VS203B Problem Set: Diffraction, Interference and Resolution

1. Two thin prisms of power 1^{Δ} are placed base-to-base. A single point light source of wavelength 630 nm is placed 1 cm behind the prisms and an interference pattern is generated at a distance 3 m from the prisms. What is the separation in cm between the peaks of the interference pattern?

2. If a blue point source of wavelength 440 nm is used in the same system, how much are the red (630 nm) and blue peaks (440 nm) shifted with respect to each other at the…
a) central peak (m=0)?
b) first side peak (m=1)?
c) second side peak (m=2)?

3. To determine the distance between two slit apertures, a scientist uses a 630 nm light source to project an interference pattern on the wall at a distance of 1 m. The separation between the peaks in the interference pattern is 0.1 cm. What is the distance between the two slits?

4. Calculate the rectangular aperture size that will produce a diffraction pattern with 550 nm light whose central spot has an angular width (measured between the first minima on either side of the central spot) of 2 degrees and an angular height of 4 degrees.

5. Calculate the circular aperture size that will produce a diffraction pattern with 450 nm light whose first dark ring has a diameter of 1 mm at a distance of 2 m.

6. Thomas Young needed to measure the distance between the two apertures he used for his double-slit experiment. Because he had measured his own aberrations, he knew he was diffraction-limited for a pupil size of 2.5 mm or less. So, he controlled the light to keep his pupil size at 2.5, illuminated the room with 586 nm light, and moved the aperture toward his eye until he could resolve the two apertures as distinct. If the distance of the aperture to his eye was 50 cm, what was the separation between the apertures?

7. A thin film of magnesium fluoride (n = 1.38) is deposited on glass (n = 1.5) so that it is anti-reflecting at a wavelength of 580 nm under normal incidence. What is the percentage of reflected intensity for 450 nm light?

8. Design an anti-reflection coating to optimize transmission of 550 light in a spectacle lens with a refractive index of 1.60. It turns out that the only coating material is MgF_2, which has a refractive index of 1.38. What would the thickness of the MgF_2 coating be, and what would the reflectance be at 550 nm?

9. Two flat microscope slides, 10 cm long are touching on one side and are separated by 3 microns on the other. How many dark interference bands will appear on the slide if you look the reflection in 450 nm light?

10. At what separation are two small light sources, held 1 m from the eye, just resolved (according to the Rayleigh criterion) for the following conditions? Assume the eye is diffraction-limited for all pupil sizes.
    a) 450 nm (blue) light, 5 mm pupil.
    b) 650 nm (red) light, 5 mm pupil.
    c) 500 nm (green) light, 1 mm pupil.

If the sources were 600 nm (red) light, what pupil size would the eye need to get the same resolution as in part (a)?

Answers

1. 0.95 cm
2. a) 0; b) 2.86 mm; c) 5.72 mm
3. 0.63 mm
4. aperture size is 15.76 (height) X 31.53 (width) micrometers
5. 2.2 mm diameter
6. separation is 0.143 mm
7. reflected intensity is 1.92%
8. thickness = 99.6 X 10-9 m, reflectance is 0.74%
9. 14 dark bands
10. a) 0.11 mm b) 0.16 mm c) 0.67 mm