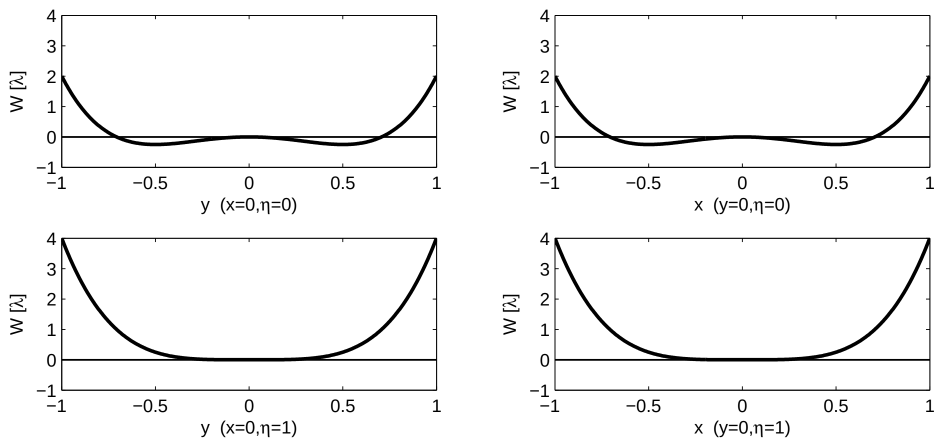
Exam SK2330 Optical Design 2015-01-14 14-19 FB52

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. Answers without explanations give 0p, even if correct.

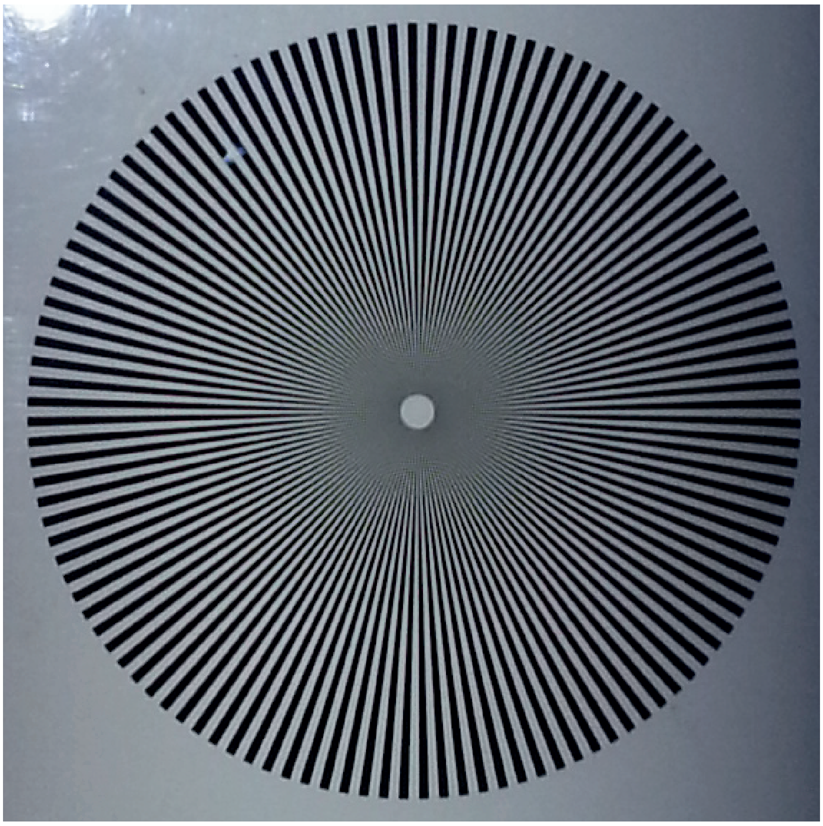
Grading limits: 0-10p F, 10p or over Fx, 12p or over D, 15p or over C, 19p or over B, 22–24p A

1. A lens has an exit pupil radius of 20 mm and the paraxial image plane, in air, is 225 mm from the exit pupil. The wavefront 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 thick, plano-convex lens in air has its stop is at the first surface, which is flat. The object is at infinity. Express the Seidel sums S_{I} to S_{IV} as a function of refractive index, aperture size, thickness, curvature of the second surface, and incident principal ray angle. (5p)

3. A cell-phone camera is used to image a Siemens star, producing the image below (which has an unknown scale). The camera objective has a focal length of 6 mm and an F-number of 2.0, and can be approximated as a thin lens. The sector star has a diameter of 10 cm, and the object distance is 25 cm. Is the camera diffraction limited? Motivate and discuss your answer. (5p)



4. A thin plano-convex lens is used to focus an expanded collimated laser beam, which covers the entire aperture of the lens. By how much do the relevant aberrations change, if a lens with refractive index 1.8 is used instead of one with refractive index 1.5? Both lenses have the same focal length and the same F-number, and are turned so as to minimize the relevant aberrations. You can disregard higher-order aberrations. (4p)

5. An achromatic doublet lens of focal length 100 mm and F-number 5, which is also adjusted to have no spherical aberration or coma, images an object at infinity using monochromatic light of wavelength 550 nm. Below is a through-focus spot diagram for this lens, at three different image heights. Use it to estimate the wavefront aberration coefficients of the remaining third-order aberrations. The stop is at the lens, which can be considered as thin. (6p)