October 18, 2017 Lecture 17 Name________________________

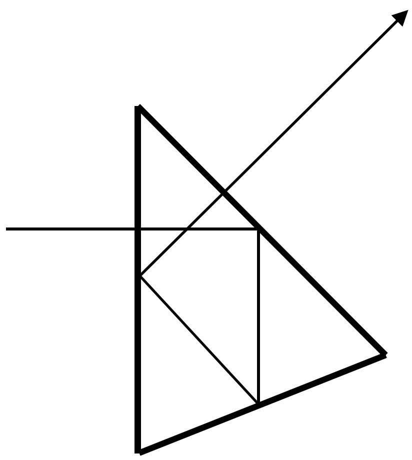
Closed book; closed notes. Time limit: 75 minutes.
An equation sheet is attached and can be removed. A spare raytrace sheet is also attached.
Use the back sides if required.
Assume thin lenses in air if not specified.
If a method of solution is specified in the problem, that method must be used.
Raytraces 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.
Provide your answers in a neat and orderly fashion. No credit if it can't be read/followed.
Use a ruler or straight edge!
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 conventions and reference definitions 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) A 10 mm square LCD is used in a projector. A 2 m square screen is located at a distance of 5 m from the projector. Approximately what focal length lens is required for the image to fill the screen?

Focal Length ≈ __________ mm

2) (10 points) Draw the tunnel diagram for this prism and the ray path shown.



3) (15 points) An optical system is to be constructed using two thin lenses in air. The system must have a focal length of 100 mm and a back focal distance of 75 mm. The spacing between the two thin lenses is 50 mm.

Determine the focal lengths of the two thin lenses. Sketch the system noting the positions of P' and F'.

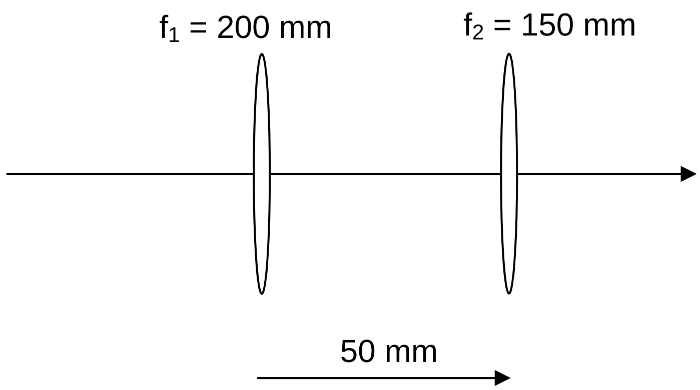
NOTE: Use Gaussian Reduction and Gaussian Imaging for this problem. Cascaded imaging may not be used (you may not image through one lens and then use this image as an object for the other lens).

f_1 = __________ mm f_2 = __________ mm

4) (10 points) A thin lens is made of a glass with an index of 1.70. When immersed in water, the rear focal length of the lens is 100 mm. The index of water is 1.33. What is the focal length of this lens in air?

Focal Length = __________ mm

5) (15 points) An optical system in air is comprised of two thin lenses:



An object is placed 500 mm to the left of the first lens. The object size is ± 10 mm. Use paraxial raytrace methods to determine the system focal length and the location and size of the image.

Determine:
- System Focal Length
- Back Focal Distance
- Image Location and Size

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 image size must be determined from a separate raytrace. Raytraces must be done on the raytrace form. Be sure to clearly label your rays on the raytrace form. A method of solution explaining your procedure and calculations must be provided. Calculations may NOT be done in the margins of the raytrace sheet. Gaussian imaging methods may not be used for any portion of this problem.

System Focal Length = ___________ mm

Back Focal Distance = ___________ mm

Image Location = ___________ mm to the ______ of the second lens

Image Size = +/- ___________ mm

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

Continues…

Method of Solution:

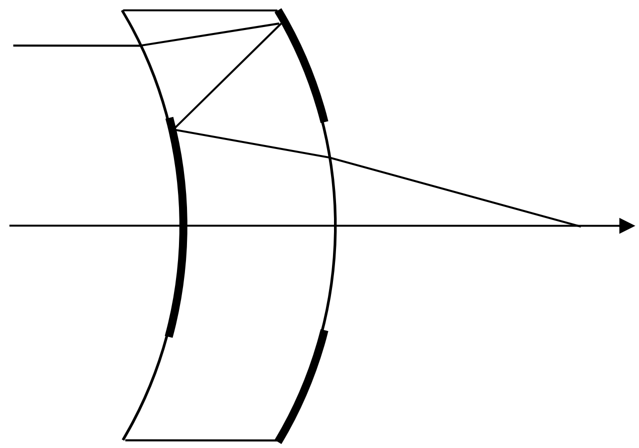
6) (20 points) A catadioptric system uses both reflection and refraction to achieve its focal power. A solid catadioptric system (a solid-cat) can be produced by coating portions of the front and rear surfaces of a thick lens so that there are transmissive and reflective zones on each surface. In this system, both surfaces have the same radius of curvature.

R1 = R2 = -100 mm

t = 30 mm

n = 1.5

The system is in air.



Use a paraxial raytrace to determine the back focal distance and the system focal length.

NOTE: This problem is to be worked using raytrace methods only. All answers must be determined directly from quantities derived from the rays you trace. Raytraces must be done on the raytrace form. Be sure to clearly label your rays on the raytrace form. A method of solution explaining your procedure and calculations must be provided. Calculations may NOT be done in the margins of the raytrace sheet. Gaussian imaging methods may not be used for any portion of this problem.

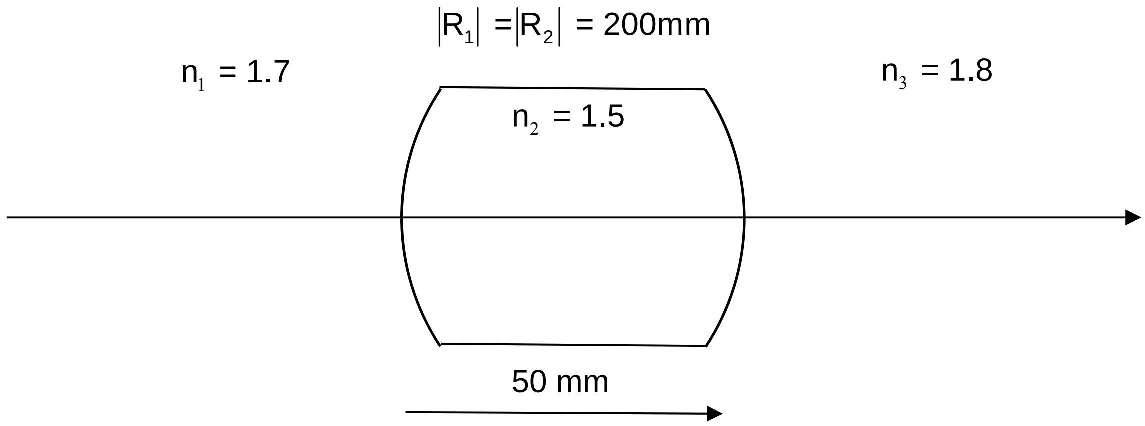
A sizeable portion of the credit for this problem is properly setting up the raytrace sheet.

Focal Length = ____________ mm Back Focal Distance = ___________ mm

Method of Solution:

Surface	0	1	2	3	4	5	6
C							
t							
n							
$-\phi$							
t/n							
y							
nu							
u							
y							
nu							
u							

7) (20 points) An equi-convex thick lens of index 1.5 separates media of indices 1.7 and 1.8. Both radii are 200 mm and the lens is 50 mm thick.



A 10 mm high object is located 100 mm to the left of the front vertex of the lens. Determine image size and the location of the image relative to the rear vertex of the lens.

NOTE: Use Gaussian Reduction and Gaussian Imaging for this problem. Explain your process. Cascaded imaging may not be used for this problem. No credit will be given for any answers obtained by raytrace methods

Continues…

Image: Located _________ mm to the ____ of the rear vertex Size = _______ mm

Spare raytrace sheets

Surface	0	1	2	3	4	5	6
C							
t							
n							
$-\phi$							
t/n							
y							
nu							
u							
y							
nu							
u							

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

OPTI-502 Equation Sheet
Midterm

$$OPL = nl$$

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

$$\gamma = 2\alpha$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\omega' = \omega - y\phi \qquad n'u' = nu - y\phi$$

$$\phi = -\frac{\omega'_k}{y_1}$$

$$y' = y + \omega'\tau' \qquad y' = y + u't'$$

$$Sag \approx \frac{y^2}{2R}$$