October 24, 2018 Lecture 19 Name________________________

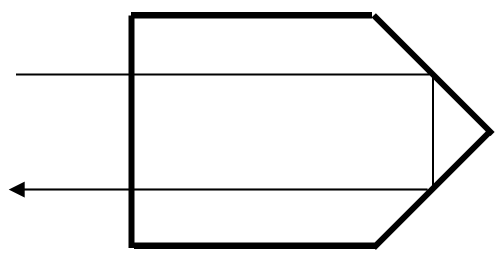
Closed book; closed notes. Time limit: 75 minutes.
An equation sheet is attached and can be removed. A spare raytrace sheet is also attached.
Use the back sides if required.
Assume thin lenses in air if not specified.
If a method of solution is specified in the problem, that method must be used.
Raytraces 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) An object is located 10 m to the left of a 50 mm focal length thin lens. The detector size is 5 x 5 mm. What is the approximate maximum object size that can be imaged?

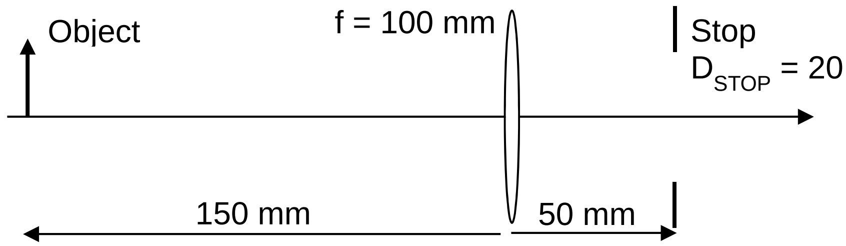
Object Size ≈ ______ m x ______ m

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



3) (15 points) An object is located 150 mm to the left of a 100 mm thin lines in air. The system aperture stop is 50 mm to the right of the lens. The stop diameter is 20 mm.

**NOTE: Use Gaussian Reduction and Gaussian Imaging for this problem.**



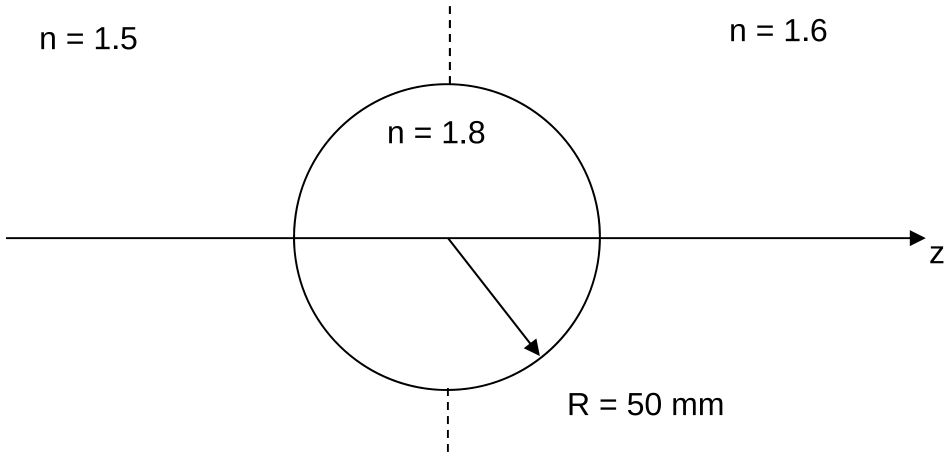

a) Determine the location and size of the Entrance Pupil.

EP: _______ mm to the ______ of the lens; $D_{EP}$ = _____ mm

b) What is the required minimum lens diameter so that the lens does not serve as the system stop?

Minimum Lens Diameter = _______mm

4) (25 points) A spherical ball of index 1.8 is mounted between two media with indices of refraction of 1.5 and 1.6. The radius of the ball is 50 mm.




An object of size ±10 mm is placed 500 mm to the left of the front vertex of the sphere.

Determine: System Focal Length
Locations of the Principal Planes relative to the respective vertices
Locations of the Nodal Points relative to the respective vertices
Front Focal Distance
Back Focal Distance
Image Location relative to the rear vertex of the sphere
Image Size

Sketch the approximate locations of F, F', P, P', N, N' on the above figure.

**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).**

*Continues…*

*Continues…*

Focal Length = ___________ mm

P: Located ________mm to the ________ of the front vertex.

P': Located ________mm to the ________ of the rear vertex.

N: Located ________mm to the ________ of the front vertex.

N': Located ________mm to the ________ of the rear vertex.

FFD = ___________ mm BFD = ____________ mm

Image': Located ________mm to the ________ of the rear vertex.

Image Size = ± ___________mm

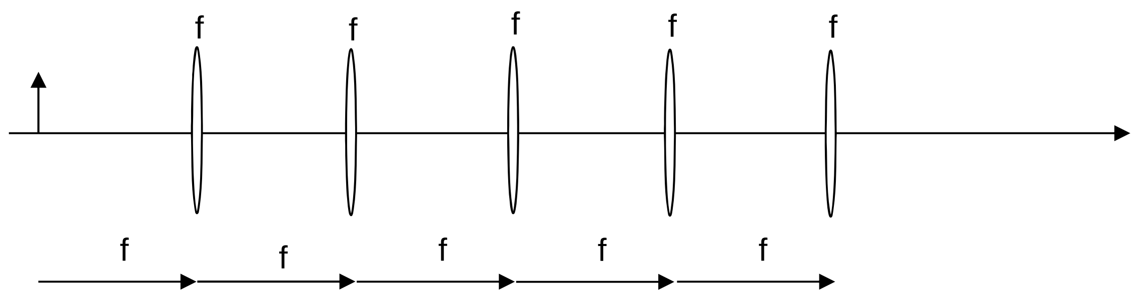
5) (10 points) An afocal system in air is constructed with two positive thin lenses. The system is 150 mm long and has a longitudinal magnification $\bar{m} = 25$.

Sketch the system and provide the focal lengths of the two lenses.

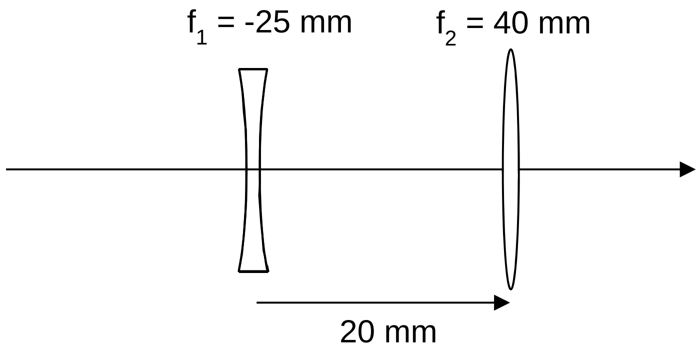
$f_1$ = __________mm $f_2$ = __________mm

6) (10 points) Consider the following optical system comprised of five identical thin lenses of focal length f that are each separated by this same distance f.

An object is located at the front focal point of the first lens element. Determine the image location and size by sketching rays. Please use a straightedge. No calculations are required or permitted.



7) (20 points) An optical system in air is comprised of two thin lenses:




An object is placed 300 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
- Front 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

Front Focal Distance = ___________ mm

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

Image Size = +/- ___________ mm

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*Continues…*

Method of Solution:

**Spare raytrace sheet**

| Surface | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
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# OPTI-502 Equation Sheet
# Midterm

$OPL = nl$

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

$\gamma = 2\alpha$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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