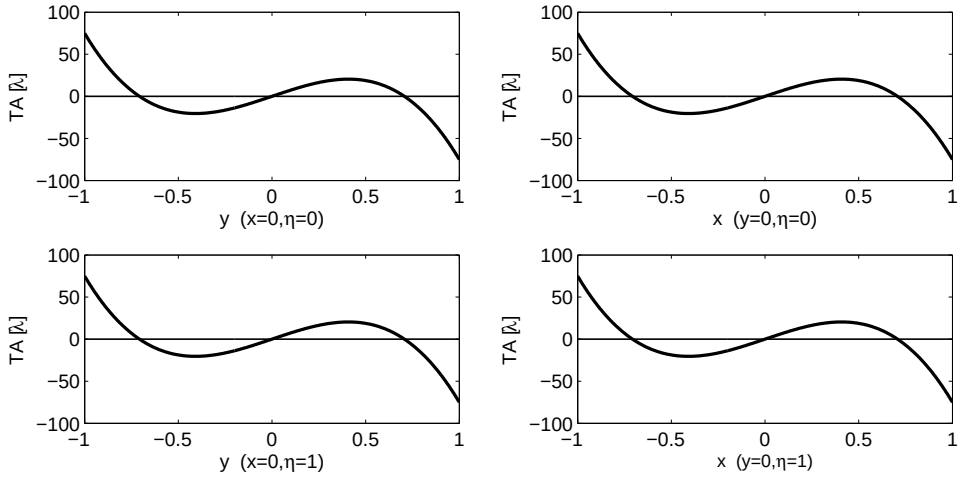
Exam SK2330 Optical Design 2013-08-26 8-13 FB52

No devices that allow for communication with the outside world, or that would permit installation of commercial optical design software, are permitted (i.e., no phones or computers). Any other material such as books, notes, and calculators may be used.

Solutions should be well outlined and explained, and figures used when needed. Correct answers without explanations give 0p.

Grading limits: 0-10p F, 10p or over Fx, 12p or over D, 15p or over C, 19p or over B, 22–24p A

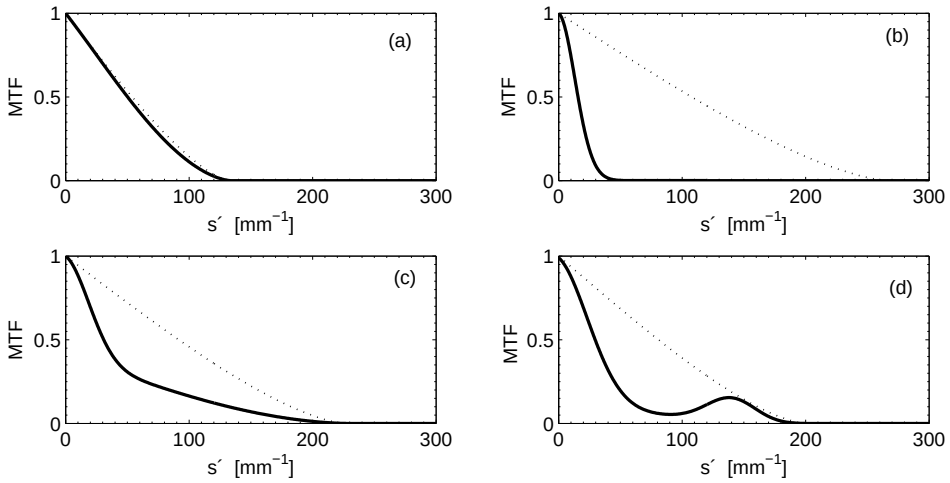
1. A lens has an exit pupil radius of 12 mm and the paraxial image plane, in air, is 150 mm from the exit pupil. The transverse aberration plots of the lens are given below, where (x, y) are normalized pupil coordinates and $(0, \eta)$ normalized image coordinates. No higher-order aberrations are present.
   a) Explain which aberrations may be present in this system, and which are not. Motivate your answer! (2p)
   b) Estimate the relevant wavefront aberration coefficients. (2p)



2. A doublet lens made from BK7 (n=1.51679, V=64.17) and SF12 (n=1.64830, V=33.85) of focal length 200 mm is constructed to image a far-away object without longitudinal chromatic aberration, spherical aberration, or coma. One important remaining aberration is field curvature, described by the S_{IV} Seidel term. The S_{IV} term should now be minimized by inserting a field lens close to the image plane. a) Assuming the field lens has a plane surface facing the image plane, suggest a glass type for the field lens and find the curvature of the front surface. You may regard the lenses as thin. b) What limits the field of view of this system? (6p)

3. A spherical surface of radius of curvature 50 mm separates air from plastic, with refractive index 1.46. A ray parallel to the optical axis enters the plastic at a height of 3 mm and is refracted. Find out where the ray crosses the optical axis (still inside the plastic) by tracing it a) paraxially and b) exactly. Explain the difference (or similarity) of the results. (5p)

4. Displayed below are the image-plane MTF curves of four different systems, all of focal length 100 mm. Dashed lines indicate the diffraction-limited MTF of each lens. Which system is best suited to image a sinusoidal grating placed 300 mm in front of the lens, if the grating period is a) $25\,\mathrm{mm}^{-1}$ b) $50\,\mathrm{mm}^{-1}$ c) $75\,\mathrm{mm}^{-1}$. Motivate your answer! (4p)



5. A plano-convex lens of refractive index 1.5 and focal length 200 mm is used on-axis to focus white light from infinity. The aperture is at the lens, and its size can be chosen freely (up to a fundamental limit). Estimate the smallest spot size that can be achieved with this lens. (5p)