# Geometrical Optics EOP 501
## Third Exam (In Class)
## 13 December 1999

1. Define (3 points each)

   (a) Marginal focus of spherical aberration

   (b) Achromatic lens

   (c) Caustic

   (d) Wavefront error

2. Draw examples of barrel distortion and pincushion distortion. (2 points)

3. What are the central core and flare regions of spherical aberration? (2 points)

4. Identify the field dependence (power of $h$ or $L$) for spherical aberration, coma, and astigmatism. (2 points)

5. State Petzval's Theorem and define the Petzval sum. (4 points)

6. Given a thin lens of focal length 50 and index $n_{\mathrm{g}} = 1.5$), find the radius of curvature of the image surface if the object surface is flat.? (3 points)

7. 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 be corrected by changing the shape of a lens.

   (f) T F Tilt is the only aberration with fringes consisting of straight parallel lines.

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

   (h) T F Astigmatism is characterized by two line images in space, oriented 45° with respect to each other.

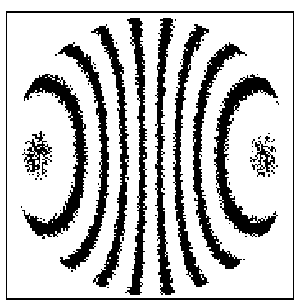
   (i) T F Coma is the only monochromatic fourth-order aberration where the center of the resulting point image is not where the central ray through the pupil intersects the image plane.

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

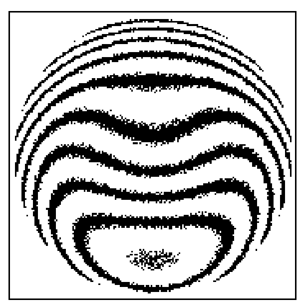
   (k) T F Fourth-order astigmatism has a uniformly illuminated elliptical blur spot predicted by geometrical optics.

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

8. Identify the aberration, if any, in addition to tilt or focus. (8 points)



A______________



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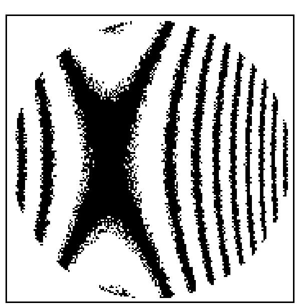

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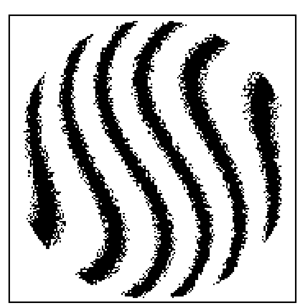

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# Geometrical Optics EOP 501
# Third Exam (take-home)
# 9 December 1999

1. Use OSLO to design an f/10 landscape lens (BK7 glass) with a focal length of 100 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 a cemented achromatic doublet using the glasses BK7 and F2. Make the focal length 100 mm, the aperture f/5, and half field of view 2°. 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. (10 points)

3. Given a focal shift of -1.5 mm to minimize the rms spot size for spherical aberration. Assume a pupil diameter of 24 mm, an image distance of 100 mm, and a wavelength of 0.55 $\mu$m. Find the magnitude of the spherical aberration in waves. (5 points)

4. Measurements through focus show line foci 0.8 mm apart for light of 0.63 $\mu$m. The pupil has a diameter of 20 mm and the image distance is 100 mm. Find the magnitude of the astigmatism in waves. (5 points)

5. Find the maximum transverse ray error at paraxial focus for spherical aberration of 8 $\lambda$. Find the longitudinal distance from paraxial focus to marginal focus. Assume a pupil diameter of 20 mm, wavelength of 0.55 $\mu$m and image distance of 100 mm. (5 points)

6. Given a thin lens (BK7) of focal length 100 mm, shaped for minimum spherical aberration at infinite conjugate. What f/number is required to limit the spherical aberration to less than 5 waves at 0.5 $\mu$m wavelength? (5 points)

7. Design a compact thin-lens triplet by finding the powers of the three lens that produce a 100 mm focal length, zero chromatic aberration, and zero Petzval sum. Assume a BK7 - SF5 - SK5 combination. Use ($n$ = 1.5168, $V$=64.17) for BK7, ($n$ = 1.6727, $V$=32.21) for SF5, and ($n$ = 1.58913, $V$=61.27) for SK5. (5 points)

8. Given a concave spherical mirror with a diameter of 100 mm and a radius of curvature of 500 mm. Find the wavefront aberrations for a distant point object at a 2-degree half-field angle. Assume a wavelength of 1 $\mu$m for this calculation. You can use OSLO for this problem. (See Problem 7.3) (5 points)