PHS – 1201: ELECTRICITY, MAGNETISM & OPTICS

Assignment #2 - Interference and Diffraction

UNDERSTANDING INTERFERENCE AND DIFFRACTION

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INSTRUCTIONS

- You are free to discuss the questions among yourselves if you choose to do so. However, each one should write the answers independently at the end and submit it. You should be prepared to explain the steps and arguments in your answer if called upon to do so.
- Interpret the questions as a physicist; not as a mathematician. Make reasonable assumptions when required and mention them.
- Your answers can be brief and to the point, giving just the essential algebraic steps and arguments. The marks for each of the questions are given at the right end of the question. Total marks: **70**.
- I have tried to keep the questions clear, consistent with the notation used in the class and error-free. But if you have any difficulties on these counts, feel free to email me.

1. In Young's double slit experiment the separation between the slits is 1.2 mm and fringe spacing is 0.5 mm on a screen kept at a distance of 1 m from the slits. Find the wavelength of light. [**5**]

2. A Lloyd's mirror experiment is done with a plane metallic sheet and a microwave source of wavelength 40 cm. If the source is 6 cm above the plane of the sheet, find the height of first maximum above this plane at a distance 4 m from the source. [**5**]

3. In Newton's ring experiment, the diameter of mth dark fringe is 8 mm and the diameter of $(m+5)$th dark fringe is 12 mm. If the radius of curvature of the lower surface of the lens is 10 m, find the wavelength of light used. [**5**]

4. Fringes are produced with monochromatic light of wavelength 689 nm. A thin film of glass of refractive index 1.52 is placed normally in the path of one of the interfering rays. The central bright fringe is found to move to a position occupied by the fifth bright fringe from the centre. Calculate the thickness of the glass film. [**5**]

5. When a narrow monochromatic source of light ($\lambda = 589.3$ nm) is placed at a distance of 50 cm from the bi-prism (refractive index=1.5), width of the fringes obtained on a screen placed 1m from the bi-prism is found to be 0.12 mm. Find the obtuse angle of the bi-prism. [**5**]

6. In a Newton's ring experiment, the rings are formed using a source of light which has two wavelengths λ_1 and λ_2. If mth order dark ring due to λ_1 coincides with the $(m+1)$th order dark ring due to λ_2, prove that the radius of mth dark ring of λ_1 is equal to $\sqrt{\lambda_1\lambda_2 R/(\lambda_1 - \lambda_2)}$. Here R is the radius of curvature of the lower surface. [**5**]

7. In a double slit experiment with a light of wavelength 600 nm falls on the slits separated by 0.2 mm and interference fringes are seen on a screen 1.2 m away. Find the distance of the third order maximum from the central zeroth order maximum. How will this distance change if the whole experiment is performed in water (refractive index=1.33). [**5**]

8. An oil film (refractive index=1.2) on water (refractive index=1.33) is viewed from directly above with light of wavelength 600 nm in air. The film appears circular and the thickness goes to zero starting from 1 μm at the center. Explain whether the edges of the film will appear dark or bright. How many dark fringes will appear? [**5**]

9. In a Young's experiment the distance between the slits is 0.1 mm and the perpendicular distance of the screen from the plane of the slits is 50 cm. Find the separation on the screen between maxima for violet light ($\lambda = 400$ nm) and the red light ($\lambda = 700$ nm) in the first order. [**5**]

10. Consider a double slit experiment with a light containing two wavelengths 450 nm and 600 nm respectively. Find the least order at which a maximum of one wavelength falls exactly on a minimum of the other. [**5**]

11. A thin transparent plate of refractive index 1.5 is introduced in one arm of Michelson interferometer. It causes 10 fringe shift. Find the thickness of the plate. Assume the wavelength of light to be 600 nm. [**5**]

12. The separation between two glass plates in a Fabry-Perot interferometer is 2.5 cm. Find the smallest resolvable wavelength difference at $\lambda = 500$ nm. Take the reflectivity of the surface to be $r = 0.95$. [**5**]

13. A parallel beam of light of wavelength 500 nm is incident normally on a narrow slit of width 0.2 mm. The Fraunhofer diffraction is observed on a screen which is placed at the focal plane of a convex lens of focal length 20 cm. Calculate the distance between the first two maxima. [**5**]

14. A double slit diffraction pattern is observed in the focal plane of a lens of focal length 0.5 m. The wavelength of incident light is 500 nm. The distance between two maxima adjacent to the maximum of zero order is 5 mm, while the fourth order maximum is missing. Find the width of each slit and distance between their centers. [**5**]