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

Practice Project 5

Design a rigid endoscope for industrial inspection.

- All of the lens elements of the endoscope must fit inside a tube with an inner diameter of 2 mm. All of the lens elements must have the same diameter of 2 mm.
- The first lens or the objective lens is also the system stop.
- After some number of image relays, the object is imaged onto a 1/3" format CCD array (3.6 mm x 4.8 mm).
- All of the internal lenses (both the field lenses f_F and the relay lenses f_R) must have the same focal length. The objective lens f_O and the final imaging lens f_I may have different focal lengths.

Section A

Provide the first-order design of an endoscope for the following situation:

- Object size: +/- 2 mm The object is in air.
- This circular FOV must be imaged within the active area of the CCD array.
- Standoff distance: 20 mm (distance from the object to the objective lens)
- System length: 280 mm < L < 300 mm
  (L is the distance from the objective lens to the CCD array)
- Field lenses are placed at the image planes (no offset)
- Unvignetted

Note that the orientation (erect or rotated 180 degrees) of the image on the CCD array is unimportant as the CCD array can be rotated to match the image orientation during the assembly of the endoscope.

Section B

The endoscope designed in Section A is now to be used with an object with a standoff distance of 15 mm (The object is 15 mm from the objective lens). Since the lens elements are fixed in the endoscope tube, the CCD array must be translated for the image to be in focus on the CCD.

Where must the CCD be located relative to the final imaging lens?
What is the unvignetted object FOV of this refocused system?
This FOV is measured in mm in the plane of the object.
Does this FOV underfill or overfill the CCD array? (It will underfill the CCD if the image of this object FOV is less than the sensor size.)

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.

All of the given specifications must be met exactly.

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NAME _____ Cover Sheet for Solution

Section A

Objective Focal Length f_O =

Imaging Focal Length f_I =

Field Lens Focal Length f_F = Number of Field Lenses =

Relay Focal Length f_R = Number of Relay Lenses =

Total Number of Lens Elements Required =

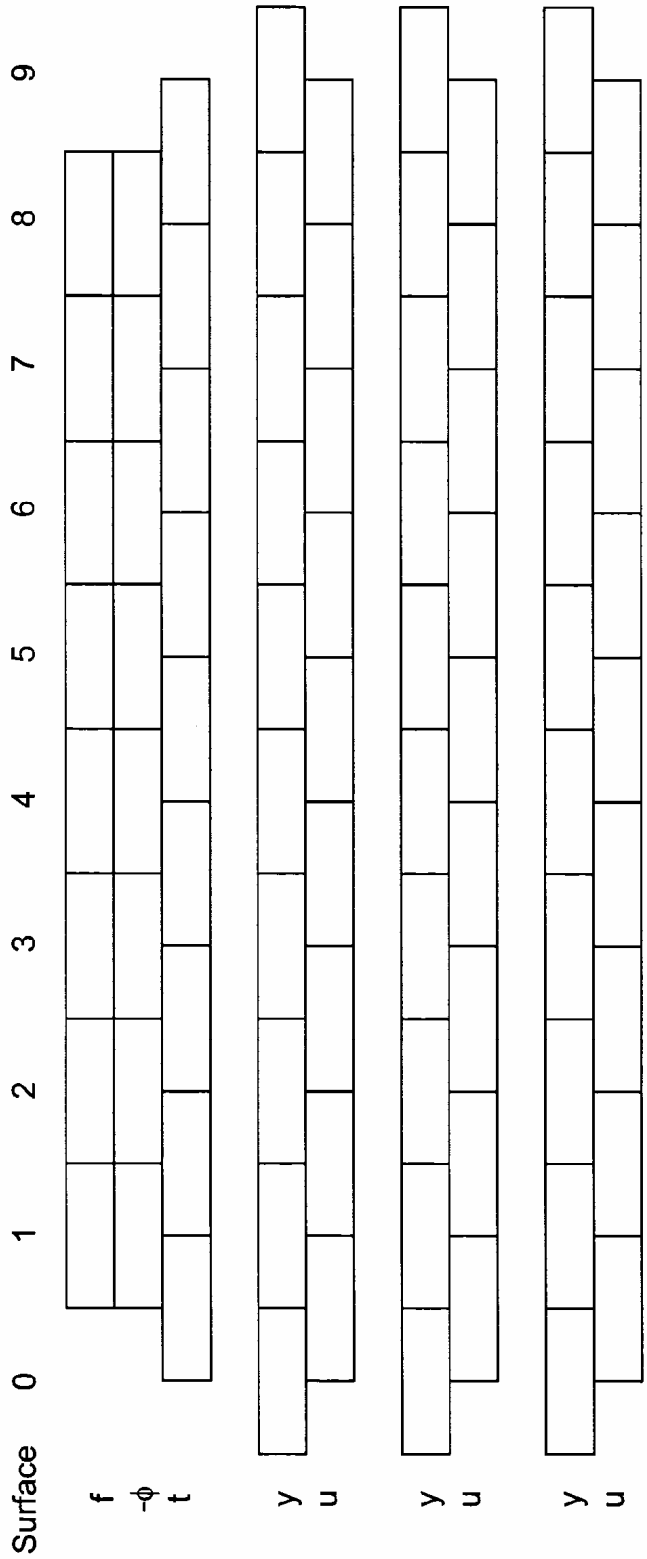
Total System Length (Objective Lens to the CCD Array) =

Section B

CCD Location Relative to the Imaging Lens =

Unvignetted Object FOV =

Does the image of this object FOV underfill or overfill the CCD?


Surface
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