

- (6 pts) (a) Two stars have an angular separation of $4.35 \mu\text{rad}$ as viewed from Earth. Assuming that most of the light from the star is yellow with a wavelength around 580 nm , how big must the diameter of a telescope be in order to see that there are two stars, not one? (b) If my eye has a pupil which is 4 mm in diameter, what must the magnitude of the angular magnification of the telescope be for me to be able to see that there are two stars rather than one?
- (6 pts) A television screen generates images which are composed of little red, green, and blue dots. Far from the screen, the dots blend together. (a) If there are 29 dots per cm, how close would you have to put your eye to the screen in order to see the individual dots? (b) If you can't focus on anything closer than 25 cm from your eye, how close must the dots be such that I can't see them no matter how close I get my head to the screen? Use a wavelength of 520 nm , and assume that your pupil has a diameter of 4 mm .
- (6 pts) A stereo is playing a tone through two speakers which are spaced apart by 1.5 m . (a) If the tone being played has a frequency of 880 Hz , use the equation $\theta_{min} = 1.22\lambda/D$ derived from Rayleigh's criterion to approximate how close to the stereo you must be before you can discern that the sound comes from two separate sources. Assume that your ears are spaced apart by 16 cm , and that the speed of sound is 343 m/s . (Note: You should find that you have to be pretty close! This is the reason why a pair of speakers can do a somewhat reasonable job imitating a wide sound field. In other words, this is why a stereo can sound like a symphony of instruments at various locations rather than just two points of sound.) (b) It turns out that this equation doesn't give the right answer for this problem because of approximations made when it was derived. What approximations are violated by this problem?
- (6 pts) The students in my lab sometimes forget to label optics, and sometimes I'll find a diffraction grating with no indication of what the spacing between lines is. Imagine that I take such a grating and shoot a HeNe laser (with a wavelength of 633 nm) at it at normal incidence, and I find that the first-order diffraction peak occurs at an angle of 49.4° . What is the spacing between adjacent grooves on the grating?
- (6 pts) Argon-ion lasers can produce laser beams containing several different wavelengths of light. Two of the wavelengths they can emit are 351.1 nm and 351.4 nm . If my laser is producing both of these wavelengths at the same time, but I only want one of them in my beam, I can separate the two spectral components by reflecting the beam off of a diffraction grating. If I use the first diffraction order, what is the maximum acceptable separation between lines on my diffraction grating? Assume that my laser beam has a total power of 5 Watts and a diameter of 2 mm .

Extra problems I recommend you work (not to be turned in)

- If I have a collimated laser beam which has a diameter of 1 mm , about how big will the diameter of the beam be after it has traveled 10 meters ?
- If I don't want light from different orders to overlap, what is the highest diffraction order I can use if I am looking at visible light (with wavelengths from $400\text{-}700 \text{ nm}$) using a grating with a line spacing of $2\mu\text{m}$?
- An eye chart has two thick red lines separated by a distance of 1 cm . If your eyes are diffraction limited, and your pupils are 4 mm in diameter, how close do you have to be to the chart in order to be able to discern that there are two lines, not just one? Use a wavelength of 650 nm .
- I want to make a telescope with 100 times angular magnification. I am going to use this telescope to look at things with my eye, which has a pupil 4 mm in diameter. If I don't want diffraction in the telescope to limit what I can resolve, what should the minimum diameter of the telescope be?