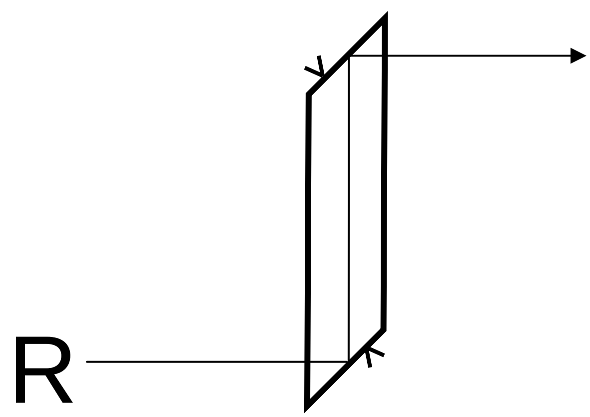
October 10, 2006 Lecture 15 Name_________________________

Closed book; closed notes. Time limit: 75 minutes.
An equation sheet is attached and can be removed.
Use the back sides if required.
Do not use any pre-stored information or programs in your calculator.
Note any assumptions you make in solving the problems.
Show your work. Present it in a neat and logical fashion.
If a method of solution is specified, that method must be used.

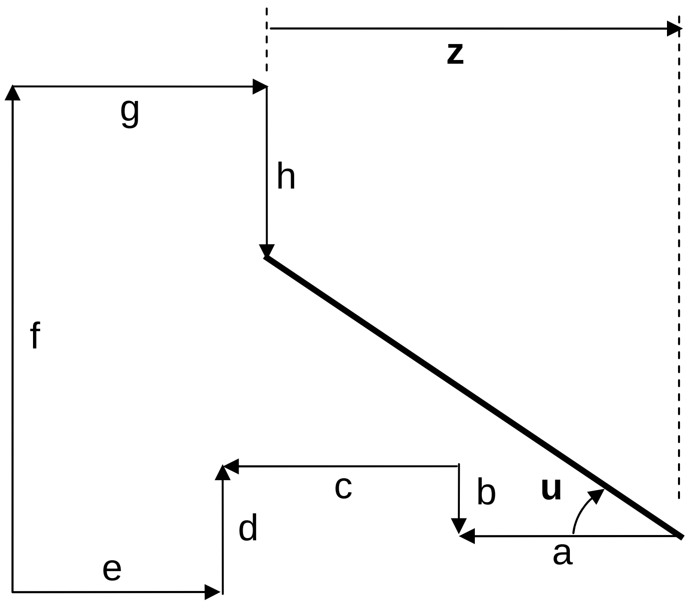
Distance Students: Please return the original exam only; do not FAX an additional copy.

1) (10 points) Draw the tunnel diagram for this prism with the ray path shown. As shown, the prism has two roof surfaces.



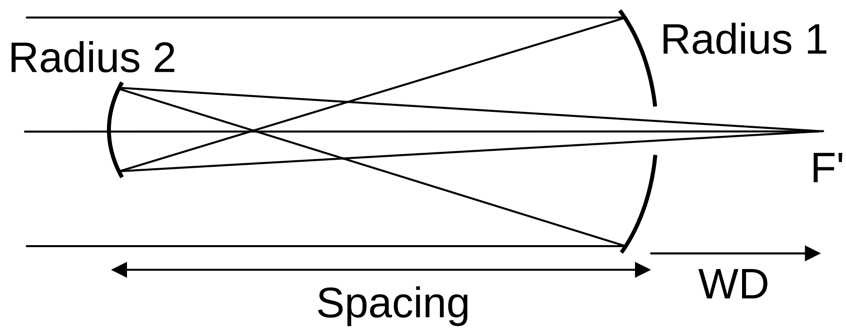
Also show the output parity and orientation. How do the optical properties of this prism change if the roofs on the two surfaces are deleted?

2) (10 points) The diagram below shows a number of directed distances. Using the sign conventions of the class, determine equations for the paraxial angle u and the directed distance z in terms of a, b, c, d, e, f, g and h.



3) (10 points) A 4 cm flower is to be imaged onto a 1 cm detector. The image of the flower fills the detector, and the separation between the flower and the detector is 25 cm. What is the required focal length of the thin lens?

4) (25 points) A Gregorian objective is an all reflective system that uses two concave mirrors:



Radius 1 = 100 mm
Radius 2 = 40 mm
Spacing = 75 mm

a) Use Gaussian reduction to determine the focal length and working distance (WD) for this system.

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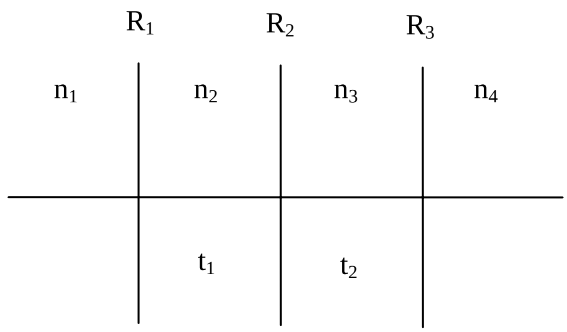
b) You should have found that this system has a negative power and focal length, yet it forms a real image. Explain this result.

5) (15 points) An afocal system is to be fabricated by polishing convex surfaces onto both ends of a 150 mm long glass rod. The magnitude of the lateral magnification of the system is 0.5, and the glass has an index of refraction of 1.5.

What are the two required radii of curvature? $|m| = 0.5$

6) (20 points) An optical system is comprised of three refracting surfaces with the following prescription:



$n_1 = 1.0$
$n_2 = 1.40$
$n_3 = 1.80$
$n_4 = 1.33$

$t_1 = 20.0$ mm
$t_2 = 20.0$ mm

$R_1 = 20.0$ mm
$R_2 = -10.0$ mm
$R_3 = -15.0$ mm

Use paraxial raytrace methods to determine the system power and focal length, and the locations of the rear focal point F' and rear principal plane P' relative to the last surface.

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

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7) (10 points) An optical system in air is comprised of two thin lenses:

$f_1 = 50$ mm
$f_2 = -50$ mm
$t = 20$ mm

Use a paraxial raytrace to determine the system focal length and the location of the front focal point F relative to the first lens.

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

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							

OPTI-502 Equation Sheet
Midterm

$$OPL = nl$$

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

$$\gamma = 2\alpha$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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