OPTI-502 **Optical Design and Instrumentation I** John E. Greivenkamp

Homework Set 8 Fall, 2011

Assigned: 10/20/11 Lecture 18
Due: 10/27/11 Lecture 20
(but it will be turned in 11/1/11 - Lecture 21 due to instructor travel)

8-1) A perfectly flat Lambertian source radiates a total of 21W into a hemisphere. Its area is 5 cm^2. Determine its radiance.

8-2) A detector requires a total radiant input of 1 microwatt (10^{-6} Watt) in order to produce a useful signal. The square detector is 2 cm x 2 cm. An f/2 lens is used to image a large distant extended object onto the detector. The image of this object overfills the detector. Assume the object is Lambertian and uniform. The detector is integrates all of the light falling on it to produce a single output; it does not produce an image.

What is the required radiant exitance (W/m^2) of the object?

8-3) Design an optical system to photograph an antelope at 100 m on a sunny day. You will use 35 mm film (24 mm x 36 mm) that requires an exposure of 0.2 lux-s (or lm-sec/m^2). The antelope can be modeled to be 1 m x 1 m and your exposure time must be shorter than 0.02 sec. Lay out the optical system, and try to use "commercially" available focal lengths (i.e. round numbers like 50, 100, 200, 1000, 5000...); specify the focal length and f/#. You may assume that the lens is a simple thin lens (do not design a telephoto lens). Note any assumptions you have to make.
Assume the illuminance on the scene is 1.2 x 10^5 lx (or lm/m^2).

8-4) An 80 mm focal length thin lens is used to image an object with a magnification of -1/2. The lens diameter is 25 mm and a stop of diameter 20 mm is located 40 mm in front of the lens.

How big is the unvignetted field of view (in mm)?
How big is the fully vignetted field of view?

8-5) An air-spaced triplet objective is comprised of three thin lenses in air:

	Focal Length	Spacing
Lens 1	100 mm	25 mm
Lens 2	-50 mm	25 mm
Stop	-----	50 mm
Lens 3	100 mm	

The object is at infinity, and the stop diameter is 20 mm. Use separate raytrace sheets for your chief ray and for your marginal ray. Clearly identify the surfaces on the sheets.

a) Use paraxial raytrace methods to determine the entrance pupil location and size, the exit pupil location and size, the system focal length, and the back focal distance.

b) The maximum image height of the system is 50 mm. This dimension corresponds to the half field of view of the system. Determine the required lens diameters for the system to be unvignetted over this half field of view.

c) What is the angular Field of View of the system in object space? Give your answer in degrees.

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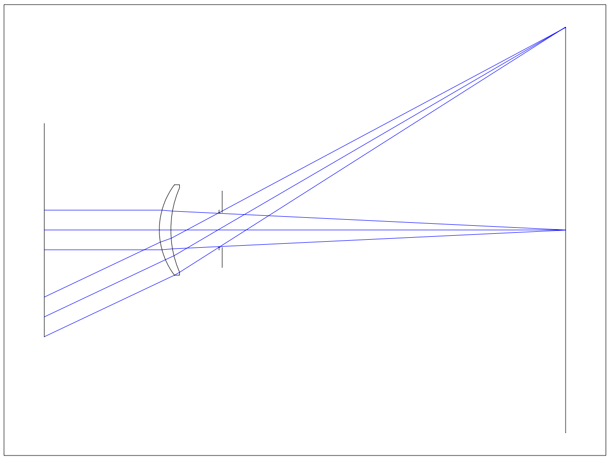
8-6) A landscape lens is a common lens configuration for inexpensive and single use cameras. This lens consists of a positive meniscus element with a separated stop. The lens is relatively slow, but its aberrations are well balanced over its field of view.



For the purpose of this problem, we can consider the lens element to be a thin lens. Since the thickness of the thin lens element is zero and we are only interested in the first order properties of the system, we do not need to discuss the bending of the lens. (The bending of the lens corrects the aberrations of the system.)

Focal length	38 mm
Lens to stop separation	5 mm
Stop diameter	3 mm
Maximum image height	+/- 18 mm

(to match the long dimension of a 35 mm negative)

a) Determine the location and size of the entrance pupil. What is the f/# of this system?

b) What is the required lens diameter for the system to be unvignetted over this field of view?

8-7) Design a thin-lens telephoto lens with a back focal distance of 50 mm and an effective focal length of 200 mm.

8-8) The goal of this problem is to design a variable focal length lens using a plano-convex lens, a plane parallel plate, and a fluid that has a variable index of refraction. The fluid is placed between the lens and the plane parallel plate to produce a sandwich of thin lenses. There are no moving parts, and the finished system is in air.

Plano-convex lens:	focal length = 100 mm	n = 1.517
Plane parallel plate:	thickness = 2 mm	n = 1.517

a) Sketch the arrangement of elements and give the equation for the system focal length as a function of the index of the fluid.

b) If the index of this fluid can vary from 1.3 to 1.7, what range of power or focal length can be obtained with the system? Note that this is a fictitious fluid!

Thin Lens YNU Method

	0	1	2	3	4	5	6	7
f								
-φ								
t								
y								
u								
y								
u								
y								
u								