PH 221 Homework Assignment Chapter on Diffraction & Polarization – 18 Problems Total

1. Monochromatic light illuminates a single slit that has a width $(\mathrm{a} = 1.86 \times 10^{-6}\ \mathrm{m})$. If the angle between the first dark fringes on either side of the central maximum is $(44.0°)$, what is the wavelength of the light used?

Solution for Problem 1

2. Blue light $(\lambda = 460.\ \mathrm{nm})$ falls on a single slit of width (a) . The angle between the two second-order diffraction minima $(\mathrm{m} = -2, \mathrm{m} = +2)$ is found to be $86.0°$. What is the width of the slit?

Solution for Problem 2

3. Light of wavelength $(\lambda = 435.0\ \mathrm{nm})$ is incident on a single slit of width $(\mathrm{a} = 4.76 \times 10^{-6}\ \mathrm{m})$. What is the maximum number of diffraction minima that would be present on a wall far enough away to show them all?

Solution for Problem 3

4. A particular double-slit pattern contains exactly 7 interference fringes inside of the diffraction envelope central maximum. Assume the first diffraction minima coincides with an interference minimum. What is the relationship of slit spacing to slit width $\left(\frac{\mathrm{d}}{\mathrm{a}}\right)$?

Solution for Problem 4

5. Design a double-slit apparatus so that the central maximum of the diffraction envelope contains exactly fifteen interference fringes.

(a) Determine ${}^{\mathrm{d}}/_{\mathrm{a}}$ if the first diffraction minimum coincides with an interference minimum.

(b) Determine ${}^{\mathrm{d}}/_{\mathrm{a}}$ if the first diffraction minimum coincides with an interference maximum.

Solution for Problem 5

6. The central maximum of the diffraction envelope for a particular double-slit apparatus contains seventeen interference fringes. Assume the diffraction minimum occur on an interference maximum creating so called "missing" fringes. How many fringes will exist in the secondary diffraction maximum in between the first and second diffraction minima?

(a) How many fringes will exist in the secondary diffraction maximum in between the first and second diffraction minima?

(b) What would be interference order numbers (m_I) ?

Solution for Problem 6

7. Assuming an average visible wavelength of $(\lambda = 550.\,\mathrm{nm})$, what is the angular resolution limit due to diffraction for the following telescopes:

(a) Yerkes Telescope, Williams Bay Wisconsin, diameter $1.02\ \mathrm{m}$

(b) James Webb Telescope, in orbit, diameter 6.50 m

(c) Keck Telescope, Mauna Kea Hawaii, diameter 10.0 m

Solution for Problem 7

8. Two astronomical objects are just barely resolved in a telescope whose objective mirror has a diameter of $(\mathrm{D} = 0.784\ \mathrm{m})$. The objects are estimated to be a distance $(\mathrm{d} = 24.0\ \mathrm{ly})$. A light year $(1\ \mathrm{ly} = 9.46\ \mathrm{x}\ 10^{15}\ \mathrm{m})$ is the distance light can travel in one year. Assume a wavelength of light $(\lambda = 550.\,\mathrm{nm})$ is used and the resolution is limited only by diffraction. How far apart are the two objects in space?

Solution for Problem 8

9. The base of the lunar landers which remained on the surface of the Moon when the astronauts used the upper portion to return to the Apollo capsule orbiting the Moon are $(\mathrm{S} = 4.20\ \mathrm{m})$ wide. The Moon is a distance $(\mathrm{d} = 3.84\ \mathrm{x}\ 10^{8}\ \mathrm{m})$ away from the Earth. Assuming light of wavelength $(\lambda = 550.\,\mathrm{nm})$, what would the diameter of a telescope objective (probably a mirror) have to be for you to look through a telescope and be able to "see" resolve the base of the lunar landers?

Solution for Problem 9

10. The distance between the two main headlights on many US cars is approximately $(S = 1.50\ m)$. Use a wavelength of light emitted as $(\lambda = 550.\ nm)$. At night the average diameter of your pupil is $(D = 6.00 \times 10^{-3}\ m)$. Assuming diffraction limitations, how far away can a car be and you just resolve that you see two distinct headlights?

Solution for Problem 10

11. At what angle with light $(\lambda = 495.\ nm)$ produce a fourth order maximum when falling on a diffraction grating whose slits are $(d = 1.23 \times 10^{-5}\ m)$ apart?

Solution for Problem 11

12. How many lines per centimeter does a diffraction grating have if the third-order maximum for green light $(\lambda = 535.\ nm)$ occurs at an angle of $(\theta = 23.0°)$?

Solution for Problem 12

13. White light contains wavelengths $(\lambda_{Violet} = 410.\ nm \text{ to } \lambda_{Red} = 750.\ nm)$ is incident on a diffraction grating with a grating constant $\left(\frac{1}{d} = 10{,}000\ {}^{lines}/_{cm}\right)$. The resulting spectrum is viewed on a screen located $(L = 3.20\ m)$ away. How wide is the first – order spectrum on the screen?

Solution for Problem 13

14. Consider white light which has visible wavelengths $(400.\ nm \ - \ 700.\ nm)$. When this light is incident any diffraction grating, find which wavelengths of the second – order spectrum overlaps with wavelengths of the third – order spectrum.

Solution for Problem 14

15. When you consider both interference and diffraction effects from a diffraction grating, there is a chance that a diffraction minimum occurs at the same location as an interference maximum which then results in "missing" fringes. Assume the width of each slit is (a) and the spacing between slits is (d).

(a) Determine the condition which will determine the "missing" fringes will occur.

(b) Determine which fringes are "missing" if the relationship between spacing and width of slits is $(d = 2a)$.

(c) What would the pattern from a diffracting grating look like if the width of the slits is equal to the spacing of the slits?

Solution for Problem 15

16. Two plane polarizers are oriented with the polarization directions having an angle of $(50.0°)$ between them. If the light is unpolarized, what is the fraction of the light intensity that passes through both polarizers?

Solution for Problem 16

17. Determine Brewster's angle for light reflecting from air $(n_{\text{Air}} = 1.000)$ off a glass $(n_{\text{Glass}} = 1.760)$ plane

Solution for Problem 17

18. Determine Brewster's angle for light reflecting off a surface of water $(n_{\text{Water}} = 1.333)$. Assume the index of refraction for air is $(n_{\text{Air}} = 1.000)$.

Solution for Problem 18

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