Physics 256 Assignment 9

Due: Wednesday, November 21st, 2012 4:00 pm in the drop box Physics 2nd floor or electronically 79 marks

1a) If a telescope is astronomical has a tube length of 12.5 cm, and an angular magnification of (-)4X, what are the focal lengths of the objective and eyepiece lengths? **3 marks**

b) If the exit pupil is 1 cm in diameter, what size is the entrance pupil? **2 marks**

2) Determine the power of the eyepiece and the lens spacing (tube length) to provide a Galilean telescope with a magnification of 4X with Galileo's objective with a focal length of 1.7 m. Notice that in the Galilean telescope one can use lower powered lenses for the same magnification and length as the astronomical or similar powers with a more compact size. **3 marks**

b) If the objective is 5.6 cm in diameter, what is the minimum eyepiece diameter? **2 marks**

3) Telescope used as a reverse laser beam expander: Hecht 5.40. **4 marks**

4) In the diagram below, which surface is the aperture stop and which is the field stop. Justify your answer. **4 marks** From Smith: Modern Optical Engineering:

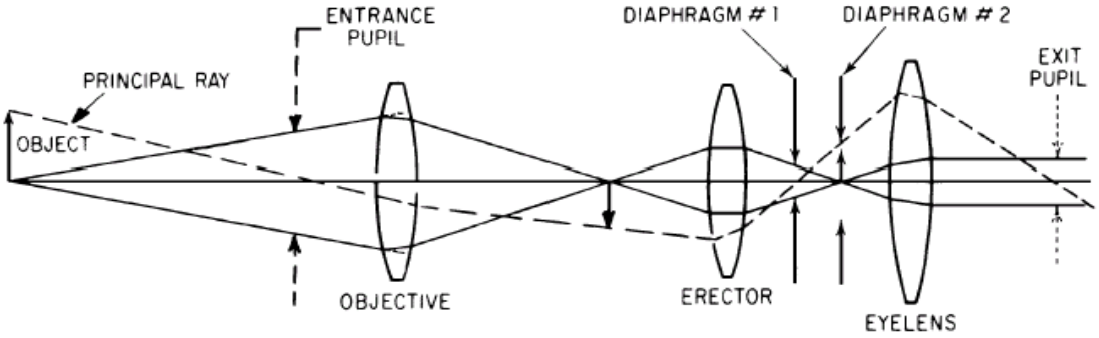
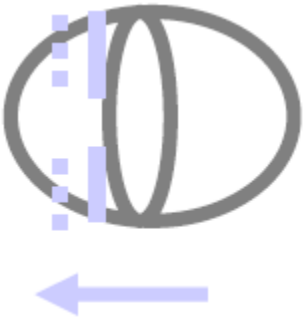


Figure 6.2 Schematic sketch of an optical system to illustrate the relationships between pupils, stops, and fields.

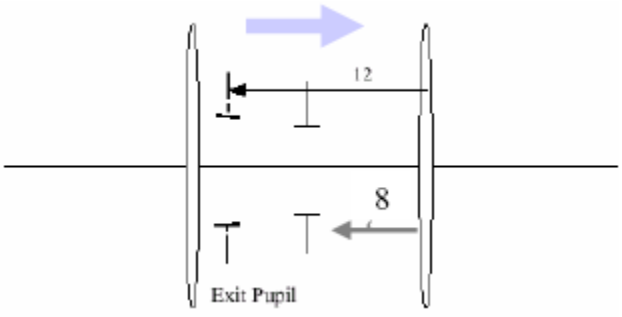
5) The entrance pupil of the eye is the image of the iris seen by an observer looking through the cornea. If the cornea is considered to be a single surface of R=7.8 mm with air in front and water (n=1.333) behind, and the iris is located 3.6 mm behind the cornea, what is the size and magnification of the entrance pupil? Show that the entrance pupil is 3.0mm behind the cornea and is 13% larger than the iris. HINT: Assume that the iris is the object and light comes from the object. (see slide 26). **4 marks**



b) If the iris is 3.5 mm in diameter, what size is the entrance pupil? Is the entrance pupil real or virtual? **2 marks**

c) Trace a marginal and a chief ray through the pupil. **2 marks**

6) Calculate the exit pupil position and size: In the picture opposite, f_i of lens 2 is 24 cm. and the aperture stop is 8 cm from the 2nd lens. It is also 8 cm from the 1st lens which has a focal length of 4 cm. Show that the exit pupil is 12 cm from the second lens and, if the aperture is 2 cm diameter, the exit pupil is 3 cm. HINT: This will only involve the second lens. **6 marks**



7) a) Hecht 5.80 (f# of a camera). **4 marks**

b) By how much does the irradiance of an image change if the f# goes from f/8 to f/2? **2 marks**

c) In red light (λ=632.84 nm), what is the diameter of the image of a point source on the CCD plane assuming only diffraction blur (the "diffraction-limited case") if the entrance pupil is 1 cm and the camera lens has a focal length of 150 mm? **2 marks**

d) What is the angular extent of the diffraction blur at the entrance pupil plane for the point source in c) above? **2 marks**

8) a) 10.28: telescope resolution compared to the eye's resolution- the objective mirror is also the entrance pupil. This resolution would be reduced by wavefront aberrations caused by the atmosphere unless adaptive optics are used. **11 marks**

b) What is the radius of the central portion of the Airy disk formed by a small star at the focal plane of the objective mirror if its f# is 3.3? **3 marks Note**: In the case of an in-focus image for a distant source (in air), the image will be located at the focal point of the optical system. In most systems it can be approximated that the entrance pupil of the system is close to the principal plane.

9) Answer the questions on slide 74 of the Depth of Focus slides: How does the change in f# from f/22 to f/2 change each of the following? Quantify your answer where possible. **9 marks**

- Flux density?
- Diffraction?
- Aberrations?
- Depth of field?

How does doubling the focal length of a camera change the CCD resolution?

10) Depth of Focus and Depth of Field: a) If the acceptable blur diameter in the film plane of a 50 mm focal length camera is 0.01 mm, and the f/# is set at f/16, what is the depth of focus in the camera? Assume that the camera is focused at distance. **2 marks**

b) If the camera is sharply focused an object at 1 m from the lens, how close to the camera can the object be moved before it appears blurred? The distance that the object is moved is δ, the depth of field. First the camera lens is moved so that the image is in sharp focus for an object at 1 m. Find the lens to image plane distance in this case by assuming that the focal length does not change. Then find the depth of

field in object space approximately by calculating the transverse magnification M_T. δ will be approximately δ'/M_T^2 where δ' is the depth of focus calculated previously. Note that this calculation gives symmetric δ and δ' towards and away from the best focus. **6 marks**

c) How does your answer compare to the calculation on the web page that is linked to slide 67? What is the δ away from the object at 1 m? Inwards from the object? **2 marks**

d) If the f# becomes f/8, what happens to the depth of focus? Depth of field? **4 marks**