Geometrical Optics EOP 501
Third Exam (In Class)
11 December 2000

1. Define (3 points each)
   (a) Marginal focus of spherical aberration
   (b) Achromatic lens
   (c) Caustic
2. What four properties are controlled in the design of an achromatic doublet? (4 points)
3. Draw examples of barrel distortion and pincushion distortion. (4 points)
4. What are the central core and flare regions of spherical aberration? (4 points)
5. Why are transverse chromatic aberration and distortion zero for a thin lens? (4 points)
6. State Petzval's Theorem and define the Petzval sum. (4 points)
7. Given a thin lens of focal length 80 and index $n_g = 1.6$), find the radius of curvature of the image surface if the object surface is flat. (3 points)

8. Answer true or false (1 point each)

   (a) T F A thin lens has a longer focal length for blue light than red light.

   (b) T F The Petzval contribution to field curvature is zero if astigmatism is corrected.

   (c) T F Distortion and Field Curvature affect image position but not image blur (on the best focal surface).

   (d) T F The fringes due to focal shift change from circular to elliptical when tilt is added.

   (e) T F Coma can not be corrected by changing the shape of a lens.

   (f) T F For a positive thin lens with flat object field, the image field curves away from the lens.

   (g) T F Fourth-order spherical aberration depends on the position of the stop.

   (h) T F For a positive thin lens the more curved side goes toward the long conjugate.

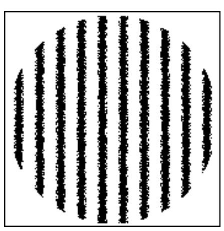
   (i) T F Spherical aberration is a systematic variation in focus as a function of pupil radius.

   (j) T F Some portrait lenses deliberately introduce spherical aberration.

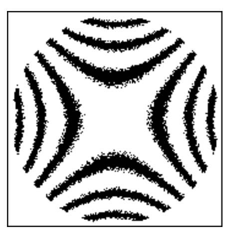
   (k) T F Fourth-order astigmatism has a uniformly illuminated elliptical blur spot predicted by geometrical optics.

   (l) T F Diffraction effects are most important when the geometrical spot size is approximately the Airy diameter.

9. Identify the aberration or reference pattern from the following choices: spherical aberration, coma, astigmatism, distortion, field curvature, focus, tilt, cylinder. (6 points)



A __________



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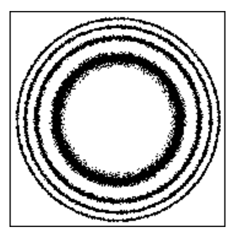

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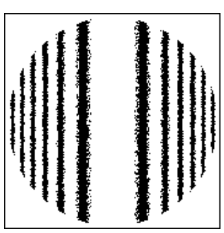

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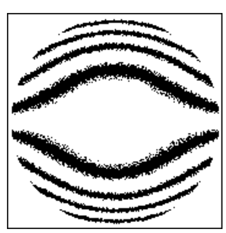

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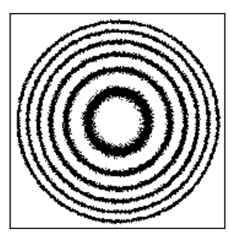

F __________

Geometrical Optics EOP 501
Third Exam (take-home)
6 December 2000

1. Use OSLO to design an f/12 landscape lens (BK7 glass) with a focal length of 60 mm and a 10° half-field of view. Fix the lens thickness at a reasonable value and vary the curvatures and distance to the stop. Show a drawing of the lens, a print-out of the lens description, the paraxial setup data, and the Seidel wavefront aberrations. (10 points)

2. Use OSLO to design an achromatic doublet using the glasses BK7 and SF10. Make the focal length 50 mm and the half field of view 2°. Design the lens at f/10, but size the lens for f/2, that is, set the element thicknesses and lens aperture for f/2, but use an entrance pupil height of 2.5 mm. Place the crown glass (BK7) in front. Fix the lens thicknesses at reasonable values and vary the curvatures. Show a drawing of the lens, a print-out of the lens description, the paraxial setup data, the Seidel wavefront aberrations, and chromatic ray aberrations. Plot the focal length of the lens as a function of wavelength over the range 0.4 to 0.7 μm. (15 points)

3. Change the lens above to a cemented doublet and reoptimize the lens. Show a a drawing of the lens, a print-out of the lens description, the Seidel wavefront aberrations, and chromatic ray aberrations. Compare the aberrations to the results of the previous problem. (5 points)

4. Given a focal shift of -2 mm from paraxial focus to marginal focus. Assume a pupil diameter of 20 mm, an image distance of 100 mm, and a wavelength of 0.5 μm. Find the magnitude of the spherical aberration in waves. (5 points)

5. Measurements through focus show line foci 0.8 mm apart for light of 0.6 μm. The pupil has a diameter of 16 mm and the image distance is 75 mm. Find the magnitude of the astigmatism in waves. (5 points)

6. Given a thin lens (BK7) of focal length 120 mm, shaped for minimum spherical aberration at infinite conjugate. What f/number is required to limit the spherical aberration to less than 4 waves at 0.5 μm wavelength? Use OSLO to verify your results. (5 points)

7. Given a concave spherical mirror with a diameter of 200 mm and a radius of curvature of 1000 mm. Find the wavefront aberrations for a distant point object at a 2-degree half-field angle. Assume a wavelength of 1 μm for this calculation. You can use OSLO for this problem. (See Problem 7.3) (5 points)