

110B Homework 7

1. (10 points) A narrow single slit in an opaque screen is illuminated by infrared laser at 1152.2 nm, and it is found that the center of the tenth dark band in the Fraunhofer pattern lies at an angle of 6.2 degree off the central axis. Please determine the width of the slit. At what angle will the tenth minimum appear if the entire arrangement is immersed in water ($n=1.33$)? (10 points)

2. (20 points) The Mount Palomar telescope has an objective mirror with a 508 cm diameter. Determine its angular limit of resolution at a wavelength of 550 nm. How far apart must two objects be on the surface of the Moon if they are to be resolvable by the Palomar telescope? The earth-moon distance is 376,000 km; take the wavelength to be 550 nm. In comparison, how far apart must two objects be on the moon if they are to be distinguished by a naked eye with a pupil diameter of 4 mm?

3. (10 points) Plot the diffraction pattern from two slits, where the slit width is a , and the distance between the two slit centers is $2a$.

4. (30 points) We have a diffraction grating with slit density of 1000 lines per millimeter and a grating size of 5cm. The diffraction can take place not only in the transmission direction, but also the reflection direction. Now we have a parallel beam with wavelength of 632 nm and diameter of 1cm shining on the grating at 30 degree.

(a) What are the diffraction angles that can satisfy the Bragg condition (i.e. constructive interference from all slits) in the reflection angle? How many diffraction peaks will there be?

(b) What is the angle divergence of each diffraction peaks?

(c) How small a change of wavelength of the incident beam will we be able to distinguish through the first order diffraction peak?

5. (30 points) A plane-wave of amplitude A and wavelength λ is incident at normal incidence in the z -direction on the object with transmission coefficient $U(x,y)$ described below.

$$\begin{aligned} U(x,y) &= e^{i\pi/2} & (0 < x < a) \\ &= e^{-i\pi/2} & (-a < x < 0) \\ &= 0 & \text{anywhere else} \end{aligned}$$

(a) Draw a sketch of this object in the x - y plane

(b) Give an example of how you would make such an object.

(c) Compute analytically the intensity of the Fraunhofer diffraction field owing to this object.

(d) Sketch the Fraunhofer diffraction field of part (c).