Geometrical Optics EOP 501
First Exam (in-class)
10 October 2001

1. Define (3 points each)

   (a) Back focal distance

   (b) Wavefront

   (c) Hyperfocal distance

   (d) Meridional plane

2. Given thin lenses, with focal lengths of ±1000 mm , ±500 mm, ±100 mm and ±20 mm find a combination of thin lenses (in contact) to produce an effective focal length of 35 mm. Assume you have several lenses of each focal length. (4 points)

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

4. Given a thin lens with 80-mm focal length and an object located 180 mm in front of the lens. Find the image distance and magnification. (4 points)

5. Define the axial and chief rays of an optical system. (4 points)

6. Find the focal length of a 150-mm radius of curvature concave mirror. (3 points)

7. Given an object and image separated by 1000 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	40	0	1.6
2	6	120		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. Complete the following system and find the power and focal length of the system. (4 points)

$$\begin{bmatrix} 0.8 & ? \\ 2.2 & 0.7 \end{bmatrix}$$

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First Exam (take-home)
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1. Given a detector array with elements placed on 5 μm centers (blur diameter of 5 μm is allowed) and a f/4 80-mm focal length lens in front of this array. Suppose that the system is focussed at a distance of 2 meters. What is the near and far depth of field? (5 points)

2. Given the following lens description

#	ap	rd	th	rn
1	10	19.043	3.0	BK7
2	10	63.467	0.2	1.0
3	10	16.914	0.6	SF1
4	10	13.383		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 1.51768 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 focal lengths at 0.48613 μm and 0.65627 μm. Calculate the difference between these focal lengths. (3 points)

3. Given two concave mirrors, a primary mirror of radius of curvature 900 mm and a secondary mirror of radius of curvature 600 mm. If the two mirrors are separated by 120 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)

4. Given the following thin lens description

#	ap	rd	th	glass
1	8	25	1.5	SF5
2	8	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)

(e) 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)

5. 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)

6. 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 ($-2x+y+5z-3=0$). Find the point of intersection, the angle of incidence, and the direction vector after reflection. (4 points)