Geometrical Optics EOP 501
First Exam (in-class)
6 October 2003

1. Define (3 points each)

   (a) Hyperfocal distance

   (b) Wavefront

   (c) Aperture stop

   (d) Meridional plane

2. Given two thin lenses, with focal lengths of 50 mm and 80 mm, find the effective focal length if both lenses are used together (in contact). (4 points)

3. Write a precise statement of Fermat's principle (4 points)

4. Given a thin lens with 50-mm focal length and an object located 180 mm in front of the lens. Find the image distance and magnification. (4 points)

5. Why is the focal length of a simple glass lens longer for red light than blue light? (4 points)

6. Find the focal length of a 400-mm radius of curvature concave mirror. (3 points)

7. Given an object and image separated by 1200 mm, find the focal length of the thin lens needed to produce a magnification of -1/4. (3 points)

8. Which (if any) of the following are conjugate planes? (1 point each)

   (a) Front principal plane and back principal plane.

   (b) Front focal plane and back focal plane.

   (c) Entrance pupil and exit pupil.

   (d) Aperture stop and field stop.

9. Given the following thin lens description

#	*ap*	*rd*	*th*	*rn*
1	6	25	0	1.6
2	6	-80		1.0

   where *ap* is the aperture height, *rd* is the surface radius of curvature, *th* is the center thickness, and *rn* is the refractive index.

   (a) Find the focal length and f/number. (4 points)

   (b) Describe the shape of the lens (plano-convex, bi-convex, equi-convex, meniscus) and calculate its bending factor. (4 points)

10. True/False questions (1 point each)

    (a) ____ The f-stop settings of a camera lens usually vary by factors of $\sqrt{2}$.

    (b) ____ Paraxial optics assumes that an angle and its cosine are equal.

    (c) ____ Geometrical optics is the limit as $\lambda \to \infty$.

    (d) ____ The hiatus is the distance between principal planes.

Geometrical Optics EOP 501
First Exam (take-home)
6 October 2003

1. A ray inside a glass prism (index 1.52) is incident on a glass/air interface at an angle of 35° from the normal. Find the angle of refraction. Find the critical angle for total internal reflection. (4 points)

2. Given a column of fluid 50-mm long, whose index varies as

$$n(z) = 1.52 + .00032z - (2 \cdot 10^{-6})z^2,$$

where z is the axial distance along the column, what is the optical path of a ray propagating along the axis? (4 points)

3. Given the following lens description

#	*ap*	*rd*	*th*	*rn*
1	3.2	23.14	2.3	BK7
2	3.2	-14.51	0.6	SF5
3	3.2	-38.86	?	AIR

where *ap* is the aperture height, *rd* is the radius of curvature, *th* is the center thickness, and *rn* is the refractive index. Assume a stop diameter of 6.25 at the first surface and a design wavelength of 0.58756 μm. Use OSLO and matrix calculations for the following:

   (a) Find the system matrix. (4 points)

   (b) Find the focal length, f/number and location of the back focal plane. (4 points)

   (c) Find object and image locations for a magnification of -1/2. (4 points)

   (d) Find the locations of the principal planes. Use OSLO to generate a scale drawing of the lens. Mark the positions of the principal planes on this drawing. (4 points)

   (e) Plot the focal length versus wavelength over the wavelength range 0.45 μm - 0.65 μm (4 points)

4. Given two concave mirrors, a primary mirror of radius of curvature 1000 mm and a secondary mirror of radius of curvature 800 mm. If the two mirrors are separated by 160 mm, find the distance from the secondary mirror to the focal plane and the focal length of the system. Show a drawing of the system if the primary has a diameter of 400 mm and the secondary has a diameter of 300 mm. (5 points)

5. Given the following thin lens description

#	*ap*	*rd*	*th*	*glass*
1	6	25	0	SF5
2	6	-80		AIR

where *ap* is the aperture height, *rd* is the surface radius of curvature, *th* is the center thickness, and *rn* is the refractive index.

   (a) Find the center thickness required to give an edge thickness of exactly 2 mm. (3 points)

   (b) Find the focal length of the resulting lens at 0.58756 μm (show your work) (3 points)

   (c) Use OSLO to find the focal length of the lens at 0.58756 μm. Submit a drawing of the lens. (3 points)

   (d) Find the focal lengths at 0.48613 μm and 0.65627 μm. Show the difference between these focal lengths. (3 points)

6. Given a ray starting from (0, 1, 0) in the direction (3, 1, 2), let the ray intersect a plane mirror defined by $(-2x + y + 5z - 1 = 0)$. Find the point of intersection, the angle of incidence, and the direction vector after reflection. (5 points)