Physics 1C - Discussion 10 Name: UID:

Problem 1. (Submission not needed)

Red light of wavelength 633 nm from a helium–neon laser passes through a slit 0.350 mm wide. The diffraction pattern is observed on a screen 3.00 m away. Define the width of a bright fringe as the distance between the minima on either side. (a) What is the width of the central bright fringe? (b) What is the width of the first bright fringe on either side of the central one?

$R >> Y_m$

a) $Y_{1,-1} = R\frac{\lambda}{a} = \pm 3 \frac{633\times10^{-9}}{0.35\times10^{-3}}$ [m] $\therefore$ width of central maxima $\boxed{= 2\cdot\left[3\frac{633\times10^{-9}}{0.35\times10^{-3}}\right] \text{ [m]}}$

b) $Y_{2,-2} = \pm 3\frac{2\cdot 633\times10^{-9}}{0.35\times10^{-3}}$ [m] $\therefore$ width of $m=\pm1$ maxima $= \boxed{\left[3\frac{2\cdot633\times10^{-9}}{.35\times10^{-3}}\right] - \left[3\frac{633\times10^{-9}}{.35\times10^{-3}}\right] \text{ [m]}}$

Problem 2. Monochromatic light of wavelength 580 nm passes through a single slit and the diffraction pattern is observed on a screen. Both the source and screen are far enough from the slit for Fraunhofer diffraction to apply. (a) If the first diffraction minima are at ±90°, so the central maximum completely fills the screen, what is the width of the slit? (b) For the width of the slit as calculated in part (a), what is the ratio of the intensity at $\theta = 45.0°$ to the intensity at $\theta = 0$?

a) $\sin\theta \approx \theta$ (small angle approx.)

$$\theta = \frac{\lambda}{a} = \frac{\pi}{2} \Rightarrow a = \frac{2\lambda}{\pi} \boxed{= \frac{1160}{\pi} \text{ [nm]}}$$

b) $45° = \frac{\pi}{4}$ $\quad I = I_0 \left[\frac{\sin[\pi a \theta/\lambda]}{\pi a \theta/\lambda}\right]^2$

$$\therefore I_{45°} = I_0 \left[\frac{\sin(290\pi/580)}{290\pi/580}\right] = I_0\left[\frac{1}{\frac{\pi}{2}}\right] = 2\pi I_0$$

$\lim_{x\to 0} \frac{\sin x}{x} = 1 \Rightarrow$ $\quad I_{0°} = I_0$ $\quad \boxed{\therefore I_{45°} : I_{0°} = 2\pi}$

Problem 3. (Submission not needed)

Monochromatic light is at normal incidence on a plane transmission grating. The first-order maximum in the interference pattern is at an angle of $11.3°$. What is the angular position of the fourth-order maximum?

Problem 4. (Submission not needed)

Two satellites at an altitude of 1200 km are separated by 28 km. If they broadcast 3.6 cm microwaves, what minimum receiving-dish diameter is needed to resolve (by Rayleigh's criterion) the two transmissions?