Homework for exercise session 3

Thursday Sept 16, 2021

Problems with odd numbers will be solved in class

1- Two positive lenses are to be used as a laserbeam expander. An axial 1.0-mm diameter beam enters a short focal length positive lens, which is followed by a somewhat longer focal length positive lens from which it emerges with a diameter of 8.0 mm. Given that first lens has a 50.0 mm focal length. determine the focal length of the second lens and the separation between the lenses. Draw a diagram

L=450mm
f2=400mm

2- Design an optical system using two positive lenses that will reduce the diameter of a 10mm collimated beam by 1/4. The only constrain is that the two lenses must be separated by 500 mm. Draw a diagram

f1=400mm
f2=100mm

3- A thin lens having a focal length +50.0 cm positioned 250 cm in front of a plane mirror (to the right of the lens). An ant on the central axis 250 cm in front (to the left of the lens. Locate the three image of the ant.

62.5 cm right of lens, 187.5 cm virtual image in mirror, 56.5 cm left od lens

4- An object 20 m from the objective (f, = 4 m) of an astronomical telescope is imaged 30 cm from the eyepiece (f, = 60 cm). Find the total linear magnification of the scope.

Mt=-0.5

5- An optometrist finds that a farsighted person has a near point at 125 cm. What power will be required for contact lenses if they are effectively to move that point inward to a more workable distance of 25 cm so that a book can be read comfortably? Use the fact that if the object is imaged at the near point, it can be seen clearly.

D=3.2 1/m

6- A farsighted person can see very distant mountains with relaxed eyes while wearing +3.2-D contact lenses. Prescribe spectacle lenses that will serve just as well when worn 17 mm in front of the cornea.

D lens = 3.03 1/m

7- Suppose that we wish to make a microscope (used with relaxed eye) out of two positive lenses, both with a focal length of 25mm. Assuming that the object is positioned 27 mm from the objective, how far apart should the lenses be and what magnification can we expect.

L=362.5 mm
M=-125

8- Galileo's telescope was composed of an eyepiece with -40 mm focal length and a biconvex objective with 120 cm focal length and 30 mm diameter. a) Make the corresponding drawing. b) Determine the magnification of this telescope.

M=30

9- We have an optical fiber with a core diameter of 100 microns and a numerical aperture of 0.2 and want to inject a laser beam into the fiber as efficiently as possible.

a) Assume we have a laser bean with 1 mm diameter and uniform intensity that is directly aimed at the optical fiber. What fraction of the laser light will enter the fiber? Make a sketch of the system.

b) What is the acceptance angle of the fiber corresponding to its numerical aperture of 0.2? Make a sketch.

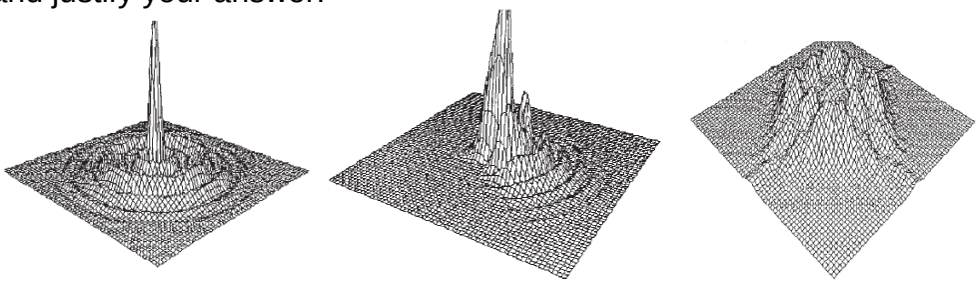
c) To improve this coupling efficiency of the laser light into the fiber, we add a lens in front of the fiber. The lens should be chosen so that the focused light is within the acceptance angle of the optical fiber. Suggest a solution and make the corresponding sketch.

f_lens=2.45 mm

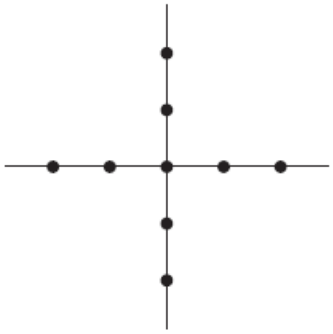
10- The orbiting Hubble Space Telescope has a 2.4-m primary which we will assume to be diffraction limited. Suppose we wanted to use it to read the print on the side of a distant Russian satellite. Assuming that that a resolution of 1cm at the satellite will do, how far away could it be from the HST.

Distance = 39km

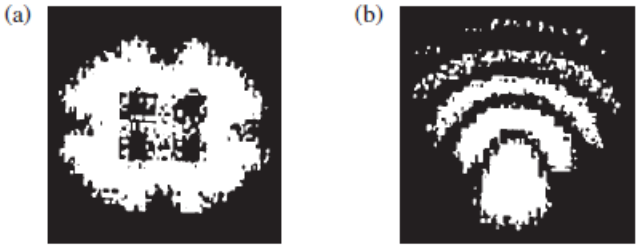
11- The next figures show the image irradiance distributions arising when a monochromatic point source illuminates three different optical systems, each having only one type of aberration. From the graphs identify that aberration in each case and justify your answer.



12- Supposing that the next figure is to be imaged by a lens system suffering spherical aberration only. make a sketch of the image.



13- The next figures show the distribution of light corresponding to the image arising when a monochrolnatic point source illuminates two different optical systems each haling only one type of aberration. Identify the aberration in each case and justify your answer.



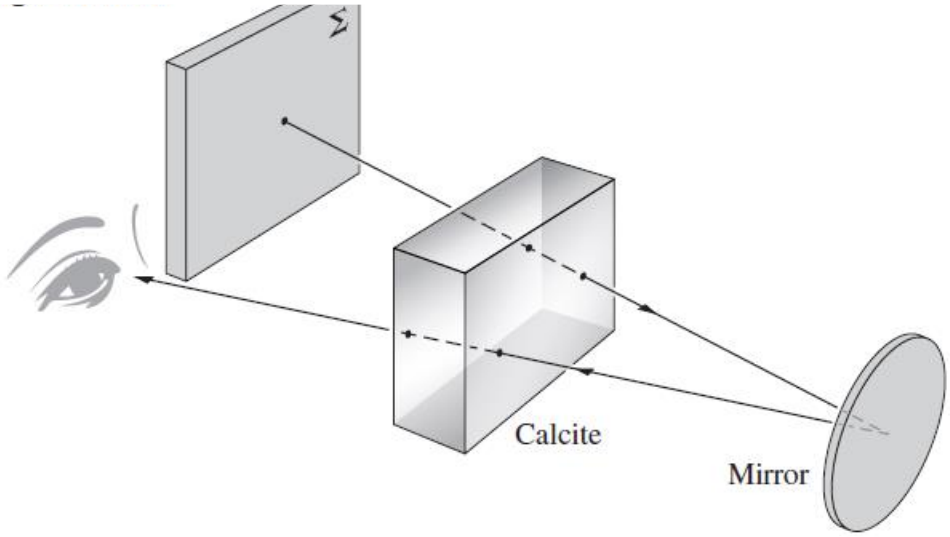
14- Two ideal linear sheet polarizers are arranged with respect to the vertical with their transmission axis at 10 degrees and 60 degrees. respectively. If a linearly polarized beam of light with its electric field at 40 degrees enters the first polarizer, what fraction of its irradiance will emerge.

Transmission=0.31

15- Imagine a pair of crossed polarizers with transmission axes vertical and horizontal. The beam emerging from the first polarizer has flux density I1, and of course no light passes through the analyzer (i.e. I2 = 0). Now insert a perfect linear polarizer with its transmission axis at 45 degrees to the vertical between the two elements, compute I2

I2=I1/4

16- The next figure shows a ray traversing a calcite crystal at nearly normal incidence, bouncing off a mirror, and then going through the crystal again. Will the observer see a double image of the spot on Sigma



17- A beam of light is incident normally on a quartz plate whose optic axis is perpendicular to the beam. If lambda = 589.3 nm, compute the wavelengths of both the ordinary and extraordinary waves.

Lambda ordinary= 381.6 nm
Lambda extra ordinary= 379.4 nm

18- The electric-field vector of an incident P-state makes an angle of +30° with the horizontal fast axis of a quarter-wave plate. Describe, in detail, the state of polarization of the emergent wave.

19- Two incoherent light beams represented by (1, 1, 0, 0) and (3, 0, 0, 3) are superimposed.

(a) Describe in detail the polarization states of each of these
(b) Determine the resulting Stokes parameters of the combined beam
and describe its polarization state.
(c) What is its degree of polarization?
(d) What is the resulting light produced by overlapping the incoherent beams (1, 1, 0, 0) and (1, -1, 0, 0)? Explain.