1. A single slit of width “b”, illuminated with HeNE laser light (\(\lambda = 6328 \text{ Å}\)) produces a Fraunhofer diffraction pattern with first order minima appearing at angular distance \(\theta = 5^\circ\) from the optical axis. How wide is the slit? If the laser light could chopped into pulses of \(10^{-13}\) sec duration: what would change in the observed diffraction pattern? Describe in words and with a sketch.

2. (a) Plot schematically on a sin \(\theta\) scale the intensity pattern of a double slit, for which the distance “a” of the two slits is six times the slit width “b”. Indicate on the sin \(\theta\) axis the values for relevant maxima or minima of the interference pattern, expressed in terms of a, b, and \(\lambda\).

(b) Plot schematically on the same sin \(\theta\) scale how the pattern in (a) changes if four more identical slits of width “b” are added to the two slits in problem (a). (All of the slits are parallel with equal distance ‘a) to their direct neighbors)

3. What is the size of the diffraction-limited image point which a perfect eye produces on the retina for light of \(\lambda = 700 \text{ nm}\) and for an object point at infinite distance (focal distance of the eye lens \(22 \text{ mm}\), with a pupil diameter of \(2 \text{ mm}\) (at daylight vision) and \(8 \text{ mm}\) (adopted to vision at night)? If you would have to “design” the eye as economically as possible (but using its full resolution potential), how would you choose the distance between the photo-receptor cells on the retina to work in an optimum way for the whole visible spectral range?

4. A perfectly corrected positive lens is required to produce an image of two distant point objects (distance \(2 \text{ km}\)) which are \(1.5 \text{ cm}\) apart, such that the conjugated two image points are just resolved. What requirements are necessary for the lens to achieve this when (a) \(400 \text{ nm}\) blue light, and (b) \(700 \text{ nm}\) red light is used?

5. A HeNe laser has a beam diameter of \(1.55 \text{ mm}\). What is the (diffraction-limited) divergence of the beam:
   (a) without and
   (b) and with using an additional telescope of magnification 20 in conjunction with the laser as a beam expander?
   (c) Draw a ray diagram to illustrate the use of the telescope together with the laser.

6. A parallel beam of light, containing two monochromatic spectral emission lines of wavelengths \(\lambda_1 = 600 \text{ nm}\) and \(\lambda_2 = 600.01 \text{ nm}\), is (in normal incidence) diffracted by a plane reflection grating, which has 6000 lines per cm. If a lens of \(5 \text{ m}\) focal distance is used to focus the diffracted line on a screen, what is the linear distance of the two lines on the screen
   (a) in first order?; (b) in second order? (c) How wide must the grating (and light illuminating it) be, so that the two wavelengths (600 and 600.01 nm) are resolved in first order?