Geometrical Optics EOP 501
First Exam (in-class)
2 October 2000

1. Define (3 points each)

   (a) Back focal distance

   (b) Wavefront

   (c) Aperture stop

   (d) Meridional plane

2. Given two thin lenses, with focal lengths of 30 mm and -40 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 60-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 200-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 -1/3. (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)
2 October 2000

1. A ray inside a glass prism (index 1.52) is incident on a glass/air interface at an angle of 25° from the normal. Find the angle of refraction. Find the critical angle for total internal reflection. (3 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? (2 points)

3. Given the following lens description

#	ap	rd	th	rn
1	7.2	17.654	1.4	BK7
2	7.2	53.898	0.1	1.0
3	7.2	16.530	0.6	SF1
4	7.2	13.075		1.0

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

   (a) Find the system matix. Assume BK7 has an index of 1.5168 and SF1 has an index of 1.71736. (4 points)

   (b) Find the focal length, f/number and location of the back focal plane. (3 points)

   (c) Find object and image locations for a magnification of -1/3. (3 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. (3 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	2.5	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. (4 points)

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

   (c) Use OSLO to find the focal length of the original 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. Trace a ray through the original lens above, parallel to the optic axis at a height of 5 mm.

   (a) Show the work in your raytrace. (4 points)

   (b) Find the distance from the second surface where the ray intersects the optic axis. (3 points)

   (c) Compare your results for surface intersection, direction cosines, and path with those generated by OSLO. (3 points)

7. Given a ray starting from (0, 1, 0) with a direction vector of (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. (4 points)