EE119 Homework 12: Diffraction and Interference

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1. A molecule sometimes emits light at 600 nm and sometimes emits light at 650 nm. You want to determine the relative intensity of emission at these two wavelengths, so you decide to split the light with a diffraction grating and direct the two first-order diffracted beams of different colored light onto two different photodetectors. You want to separate the centers of the photodiodes by 2 cm. The active area of the photodiode is 0.5 mm $\times$ 0.5 mm, and to maximize efficiency you want all of the light at the two wavelengths to hit the active area. Design the first-order diffraction grating you will use, and determine how far away from the diffraction grating you should place your photodiodes.

2. Interference: Sketch the interference pattern produced in the x-y plane by two plane waves, where the wavevector for wave 1 is $k_1 = (2\pi/\lambda)(x + y + z)$, and the wavevector for wave 2 is $k_2 = (2\pi/\lambda)z$. Take $\lambda = 500$nm. Quantitatively label the dimensions on your sketch.

3. Youngs double-slit experiment is performed with orange light from a krypton arc (λ= 6058 angstroms). If the fringes are measured with a micrometer eyepiece at a distance 100cm from the double slit, it is found that 25 of them occupy a distance of 12.87 mm between centers. Find the distance between the centers of the two slits.

4. Refer to the notes on p. 93 to identify the components of the Michelson Interferometer.

   (a) How far must the movable mirror of a Michelson interferometer be displaced for 2500 fringes of the red cadmium line (6438 angstroms) to cross the center of the field of view?

   (b) If the mirror of a Michelson interferometer is moved 1.0 mm, how many fringes of the blue cadmium line (4799.92 angstroms) will be counted crossing the field of view?

5. Design an anti-reflective coating for light of wavelength 950nm to place on top of GaAs (n=3.6) Explain your design process. Specifically, what are the criteria that must be met to ensure zero reflected intensity?

6. In an experiment involving Newton's rings between a curved and flat surface in air, the diameters of the fifth and fifteenth bright rings formed by sodium yellow light (589 nm) are measured to be 2.303 and 4.134 mm, respectively. Calculate the radius of curvature of the convex glass surface.

   Notes:

   (a) The wavelength of the yellow sodium line is 589 nm.

   (b) You can assume that the interference occurs in air, so the refractive index of the "thin film" material is 1.

   (c) There is a bright ring when m=0 in expression 9.42 of Hecht.