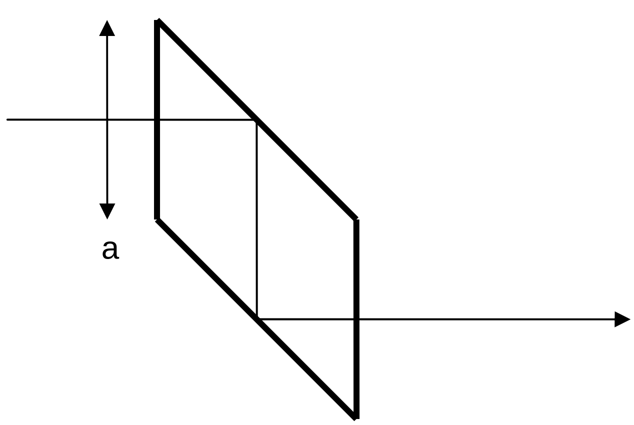
October 20, 2011 Lecture 18 Name___________________________

Closed book; closed notes. Time limit: 75 minutes.
An equation sheet is included. 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.
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.

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) Draw the tunnel diagram for this prism with the ray path shown. The tunnel diagram must be drawn to the same scale as the prism drawing.

If "a" is the width of the entrance face of the prism, what is the total length of the tunnel diagram? The prism angles are 45° and the rays enter and exit at the center of the prism faces.

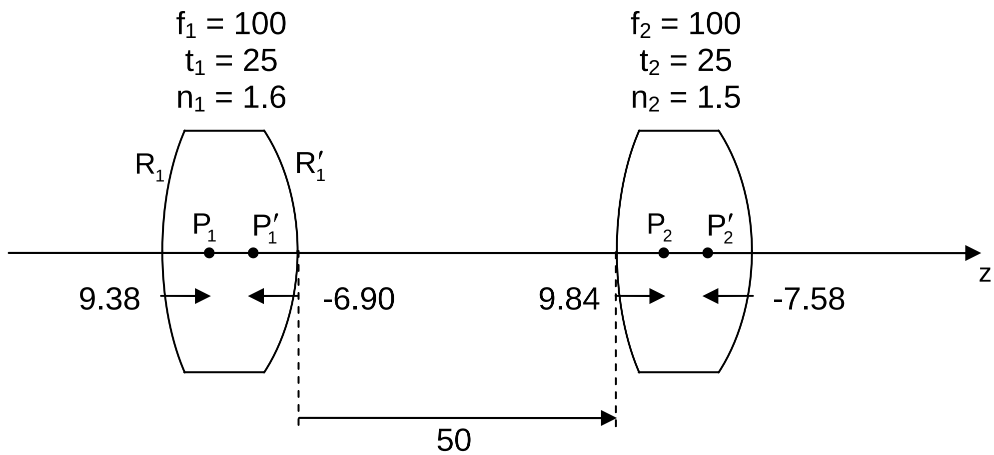


Length = ___________

2) (10 points) A 10x10 cm object is to be imaged onto a 10x10 mm detector with a 20 mm focal length thin lens. What is the overall object-to-image distance?

Object-to Image Distance = ________ mm

3) (25 points) Two thick lenses in air are combined into a single imaging system. Both lenses are 25 mm thick and both lenses have a focal length of 100 mm, however the index of the first lens is 1.6 and the index of the second lens is 1.5. The vertex-to-vertex spacing of the lenses is 50 mm. The principal plane locations for the two individual lenses with respect to surface vertices are shown in the figure. All units are in mm.



NOTE: Only Gaussian methods may be used for this problem.

<u>(a)</u> (10 points) Determine the Radii of Curvature of both surfaces of the first lens ($n_1 = 1.6$). Do this for only the first lens of the system.

R_1 = ________ mm R_1' = ________ mm

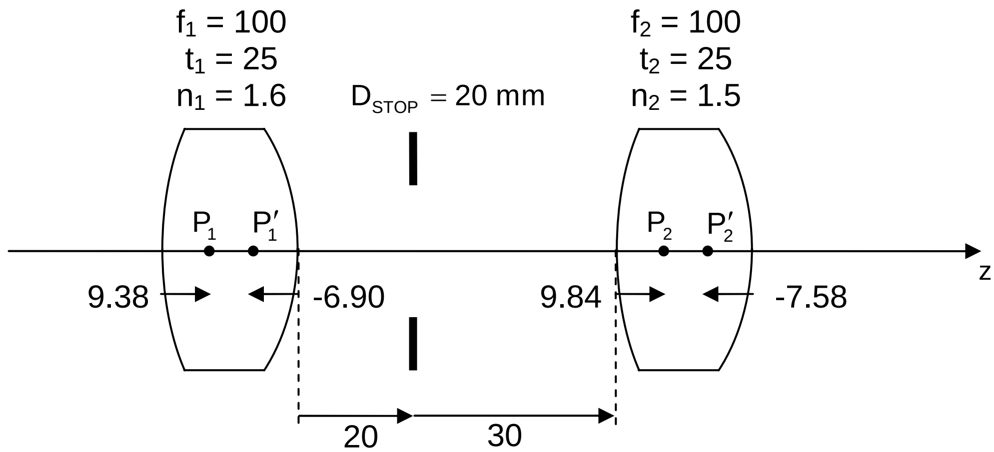
(b) (15 points) For the system comprised of the two thick lenses, determine:
System Focal Length
Location of the Rear Principal Plane of the system relative to the rear vertex of the second lens
Back Focal Distance

System Focal Length = ____________ mm

System P': Located _________mm to the _________ of the rear vertex of the second lens.

BFD = _____________ mm

4) (15 points) A 20 mm diameter stop is now inserted between the two thick lenses (f = 100 mm; t = 25 mm). The stop is 20 mm to the right of the rear vertex of the first lens. The vertex-to-vertex separation of the two lenses is 50 mm. All units are in mm.



Determine the entrance pupil and exit pupil locations and diameters. The entrance pupil is to be located relative to the front vertex of the first lens, and the exit pupil is to be located relative t the rear vertex of the second lens.

NOTE: Only Gaussian methods may be used for this problem.

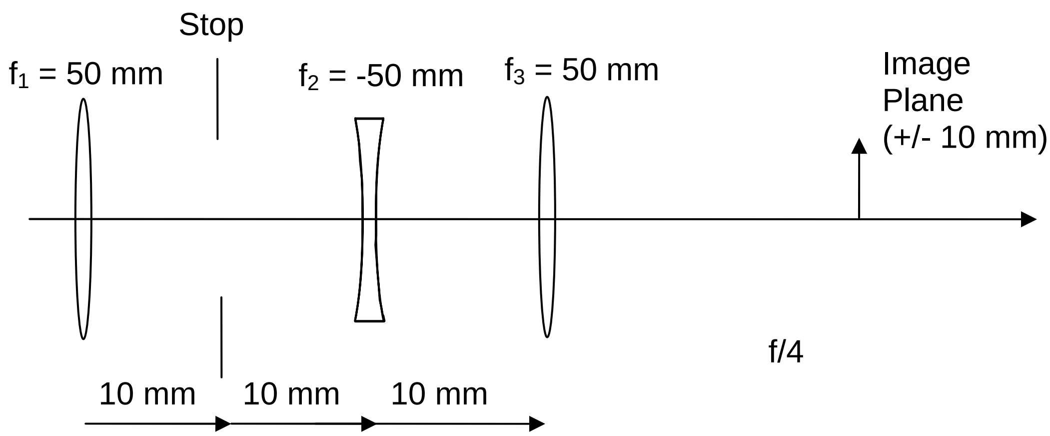
Continues…

EP: D_{EP} = ________mm; Located ________mm to the ________ of the front vertex of the first lens.

XP: D_{XP} = ________mm; Located ________mm to the ________ of the rear vertex of the second lens.

5) (30 points) The following diagram shows the design of an objective that is comprised of three thin lenses in air.

The system operates at f/4. The object is at infinity.



The maximum image size is +/- 10 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 lens. D_{EP} = ________ mm

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

Stop Diameter = _________ mm

System Focal Length = _________ mm Back Focal Distance = _________mm

FOV = +/- _______ deg in object space

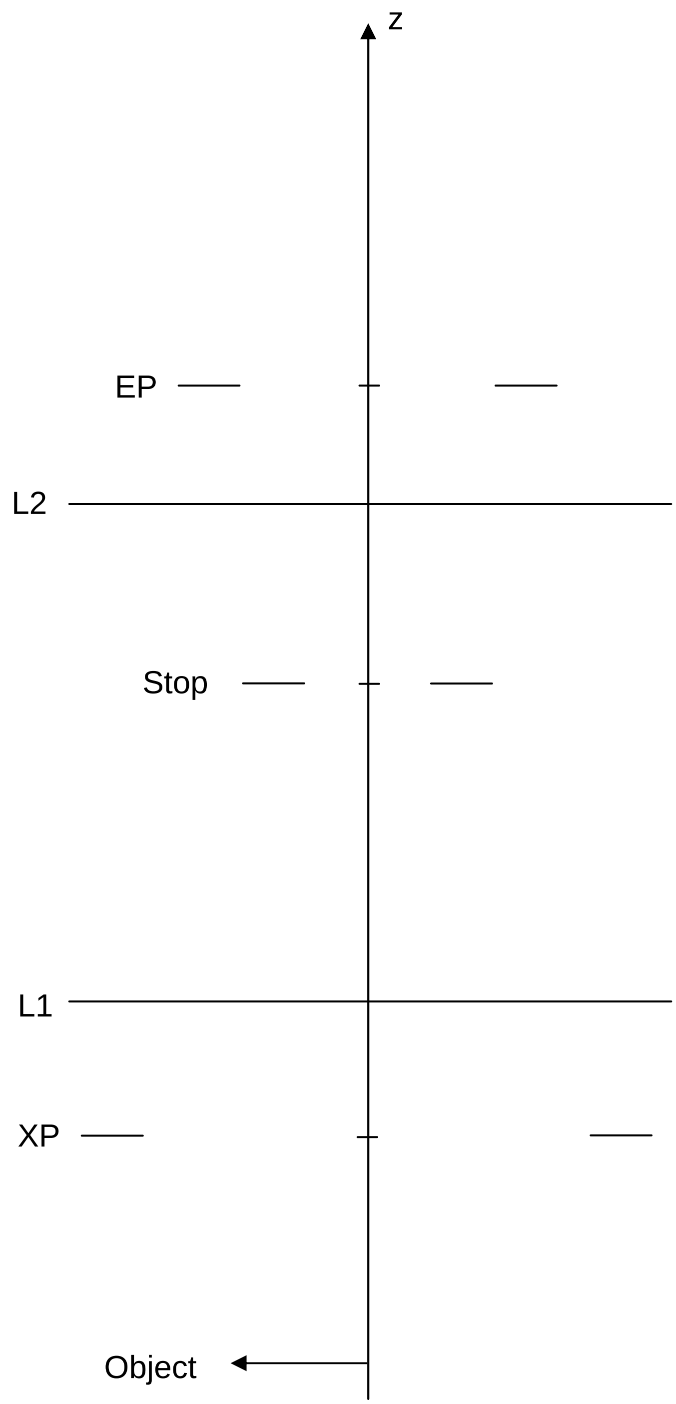
Surface	0	1	2	3	4	5	6	7
f								
$-\phi$								
t								
y								
u								
y								
u								
y								
u								
y								
u								
y								
u								
y								
u								
y								
u								
y								
u								

Continues…

Provide Method of Solution:

Continues…

6) (10 points) This diagram shows an optical system consisting of two refracting surfaces and an object. Also shown are the locations and sizes of the stop, the entrance pupil (EP) and the exit pupil (XP). Show the paths of the marginal and chief rays through the system along with the location and size of the image. No calculations are required.



Spare raytrace sheet

Surface	0	1	2	3	4	5	6	7
f								
-ϕ								
t								
y								
u								
y								
u								
y								
u								
y								
u								
y								
u								
y								
u								
y								
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y								
u								

OPTI-502 Equation Sheet
Midterm

$$OPL = nl$$

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

$$\gamma = 2\alpha$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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