Register Number:
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ST. JOSEPH'S COLLEGE (AUTONOMOUS), BANGALORE-27
M.Sc. PHYSICS – III SEMESTER
SEMESTER EXAMINATION(SUPPLEMENTARY): OCTOBER 2018
PH 9315: MODERN OPTICS

Time: 2 hours 30 min. **Max Marks:70**

This paper contains 2 parts and 3 printed pages.

Part-A

Answer any **5** questions.Each carries **10** marks. **(5x10=50)**

1. a) 'Light apparently takes only that path which corresponds to stationary optical path length.' Using Fermat's principle, justify this statement.
   b) Derive laws of reflection from Fermat's principle. (5+5)

2. What is an achromatic doublet? Derive the condition of achromatism in this doublet. Explain in detail which type of lenses should be combined to make this doublet. Also comment on their dispersive powers.

3. a) What is spatial and temporal coherence?Explain.
   b) With diagram and giving the condition for coherence, discuss how are these two achieved in Michelson's interferometer? (5+5)

4. Assuming the single slit to be made up of large number of equally spaced point sources and using Huygen's principle, find the resultant field intensity at a point on the screen due to diffraction from this single slit.

5. Using the set of three homogenous equations for propagation of wave as given below:

$$\left(\frac{k_x}{n^2}-\kappa_y^2-\kappa_z^2\right)E_x+\kappa_x\kappa_y E_y+\kappa_x\kappa_z E_z=0$$

$$\kappa_y\kappa_x E_x+\left(\frac{k_y}{n^2}-\kappa_x^2-\kappa_z^2\right)E_y+\kappa_y\kappa_z E_z=0$$

$$\kappa_z\kappa_x E_x+\kappa_z\kappa_y E_y+\left(\frac{k_z}{n^2}-\kappa_x^2-\kappa_y^2\right)E_x=0$$

   where $\hat{\kappa}=\frac{\bar{k}}{k}$ and $\kappa_x,\kappa_y,\kappa_z$ are components of the unit vector $\hat{\kappa}$ and E_x,E_y,E_z are the components of the electric field.

   Show that in a uniaxial crystal, for the extraordinary wave(e-wave)the direction of propagation of energy $\bar{S}$ is different from the direction of propagation of wave vector $\bar{k}$ where as for the ordinary wave(o-wave)the two propagate in the same direction.

   (Assume that the wave is oriented in such a way that its propagation vector lies in the xz -plane within the crystal and the wave is oriented at an angle to the z-axis which is also the optic axis of the crystal.)

6. a) Explain how visibility of fringes is related to degree of coherence in a Young's double slit

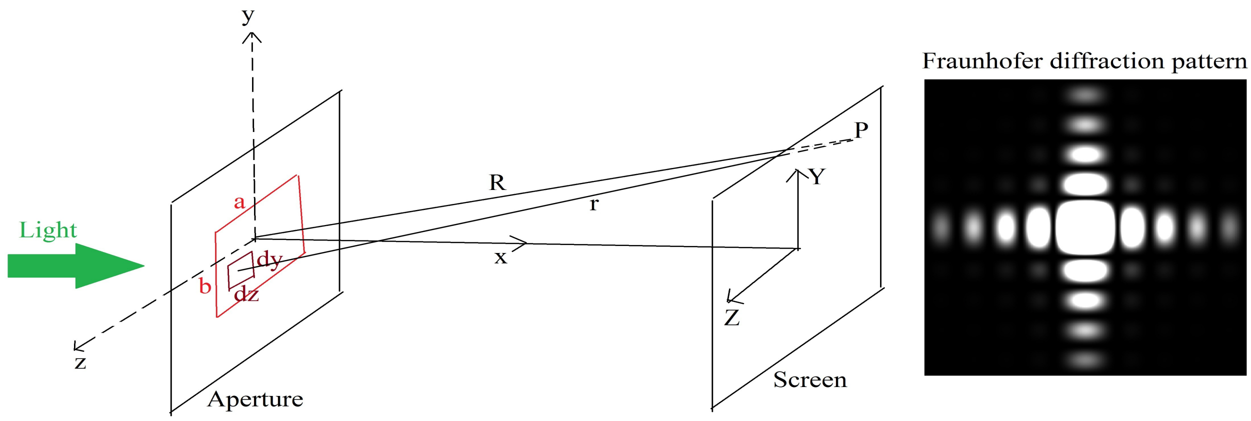
interference pattern.

b) Justify that the diffration pattern obtained from a single slit is the fourier transform of the aperture function. (5+5)

7. a) What are uniaxial and biaxial crystals?Explain.

b) Using the following dispersion relation $n^2=1+\frac{Nq^2}{m\epsilon_o}\left(\frac{1}{\omega_o^2-\omega^2+2iK\omega}\right)$ where ω_o is the resonant frequency, ω is the frequency of the incident field and K is the damping constant, differentiate between normal and anomalous dispersion. (5+5)

8. A monochromatic plane wave propagating in x-direction is incident on the opaque diffracting aperture. Using Huygen-Fresnel Principle,if ϵ_A is the source strength per unit area,assumed to be constant over the entire aperture then the optical disturbance at P due to a differential area dS within the aperture is given as $dE=\left(\frac{\epsilon_A}{r}\right)e^{i(\omega t-kr)}dS$ where r is the distance from dS to P and $dS=dydz$. Using the far-field approximation,find the total disturbance (field) arriving at P in case of Fraunhofer diffraction. Then considering the specific rectangular configuration as shown in the figure, find the resultant intensity at P. From the expression obtained justify the shown intensity pattern(in one line).



Part-B

Answer any **4** questions.Each carries **5** marks. **(5x4=20)**

1. A lens combination consists of convergent lens of focal length 12 cm kept first in the path of light(coming from left) and a divergent lens of focal length 15 cm separated by a distance of 6 cm. If the object is placed 108 cm infront of the convergent lens then using ABCD matrix analysis find the position of the image.

2. An achromatic doublet is required for a telescope objective of focal length 1.50 m. The available materials are crown glass and flint glass. Deduce the focal lengths of the component lenses. State if some freedom is still available in the designing. The refractive indices for C and F lines of hydrogen are given below:

	C	F
Crown	1.51646	1.52487
Flint	1.57422	1.58858

The D line lies in between the C and F line in the Hydrogen spectrum.

3. A plane transmission grating produces an angular seperation of 0.01 radian between two wavelengths observed at an angle of 30°. If the mean value of wavelength is 5000Å and the spectrum is observed in the second order,calculate the difference in the two wavelengths.

4. Find the Fourier transform of the function $E(x)=\begin{cases} E_o \sin k_p x & |x|<L \\ 0 & |x|>0 \end{cases}$.

   Draw graph for the obtained Fourier transform.

5. A ray of yellow light $\lambda=5770$ Å is incident on calcite plate at 50°. The plate is cut so that the optic axis is parallel to the front face and perpendicular to the plane of incidence. If the refractive index for ordinary wave is n_o =1.6584 and for extraordinary wave is n_e= 1.4864, then find the angular seperation between the two emerging rays. Also find the thickness of the calcite plate for which it behaves as a half wave plate.

6. Two light beams having intensities in the ratio 1:9 produce interference fringes of visibility 0.3. What information do we get about the degree of coherence?