Numerical Problems in Optics

Diffraction Grating:

1. A diffraction grating 20.0 mm wide has 6000 rulings.

(i) Calculate the distance between the adjacent rulings.

(ii) At what angles will intensity maxima occur on a viewing screen if the radiation incident on the grating has wavelength of 589 nm?

(Ans: (i) 3.33 x 10^{-6} m (ii) 10.177^0, 20.695^0 , 32.012^0 , 44.975^0 and 62.067^0)

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2. A diffraction grating 3 cm wide produces the second order at 33^0 with light of wavelength 600 nm. What is the total number of lines in the grating?

(Ans: 13616 lines)

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3. Assume that the limits of visible spectrum are arbitrary chosen as 430 nm and 680 nm. Calculate the number of rulings per millimeter of a grating that will spread the first order spectrum through an angle of 20^0 .

(Ans : 795 lines/mm, 502 lines/mm)

(4) A monochromatic light of wavelength 5890 A^0 is incident normally on a grating which has 6000 lines per cm. (a) At what angle will the second order image be seen? (b) Can you obtain the third order image with this grating?

(Ans: (i) 44.975^0 , $(ii)\ since$ sin $\theta_3 = 1.0602 > 1, third\ order\ can't\ be\ obtained.$)

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(5) (i) What is the resolving power required to resolve the two sodium lines at 589 nm and 589.6 nm?

(ii) If a grating is 2 cm wide, how many lines per millimeter are needed to resolve these wavelengths in 3rd order? (Ans: (i) 982 (ii) 16.4 lines per mm)

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(6) How many orders will be visible if the wavelength of the incident radiation is 5000 $A^0$and the number of the lines on the grating is 2620 in one inch. (Ans: 19)

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(7) Calculate the minimum number of lines per cm in a 2.5 cm wide grating which will just resolve the sodium lines (5890 A^0 and 5896 A^0) in the second order spectrum. (Ans: 196.4)

(8) Light is incident normally on a grating 0.5 cm wide with 2500 lines. Find the angles of diffraction for the principal maximum of the two sodium lines in the first order spectrum. (λ_1 = 5890 A^0 and λ_2 = 5896 A^0). Are the two lines resolved?(Ans: The two lines are resolved)

(9) A plane transmission grating having 6000 lines/cm is used to obtain a spectrum of light from a sodium lamp in the second order. Calculate the angular separation between the two sodium lines whose wavelengths are 5890 A^0 and 5896 A^0. (Ans: 4')

Interference: Newton's rings:

1. In a Newton's rings experiment, find the radius of curvature of the lens surface in contact with the glass plate when with a light of wavelength 5890 x 10^{-8} cm, the diameter of the third dark ring is 3.2 mm. The light is falling at such an angle that it passes through the air film at an angle of zero degree to the normal. (Ans: R = 144.9 cm)

2. A plano-convex lens of radius 300 cm is placed on an optically flat glass plate and is illuminated by monochromatic light. The diameter of the 8^{th} dark ring in the transmitted system is 0.72 cm. Calculate the wavelength of light used.

(Ans: 5760 A^0)

3. A thin equiconvex lens of focal length 4 m and refractive index 1.50 rests on a and in contact with an optical flat, and using light of wavelength 5460 A^0, Newton's rings are viewed normally by reflection. What is the diameter of the 5^{th} bright ring? (Ans: 0.627 cm)

4. Newton's rings are formed by the reflected light of wavelength 5895 A^0 with a liquid between the plane and curved surfaces. If the diameter of the 5th bright ring is 3 mm and the radius of curvature of the curved surface is 100 cm, calculate the refractive index of the liquid. (Ans: 1.179)

5. In a Newton's rings experiment, if a drop of water ($\mu = \frac{4}{3}$) be placed in between the lens and the plate, the diameter of the 10th ring is found to be 0.6 cm. Obtain the radius of curvature of the face of the lens in contact with the plate. The wavelength of light used is 6000 A^0. (Ans: 200 cm)

6. Newton's rings are observed in reflected light of λ = 5.9 x 10^{-5} cm. The diameter of the 10th dark ring is 0.5 cm. Find the radius of curvature of the lens and the thickness of the air film. (Ans: R = 1.059 m, 2.95 x 10^{-6} m)

7. The radii of nth and (n+20)th bright ring in Newton's ring experiment are 0.162 cm and 0.368 cm respectively. Calculate the radius of curvature of lower surface of lens. (λ = 546 nm) (Ans: 99.98 cm)

8. In a Newton's ring arrangement, a source emitting two wavelengths 6 x 10^{-7} m and 5.9 x 10^{-7} m is used. It is found that nth dark ring due to one wavelength coincides with (n+1)th dark ring due to another. Find the diameter of the nth dark ring if the radius of curvature of lens is 0.9 m. (Ans: 1.128 cm)

9. Newton's rings are formed by reflected light of wavelength 5895 A^0 with a liquid between the plane and curved surfaces. If the diameter of the 6th bright ring is 3 mm and the radius of curved surface is 100 cm, calculate the refractive index of the liquid. (Ans: 1.442)

10. Light containing the two wavelengths λ_1 and λ_2 falls normally on a plano-convex lens of radius of curvature R resting on a glass plate. If the nth dark ring due to λ_1 coincides with the (n+1)th dark ring due to λ_2, prove that the radius of the nth dark ring of λ_1 is

$$\sqrt{\frac{\lambda_1 \lambda_2 R}{\lambda_1 - \lambda_2}}$$

11. In an experiment on Newton's rings the light has a wavelength of 600 nm. The lens has a refractive index of 1.5 and a radius of curvature of 2.5 m. Find the radius of 5^{th} bright fringe. (Ans : 2.6 x 10^{-3} m)

Thin film:

1. A soap film of refractive index 1.33 is illuminated with light of different wavelengths at an angle of 45^0. There is complete destructive interference for $\lambda = 5890A^0$. Find the thickness of the film. (Ans: $3.132\ X\ 10^{-4}$mm)

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2. A soap film of refractive index 4/3 and of thickness $1.5x10^{-4}$ cm is illuminated by white light incident at an angle of 60^0. The light reflected by it is examined by a spectroscope in which is found a dark band corresponding to a wavelength of $5x10^{-5}$ cm. Calculate the order of interference of the dark band. (Ans: n = 6)

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3. A parallel beam of light ($\lambda = 5890A^0$) is incident on a thin glass plate $(\mu = 1 \cdot 5)$ such that the angle of refraction is 60^0. Calculate the smallest thickness of the plate which will appear dark by reflection. (Ans: $3.926x10^{-7}\ m$)

(H.W: Remaining problems of Textbook: Examples and exercises)

Recommended books for Optics:

1. Textbook (T.R.Lamichhane)
2. Textbook of optics (by Brij Lal)
3. Resnick and Halliday