

Assigned: 11/29/11 Lecture 28
Due: 12/6/11 Lecture 30

Final Exam: Tuesday 12/13/11 8:00-10:00

Distance Students: All course materials must be returned to Tucson by **Monday December 19, 2011**. You may schedule your final exam with your proctor as required by your schedule.

13-1) An Epidiascope or Opaque Projector is used to project the words or images on a piece of paper onto a screen. It is similar to an overhead projector except that it is used for diffuse objects.

Design an opaque projector:

Paper:	8.5 x 11 inch
Screen:	2 m x 2 m
Distance to the screen:	3 m (from projection lens)

Clearly the problem is going to be getting enough light onto the screen for practical viewing. For practical reasons, the projection lens is limited to a diameter of 8 inches. The desired screen luminance is 2.0 cd/ft^2 (candela/ft²) for white areas on the paper. If each light bulb used to illuminate the paper produces an illuminance of 1000 ft-cds, how many light bulbs are needed?

Note any assumptions you make.

13-2) How parallel must the surfaces of a plane parallel plate be in order for the ray deviation through the plate to be less than 1 arc min? Assume $n = 1.5$.

13-3) Design an achromatic prism producing a deviation of 30 arc min using BK7 and F2 glasses. Determine the magnitude of the secondary dispersion. Compare this secondary dispersion value to the dispersion of simple wedge of BK7 producing the same deviation.

	BK7	F2
n_F	1.52237	1.63208
n_d	1.51680	1.62004
n_C	1.51432	1.61503

13-4) In the 17th century, telescopes were made with singlet objective lenses. Resolutions of 0.1 arc min were obtained for visual observations in white light. Light collection efficiency was determined by the biggest piece of glass available. If this lens diameter is 100 mm, what focal length is required to reduce the transverse axial chromatic aberration of this objective to the point where this resolution is obtained? Use typical values for an ordinary glass type.

13-5) For the following pairs of glasses, design an $f/10$ thin lens achromat of focal length 100 mm. Show how you do the calculations and present your results in a table listing: the Δv and ΔP values for the pair of glasses, the powers of the individual elements (and which glass they are made from), the secondary longitudinal aberration of the doublet, and the primary longitudinal aberration of the two elements individually.

- a) BK 7 and SF 1
- b) K 7 and F 1
- c) LaK 8 and KF 6
- d) SSK N5 and LF 5

e) Which of these produces the best lens? This is a subjective evaluation, and there may not be a single best answer.

	F	d	C
BK7	1.52238	1.51680	1.51432
F1	1.63827	1.62588	1.62074
K7	1.51700	1.51112	1.50854
KF6	1.52434	1.51742	1.51443
LaK8	1.72222	1.71300	1.70898
LF5	1.59146	1.58144	1.57723
SF1	1.73462	1.71736	1.71032
SSK N5	1.66749	1.65844	1.65456

13-6) You are to design a microscope objective. The objective is for a microscope with an Optical Tube Length OTL of 160 mm. In order to be parfocal with other objectives, the distance from the object plane to the rear focal point of the objective must be 60 mm.

Section A

Provide the first-order design of an objective with the following specifications:

5X

Working Distance = 15 mm

The objective is to be designed as two separated thin lenses in air.

Section B

The numerical aperture of the objective is 0.25, and the objective is telecentric in object space.

The field stop of the microscope is 20 mm in diameter. This field stop at the intermediate image plane defines the FOV of the objective, and the system must be unvignetted over this FOV. This same condition would apply to any objective used with the microscope so that the same “size” image is seen through the eyepiece independent of the objective magnification.

Determine the stop position, stop size and the required element diameters. Also determine the maximum object size corresponding to the FOV defined by the field stop.

Section C

Specular illumination is to be provided by a source and condenser system. What two conditions must be met in order to properly couple the source into the stop of this objective?

As an example, sketch the illumination system for this objective using a source of diameter w and a single condenser lens of focal length f_c . Note any required relationships between w and f_c . Assume a transparent object.

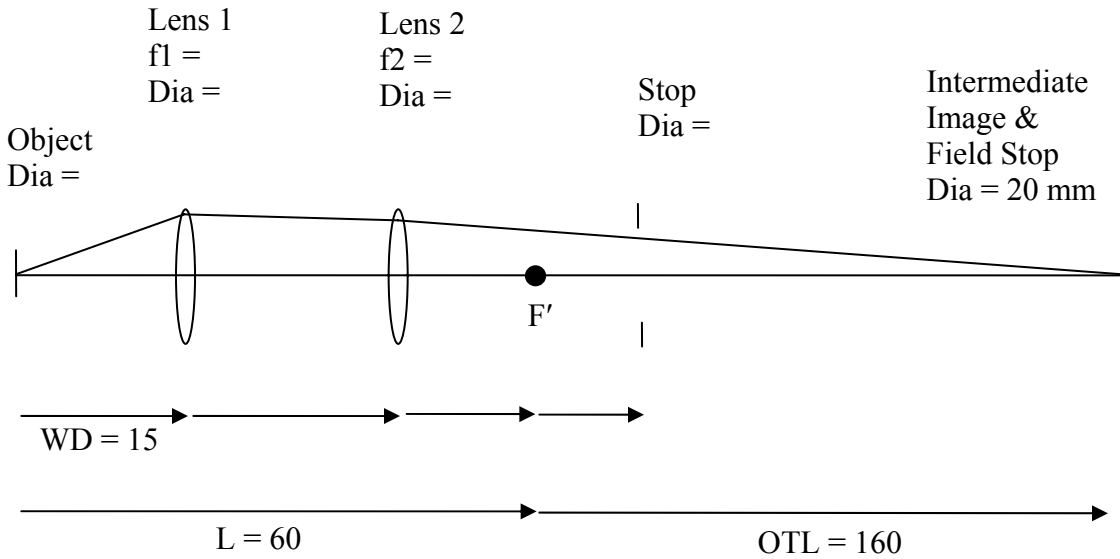
Note: This is a first-order design problem. All lenses can be assumed to be thin lenses with no aberrations and no thickness. To aid in grading, this problem may be more completely specified than you would normally encounter. In fact, the approach specified may or may not be the “best” form of the solution. All of the given specifications must be met exactly.

IMPORTANT -- The problem is to be worked in sections. Each section must start on a new page of your solution. In addition, a summary page with a diagram of the system is attached where all of the pertinent details of your design must be shown. This summary page is to be used as the cover page of your solution.

NAME _____

Cover Sheet for Solution

Sections A and B



Objective Focal Length =

Principal Plane Locations: $d =$ $d' =$

Section C – Summary only; provide further discussion in the body of the solution.

Conditions: 1)

2)

Sketch:

