Northeastern University, EECE4646 Spring 2024
Marks: 100

Homework 5

Deadline - 04/02/2024

March 28, 2024

1 Problem I

The primary mirror of the orbiting Hubble Space Telescope has a diameter of 2.40 m. Being in orbit, this telescope avoids the degrading effects of atmospheric distortion on its resolution.

1. What is the angle between two just-resolvable point light sources (perhaps two stars)? Assume an average light wavelength of 550 nm. **(10 Marks)**
2. If these two stars are at the 2 million light year distance of the Andromeda galaxy, how close together can they be and still be resolved? (A light year, or ly, is the distance light travels in 1 year.) **(10 Marks)**

2 Problem II

Diffraction gratings with 10,000 lines per centimeter are readily available. Suppose you have one, and you send a beam of white light through it to a screen 2.00 m away. (See the figure below)

1. Find the angles for the first-order diffraction of the shortest and longest wavelengths of visible light (380 and 760 nm, respectively). **(10 Marks)**
2. What is the distance between the ends of the rainbow of visible light produced on the screen for first-order interference? **(10 Marks)**

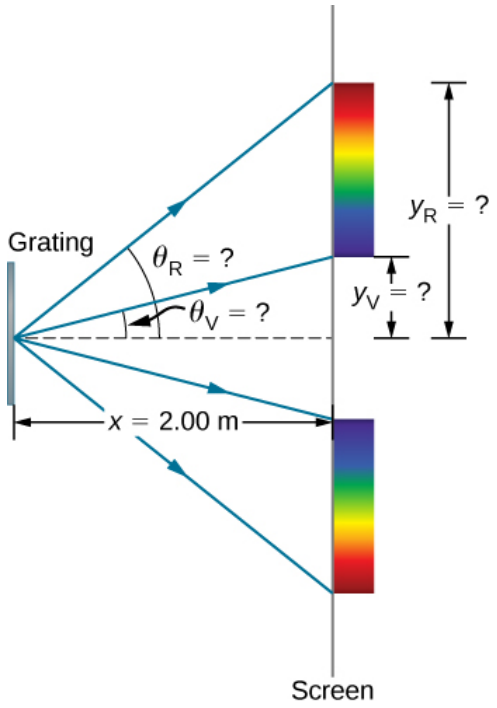

Figure 1: The diffraction grating considered in this example produces a rainbow of colors on a screen a distance **x = 2.00 m** from the grating. The distances along the screen are measured perpendicular to the x-direction. In other words, the rainbow pattern extends out of the page. In a bird's-eye view, the rainbow pattern can be seen on a table where the equipment is placed.

3 Problem III

1. Monochromatic light from a He-Ne laser (λ = 632.8 nm) is incident normally on a diffraction grating with 6,000 slits per cm. Find the angles of the first-, second- and third-order maxima. **(15 Marks)**

2. A mixture of red light (λ_R = 650nm) and blue light (λ_B = 450nm) is normally incident on a compact disk. If the distance between the ridges on the CD is 1.6e-6 m, what are the angles for the first- and second-order maxima for both wavelengths? **(15 Marks)**

4 Problem IV

Which telescope is capable of the greater resolution; the Keck telescope at Mauna Kea, Hawaii, or the radio telescope at Arecibo, Puerto Rico? Assume the following characteristics: **(a)** the Keck telescope has a diameter of 10 m

and is designed for visible light (wavelength of 600 nm), and **(b)** the Arecibo telescope has a diameter of 305 m and is designed to detect radio waves with a wavelength of 0.75 m. **(15 Marks)**

5 Problem V

Impressionist painter Georges Seurat created paintings made up of a huge number of dots of different colors(See figure below) - each about 1.50 mm in diameter - a technique called *divisionism* or *pointillism*. Assuming the pupil in your eye has a diameter of 1.50 mm and the average wavelength is 500 nm, how far away would you have to stand so you would not be able to discern individual dots? **(15 Marks)**

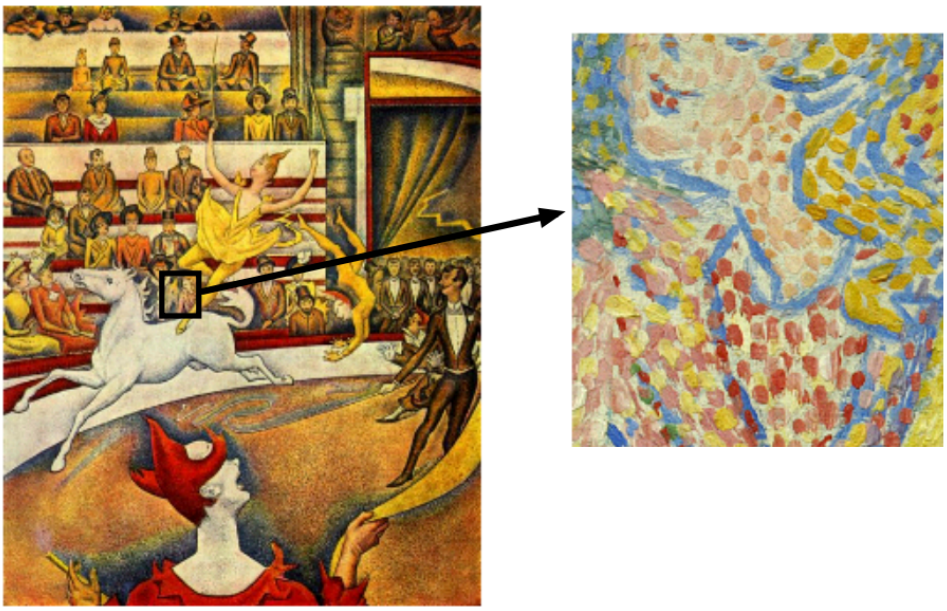

Figure 2: Painting by Georges Seurat