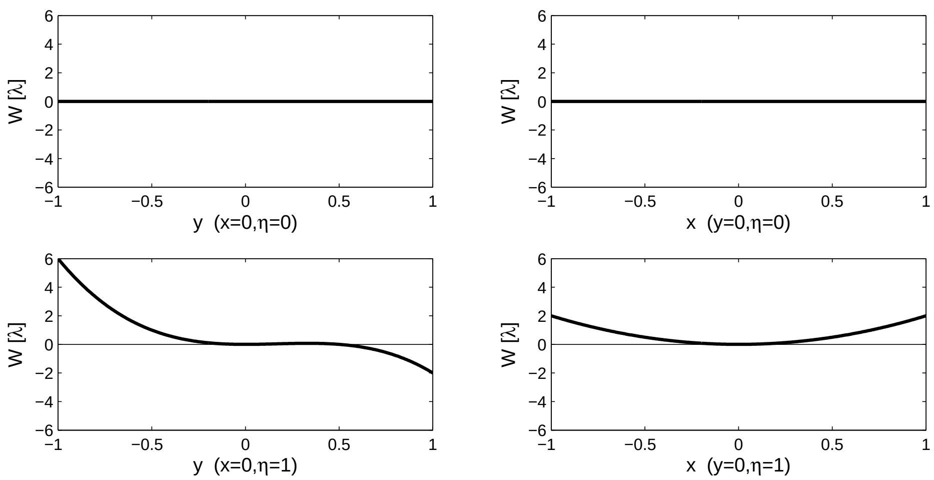
Exam SK2330 Optical Design 2013-05-21 14-19 FD41

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.

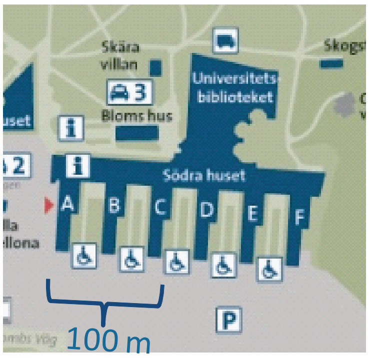
Grading limits: 0-10p F, 10p or over Fx, 12p or over D, 15p or over C, 19p or over B, 22–24p A

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 wavefront aberration plots of the lens are given below, where (x, y) are normalized pupil coordinates and $(0, \eta)$ normalized image coordinates.
   a) Identify the aberrations of the system and determine the wavefront aberration coefficients. Only third-order aberrations need be considered, and there is no distortion. (2p)
   b) Sketch the transverse aberration as a function of pupil coordinate. Do it for both tangential and sagittal planes, at relative image height $\eta = 0$ and at relative image height $\eta = 1$. There will be four graphs in total. Make sure your scales are correct. (2p)



2. A thick meniscus lens has radii of curvature $r_1 = 67\,\mathrm{mm}$ and $r_2 = 50\,\mathrm{mm}$, and a thickness of $50\,\mathrm{mm}$. It is made from BK7, with refractive index $n_d = 1.51679$.
   a) Find the sign of the Seidel sum S_{IV} of the lens. (2p)
   b) Find the power of the lens. (1p)
   c) This lens has some useful properties. How can those properties be used in an optical system? On the other hand, what are the disadvantages of this lens? (2p)

3. GeoEye-1 is a high-resolution observation satellite orbiting the earth at a height of 681 km. Its aperture diameter is 1.1 m and its focal length 13.3 m. Estimate the image contrast if you attempt to observe (a) the numbers and letters on a car license plate or (b) the Stockholm University building shown below, seen from above. You may assume an object contrast of 1, and that the object is at the center of the image. Clearly state any other approximations or assumptions. (5p)



4. Instead of using a singlet planoconvex lens, its power is split equally on two lenses, placed close together, to reduce aberrations. The object is at infinity, and the first lens is plano-convex. (a) Find the shape (bending factor) of the second lens that will minimize the spherical aberration of the system. (b) With this lens shape, how much is the spherical aberration of the system reduced compared to using a singlet plano-convex lens? All plano-convex lenses are turned as to minimize spherical aberration. All lenses are constructed from the same material and may be considered as thin. (5p)

5. Appended are Synopsys drawings and specifications for four different systems A, B, C, and D. There are also four sets of wavefront aberrations I, II, III, and IV. Explain which set of wavefront aberrations belongs to which system! Correct answers without explanations give 0p, while good explanations can give points even if the answer is wrong... (5p)