October 28, 2014 Lecture 19 Name_________________________

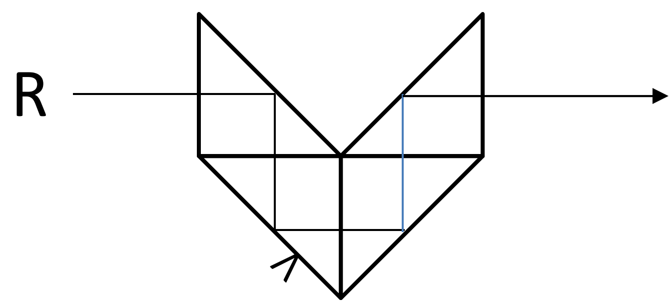
Closed book; closed notes. Time limit: 75 minutes.
An equation sheet is included and can be removed. A spare raytrace sheet is also attached
Use the back sides if required.
Assume thin lenses in air if not specified.
If a method of solution is specified in the problem, that method must be used.
Raytraces must be done on the raytrace form. Be sure to indicate the initial conditions for your rays.
You must show your work and/or method of solution in order to receive credit or partial credit for your answer.
Only a basic scientific calculator may be used. This calculator must not have programming or graphing capabilities. An acceptable example is the TI-30 calculator. Each student is responsible for obtaining their own calculator.
Note: On some quantities, only the magnitude of the quantity is provided. The proper sign convention must be applied.

Distance Students: Please return the original exam only; do not scan/FAX/email an additional copy. Your proctor should keep a copy of the completed exam.

1) (10 points) An object at infinity is imaged by a 10 mm focal length thin lens in air onto a detector that has dimensions of 4 mm x 6 mm (V x H). What are the Vertical and Horizontal Fields of View in object space (in degrees)?

Vertical FOV = ________ deg Horizontal FOV = ________ deg

2) (10 points) The following prism system consists of three right angle prisms plus one Amici or roof prism assembled and used as shown.



a) Draw the tunnel diagram and indicate the orientation and parity of the letter "R" as viewed through the prism system.

b) As the prism system is rotated about the parallel input and output ray paths, what happens to the viewed image?

3) (15 points) A 20 mm high object is 250 mm to the left of the front vertex of a thick lens in air. The lens specifications are:

R1 = 50 mm	R2 = -75 mm
t = 15 mm	n = 1.60

Determine the focal length of the lens.
Determine the image size and the image location relative to the rear vertex of the lens.

NOTE: Use Gaussian Reduction and Gaussian Imaging for this problem. Cascaded imaging may not be used (you may not image through one surface and then use this image as an object for the other surface).

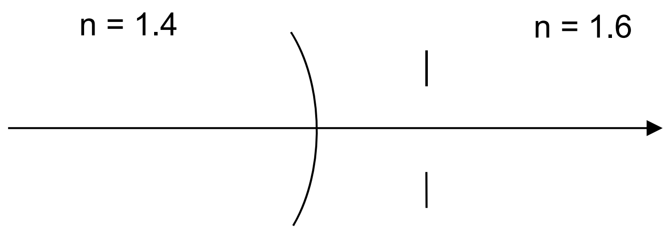
Continues…

Focal length = _______ mm

Image size = _______ mm Located _______ mm to the ______ of the rear vertex.

4) (15 points) A concave single refracting surface of radius 100 mm separates indices of refraction 1.4 and 1.6. A 10 mm diameter stop is located 25 mm to the right of the surface. Determine the size and location of the entrance pupil.

Note: Only Gaussian Methods may be used for this problem.



EP: Location: _________ mm to the _______ of the vertex. Daimeter = _______mm

5) (10 points) An optical system in air is comprised of two thin lenses:

$f_1 = 100$ mm
$f_2 = -100$ mm
$t = 40$ mm

Use a paraxial raytrace to determine the system focal length and the location of the Front Focal Point F and the Front Principal Plane relative to the first lens.

Surface	0	1	2	3	4	5	6
f							
$-\phi$							
t							
y							
u							
y							
u							

P: _________ mm to the ________ of L1; F: _________ mm to the ________ of L1

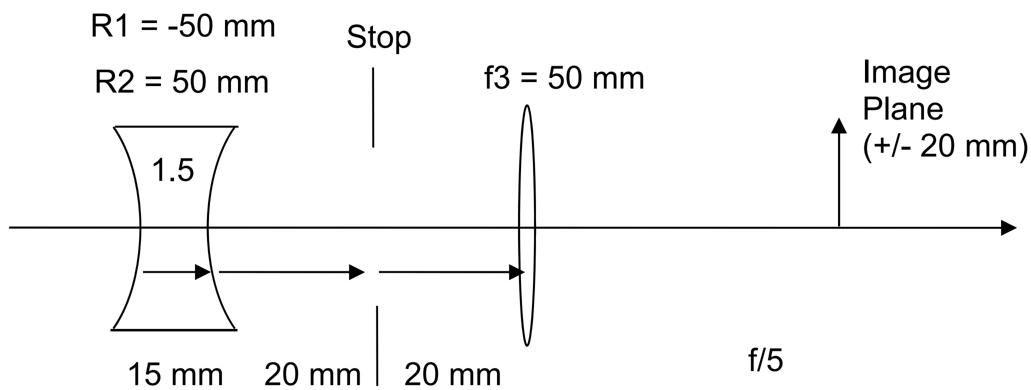
6) (10 points) An afocal system (in air) is constructed out of a positive thin lens followed by a negative thin lens. The separation between the two lenses is 100 mm and the longitudinal magnification of the system is 0.01.

Determine the focal lengths of the two lenses.

f1 = _________ mm f2 = __________mm

7) (30 points) The following diagram shows the design of an optical system that is comprised a biconcave thick lens in air, a stop, and a thin lens in air. The index of refraction of the thick lens is 1.5.

The system operates at f/5. The object is at infinity.



The maximum image size is +/- 20 mm.
Determine the following:
- System focal length.
- Back focal distance
- Entrance pupil and exit pupil locations and sizes.
- Stop diameter.
- Angular field of view (in object space).

NOTE: This problem is to be worked using raytrace methods only. All answers must be determined directly from the rays you trace; for example, the field of view must be determined from the chief ray. Gaussian imaging methods may not be used for any portion of this problem. Be sure to clearly label your rays on the raytrace form.

Your answers must be entered below. Be sure to provide details on the pages that follow to indicate your method of solution (how did you get your answer: which ray was used, analysis of ray data, etc.)

Entrance Pupil: ________ mm to the _______ of the first vertex. D_{EP} = ________ mm

Exit Pupil: ________ mm to the _______ of the thin lens. D_{XP} = ________ mm

Stop Diameter = _________ mm

System Focal Length = _________ mm Back Focal Distance = _________mm

FOV = +/- _______ deg in object space

Surface	0	1	2	3	4	5	6	7
C								
t								
n								
-ϕ								
t/n								
y								
nu								
u								
y								
nu								
u								
y								
nu								
u								
y								
nu								
u								
y								
nu								
u								

Continues…

Provide Method of Solution:

Continues

Continues…

Spare raytrace sheets

Surface	0	1	2	3	4	5	6	7
C								
t								
n								
-φ								
t/n								
y								
nu								
u								
y								
nu								
u								
y								
nu								
u								
y								
nu								
u								
y								
nu								
u								

Surface	0	1	2	3	4	5	6
f							
$-\phi$							
t							
y							
u							
y							
u							

OPTI-502 Equation Sheet
Midterm

$$OPL = nl$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\gamma = 2\alpha$$

$$d = t\left(\frac{n-1}{n}\right) = t - \tau$$

$$\phi = (n' - n)C$$

$$\frac{n'}{z'} = \frac{n}{z} + \phi$$

$$f_E = \frac{1}{\phi} = -\frac{f_F}{n} = \frac{f'_R}{n'}$$

$$m = \frac{z'/n'}{z/n} = \frac{\omega}{\omega'}$$

$$m = \frac{f_{F2}}{f'_{R1}} = -\frac{f_2}{f_1}$$

$$\bar{m} = \frac{n'}{n} m^2$$

$$\frac{\Delta z'/n'}{\Delta z/n} = m_1 m_2$$

$$m_N = \frac{n}{n'}$$

$$P'N' = PN = f_F + f'_R$$

$$\tau = \frac{t}{n} \qquad \omega = nu$$

$$\phi = \phi_1 + \phi_2 - \phi_1\phi_2\tau$$

$$\delta' = \frac{d'}{n'} = -\frac{\phi_1}{\phi}\tau \qquad BFD = d' + f'_R$$

$$\delta = \frac{d}{n} = \frac{\phi_2}{\phi}\tau \qquad FFD = d + f_F$$

$$\omega' = \omega - y\phi$$

$$y' = y + \omega'\tau'$$

$$f/\# \equiv \frac{f_E}{D_{EP}} \qquad NA \equiv n\left|\sin U\right| \approx n\left|u\right|$$

$$f/\#_W \equiv \frac{1}{2NA} \approx \frac{1}{2n\left|u\right|} \approx (1-m)\,f/\#$$

$$I = H = n\bar{u}y - nu\bar{y}$$

$$\bar{u} = \tan(\theta_{1/2})$$
