarized light?
18. What happens when a
    a) plane polarized light with its light vector making an angle $\theta = 45^\circ$ with the optic axisis passed through a quarter wave plate
    b) plane polarized light with its light vector making an angle $\theta \neq 45^\circ$ with the optic axisis passed through a quarter wave plate
    c) circularly polarised light is passed through a half wave plate
    d) right circularly polarised light is passed through a half wave plate
    e) right elliptically polarised light is passed through a half wave plate
    f) left elliptically polarised light is passed through a half wave plate
19. An analyzing Nicol examines two adjacent plane polarized beams A and B whose planes of polarization are mutually perpendicular. In one positiion of the analyzer the beam B shows zero intensity. From this position, a rotation of 30° shows the two beams as of equal intensity. Deduce the ration of the intensities I_A / I_B of the two beams.

Numerical Problems:

1. Critical angle for glass placed in air is 40°. Calculate the angle of refraction corresponding to the angle of polarization.
2. Two polaroids are aligned with their polarization axis parallel. One of the polaroids is rotated to 30° and then through 60°, both with respect to the initial position. Find the ratios of transmitted intensities at these two positions.
3. Two polarizing sheets have their polarizing directions parallel so that the intensity of the transmitted light is a maximum. Through what angle must either sheet be turned so that intensity becomes one fourth of the initial value?
4. Find the state of polarization when x- and y- components of the electric field are
   (i) $E_x = E_0 \sin(\omega t + kz)$ and $E_y = E_0 \cos(\omega t + kz)$
   (ii) $E_x = E_0 \cos(\omega t + kz)$ and $E_y = (E_0/\sqrt{2}) \cos(\omega t + kz + \pi)$

5. Write an expression for a linearly polarized light wave of angular frequency ω propagating in the +z direction with its plane of vibration making an angle 60˚to the xz plane.
6. Calculate the minimum thickness of quarter-wave plate with $\lambda = 5.8 \times 10^{-7}$ m, $\mu_e = 1.553$ and $\mu_o = 1.544$.
7. A plane polarized light of wavelength 5893 Å is incident on a thin quartz plate cut with faces parallel to the optic axis. Calculate
   a) the minimum thickness of the plate, which introduces a phase difference 60˚between the ordinary (O-ray) and extraordinary rays (E-ray) and
   b) the minimum thickness of the plate for which the O-ray and E-ray waves will combine to produce plane polarized light. [Given that, $\mu_e = 1.553$ and $\mu_o = 1.544$].
8. A right circularly polarized beam of light (λ=5250 Å) is incident normally on a double refracting crystal with optic axis parallel to the surface. The thickness of the crystal is (t) 0.003 mm. It is also given that $(\mu_e - \mu_o) = 0.175$. Find the state of polarization of the emergent light beam.

DIFFRACTION

Questions:

1. Differentiate between interference and diffraction.
2. Write the differences between Fresnel diffraction and Fraunhofer diffraction.
3. Find an expression for the intensity of Fraunhofer diffraction pattern due to a single slit. Discuss the conditions for maxima and minima. Give a graphical plot of the intensity distribution.
4. In a single slit Fraunhofer diffraction phenomenon, what happens to the intensity of central maximum when the width of the slit is doubled ? Find an expression for the width of the central maximum as obtained on screen, placed in the focal plane of a convex lens.
5. Find an expression for the intensity of Fraunhofer diffraction pattern due to a double slit. Discuss the conditions for maxima and minima. Give a graphical plot of the intensity distribution. How does double slit diffraction pattern differ from that produced by a single slit ?
6. What is missing order in a double slit pattern ?
7. Find the resultant intensity of the diffracted beams when parallel rays fall normally on a plane diffraction grating. Show that the intensity pattern for the single and double slit diffraction can be obtained from the intensity expression of a grating. Hence work out the conditions for principal maxima and secondary maxima.
8. State Rayleigh criteria of resolution and discuss its significance in studying spectral lines.

Numerical Problems:

1. A convex lens of focal length of 20 cm is placed after a slit of width (b) 0.6mm. If a plane wave of wavelength 6000Å falls on the slit normally, calculate the separation between the second minima on either side of the principal maximum.
2. A monochromatic light of wavelength 5500Å is incident on a single slit of width 0.3 mm and gets diffracted. Find the diffraction angles for the first minima and the next maximum.
3. A single slit of width 4×10^{-3} mm is illuminated by a monochromatic light of wavelength 6000Å. Find the angular separation of the diffracted 1^{st} order minimum from the principal maximum.

4. The width of each slit of a double-slit diffraction is 0.15 mm and the width of the opaque space between the two slits is 0.45 mm. If double-slit produces Fraunhofer diffraction pattern, find the missing orders.
5. Fraunhofer double-slit diffraction pattern is observed in the focal plane of a lens (f=0.5m). The wavelength (λ) of incident light is 5000Å. The distance between two maxima adjacent two zero order maximum is 5mm and the fourth order maximum is missing. Find the width of each slit and the distance between their centers.
6. Consider a diffraction grating of width 5cm with slit width 0.0001 cm the width of the opaque space between the two slits is 0.0002 cm. What is the corresponding grating element? How many orders would be observable, if λ=5500Å?
7. A parallel beam of light is incident normally on a plane grating having 4250 lines per cm and the second order spectrum is formed at an angle 30^0. Calculate the wavelength of the monochromatic light.
8. Show that in a diffraction grating with grating element $1.5*10^{-6}$ m and light of wavelength 5500Å, 3rd and higher order principal maxima are not visible.
9. What is the maximum number of lines of a grating, which will resolve 3rd order spectrum of two lines having wavelengths 5890 Å and 5896 Å.

FIBRE OPTICS

Questions:

1. What is an optical fibre? Describe the working principle of optical fibre.
2. What is the difference between step - index and graded - index optical fibre ?
3. What is meant by acceptance angle and numerical aperture of a fibre ? Obtain an expression for numerical aperture of a step index fibre.

Numerical Problems:

1. A step index fibre has a core of refractive index 1.55 and cladding of refractive index is 1.53. Determine its numerical aperture and acceptance angle.
2. A step-index fibre has a core of refractive index 1.5 and cladding of refractive index 1.4. If the fibre is used in a water environment, find its numerical aperture and acceptance angle. Refractive index of water = 1.33.