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

Practice Project 3

Design a zoom lens for an APS camera.

To refresh your memory, the APS film format is

16.7 mm x 30.2 mm The film is 24 mm wide.

The print format used is the "Classic" format; the print will have a 2:3 height to width ratio, and an example print size is 4 x 6 inches. The used area of the APS negative in this format is 16.7 x 25.0 mm.

Specifications:

Focal length range:	To be determined (as large as possible)
Stop location:	At the first element
Stop Diameter:	8 mm
Minimum element spacing:	5 mm
Minimum working distance (last element to film plane):	5 mm
Maximum system length (first element to film plane):	60 mm
Lens configuration:	Two-element zoom lens Telephoto configuration (positive-negative)
Element focal lengths:	$f_1 = -f_2$ (equal but opposite focal lengths – This is an arbitrary but useful choice)

The constraints on length, spacings and working distance assume an object at infinity.

Part A

Provide a first-order design of the zoom lens. *Use Gaussian reduction.* (This is a first-order design problem. All lenses can be assumed to be thin lenses with no aberrations and no thickness.)

The lens is to be designed to obtain the largest possible range of focal lengths while not violating any of the mechanical constraints on length, spacings or working distance. Note: all three of the given constraints need to be applied sometime during the design of the lens. One or more constraints will be applied to certain focal length configurations within the zoom range.

Determine the focal length range of the zoom lens. Provide the element focal lengths and the equations for the element separations as a function of the system focal length. Also provide a table giving the two spacings and the total length at the maximum and minimum focal lengths as well as at regular 5 mm increments of focal length (30 mm, 35 mm, 40 mm, etc.). Plot the lens positions relative to the image plane as a function of focal length (similar to the plot found in the class notes).

Note: This problem is more completely specified than you would normally encounter. In fact, the approach specified may or may not be the "best" form of the solution.

OPTI-502 **Optical Design and Instrumentation I** John E. Greivenkamp
Practice Project 3

Part B

Find the required element diameters so that the system is unvignetted out to the corner of the used area of the negative at all zoom positions or focal lengths. As part of the analysis, determine which zoom position requires the maximum diameters.

Part C

It is pretty obvious what the next marketing request is going to be, so you decide to start thinking about the design of a zoom viewfinder.

There are two options:

a) A modification of the Galilean viewfinder to include zoom. This viewfinder would be appropriate for a low-cost camera.
b) A high-end zoom viewfinder that includes a reticle plane with framing marks to define the image. In this type of viewfinder, a zoom objective forms an intermediate image at the reticle plane, and mirrors and/or prisms are used to obtain the proper orientation and parity through an eye lens. The viewfinder path is no longer straight through the camera body. The viewfinder optical system is completely separate from the zoom lens used to expose the film.

Discuss, but do NOT design these viewfinders. Provide sketch of a system layout for each and a description of how each viewfinder works. For reference (and to help guide your thinking), the camera body is about 20 mm thick, and the required magnifying power MP of the viewfinder is approximately 0.6 to 1.8.

Note: The type of viewfinder described in b) is actually built, and yes, the elements are small!