CC-4 (Waves and Optics)

Waves and Interferometer

Short type question:
1. What is meant by Huygen's principle of propagation of light through homogeneous isotropic medium?

Long type question:

1. Explain the terms" Spatial coherence" and "temporal coherence" with reference to Young's double slit experiment. (2+2)
2. Explain the production of circular fringes in Michelson interferometer and find the expression for the radii of fringes. What are the important practical applications of Michelson interferometer? (4+2)
3. State the advantage of using multiple beam interferometry. Name the interferometer which uses this technique. (2+1)
4. Define visibility and sharpness of fringes. How may the sharpness of fringes be increased in Febry-Perot interferometer?
5. Derive an expression for the intensity of the fringe system formed by transmitted light in Febry-Perot interferometer. (5)

Numerical Problems:
1. Calculate the coherence time and the spectral width $\Delta\lambda$ for a quasi-monochromatic source of mean wave length 6438 ^{0}A and coherence length 30 cm. (3)
2. Determine the minimum spacing between two spectral lines at $\lambda = 500$ nm can be resolved by Febry-Perot interferometer with the plate separation d = 0.5 cm. Assuming the reflectivity to be 0.8. (3)
3. In an Michelson interferometer if one of the mirror is moved through a distance of 0.08 mm, 250 fringes cross the field of view. Calculate the wave length of light used. (2)

Interference

Short type question (2):

1. Show that the interference pattern in the reflected and transmitted light is complementary to each other.
2. State the conditions to be fulfilled for the production of interference fringes.
3. Why is it necessary to use narrow source for bi-prism and extended source for Newton's rings experiments?
4. Enumerate the different mode of production of coherence sources with one example for each.
5. Explain how conservation of energy principle is satisfied in interference.
6. What are localised and non-localised fringes? Give one example of each.
7. Why the rings become closer in case of Newton's ring experiment?
8. What are Fizeau fringes? How they can be formed?

Long type question:

1. A thin wedge shaped film is illuminated by nearly normally parallel ray of monochromatic light. Explain (no mathematical deduction necessary) what type of interference will be observed. Where are they located? (3+1)
2. Explain why extremely thin film illuminated by white light appear to be perfectly black when viewed by the reflected light.(3)
3. Derive the theory of determination of wave length with monochromatic light with the help of Fresnel's bi-prism experiment. (6)
4. Explain the formation of interference pattern produced by thin transparent film of uniform thickness. What do you mean by Haidinger's fringes? (4+2)
5. Give the theory of Newton's rings to determine the wave length of monochromatic light and show how, from their study the refractive index of a liquid can be determined.(5+3)
6. Show that in Young's double slit experiment the shape of fringes is hyperbolic in two dimensional planes.
7. Discuss the formation of fringes by Lloyd's single mirror and explain why the central fringes are black. Find the expression for the fringe width.
8. What are the difference of fringes produced by Fresnel's bi-prism experiment and Lloyd's single mirror experiment?

Numerical Problems:

1. An oil film (μ= 1.2) on water (μ= 1.33) is viewed from directly above with a light of wave length 6000 ^{0}A in air. The film appears circular and has a central thickness 10^{-6} m decreasing to zero thickness at the edge. Explain whether the edge will appear dark or bright. How many dark rings appear in the fringe?
2. A thin plate of glass of refractive index 1.52 is introduced in one of the interfering beam of a bi-prism. The central bright fringe is observed to be shift to the position previously occupied by fifth bright fringe. If the wave length of the light used 6890 ^{0}A, find the thickness of the glass plate.
3. In Young's experiment the distance "d" between slits is 0.1 mm and the perpendicular distance of the screen from the slit plane is 50 cm. Find the separation on the screen between the maxima for violet light (λ = 4000 ^{0}A) and a red light (λ = 7000 ^{0}A) in the first order.
4. In an experimental setup for producing Newton's ring the radius of curvature of the plano-convex lens R=30 cm. Find the diameter of the second bright ring produced by the light of wave length 6500 ^{0}A.
5. Calculate the fractional change in fringe width in Young's double slit experiment if the wave length of incident ray is changed from 5000 ^{0}A to 6000 ^{0}A.
6. An air wedge is formed between the plane glass plates. It is found that the interference fringes are 1.0 mm apart when the air wedge is illuminated normally with the light of wave length 500 nm. Find the angle of the wedge.
7. In Fresnel bi-prism experiment fringes for light of wave length 5 X 10^{-5} cm are observed 0.2 mm apart at a distance of 175 cm from the prism. The prism is made of glass of r.i 1.5 and is 25 cm from the illuminated slit. Calculate the angle at the vertex of the prism.

Diffraction

Short type question (2):

1. Distinguish between Fresnel and Fraunhofer diffraction.
2. What do you mean by absent spectra in a grating diffraction pattern?
3. What is meant by ghost line?

Long type question:

1. Outline the theory of a Zone plate and compare it with a converging lens. (5)
2. In an diffraction pattern produced by N slits, find the expression for the width of the principal maxima. (4)
3. (a) A parallel beam of monochromatic light is incident on a plane diffraction grating. Find the intensity of diffraction for Fraunhofer diffraction pattern. (3)
(b) From the result find the angular separation of maxima and minima in the double slit diffraction pattern including the position of diffraction and interference minima.(2)
(c) Find the intensity of secondary maxima of a grating diffraction pattern, as a function of intensity of principal maxima and hence explain why secondary maxima are not generally observed. (1)
4. What are Fresnel half period zones? Find the area of nth half period zone with reference to the plane wave front. (2+2)
5. Obtain the formula of intensity pattern for Fraunhofer diffraction of normally incident monochromatic beam of light of wave length λ through a single slit of width "a". (5)
6. Derive an expression for the intensity due to Fraunhofer diffraction by a double slit when monochromatic light incident normally on it. (6)
7. How resolving power of diffraction grating defined? What is meant by the Rayleigh criterion of resolution? (1+2)
8. Describe the Fresnel diffraction pattern when a monochromatic light is incident on a rectangular aperture. Discuss the case when the aperture is wide (>λ), narrow (≈ λ), very narrow (<λ).
9. Describe and explain the diffraction pattern by a narrow wire illuminated by monochromatic light from a narrow slit parallel to the wire.

Numerical Problems:

1. A zone plate is constructed by drawing concentric circles of radii equal to that of dark Newton's rings formed by a equi-convex lens of radius of curvature R = 2 m. Find the first focal length of the zone plate (for same λ).
2. Sodium light is incident normally on a plane transmission grating having 3000 lines per cm. Find the direction of first order D lines and width of the grating necessary to resolve them (wave lengths of D lines 589.0 nm and 589.6 nm). (2)
3. What is Rayleigh criterion of resolution? A transmission grating is 4 cm long and having 4000 lines/cm. Compute the resolving power of grating for λ= 590 nm in the first order spectrum. Will this grating separate the two lines of λ = 589.0 nm and λ = 589.6 nm? (1+4)
4. You have given two plane transmission grating G_1 and G_2. The grating G_1 is of width 3 cm and has 3000 lines, while the grating G_2 is of width 3 cm and has 2000 lines. Compare the resolving power of these two gratings. Deduce the formula used. (5)
5. What is the radius of first zone in a zone plate of principal focal length 20 cm for the light of wave length 500 nm. (2)
6. Consider a case of double slit diffraction where slit width is $88X10^{-3}$ cm, separation between the slits $7X10^{-2}$ cm and wave length of light $6.328X10^{-5}$cm. Find the number of interference minima occurring in the central diffraction maxima.
7. A transmission type diffraction grating having 250 lines /mm is illuminated by visible light (400 nm-700 nm) at normal incidence. What wavelength appears at diffraction angle of 30^0 and what colour are they? (3+3)
8. Estimate the number of lines of plane transmission grating required to resolved D_1 and D_2 lines of Na in 2^{nd} order. (2)