PHOT 451 Fall (2025-2026) **Quiz 2** Date: 8 December 2025
Michaël Barbier Student No:
Student Name:

Grading: Each quiz counts for 15% of your total grade.

Exam type: Take-home exam, please fill in using your own-written descriptions/solutions and sketches. You can use a computer using but no typed text.

The deadline of the quiz is on Monday 8 December 2025 at 23:59.

Please fill in all questions listed below. Each of the questions is valued equally in the score calculation of the exam. Please tell if any question is unclear or ambiguous.

Question 1: Diffraction limit

Consider an optical system existing of a single thin microlens (glass $n = 1.5 = 3/2$) with clear diameter $D = 10$ micron, curvature radii $R_1 = 50$ micron, $R_2 = -50$ micron, with incident light of wavelength λ. RMS OPD is given by $\sigma_w = 0.2$ in units of wavelength $\lambda = 500$ nm.

(a) Calculate the focal length f, the Airy disk diameter of the PSF, and the approximate Strehl ratio (you can use $S \approx e^{-\sigma_w^2}$).
(b) Exchange the lens for a smaller one with clear diameter $D = 5$ micron but with equal curvature radii: how do the following values scale qualitatively?

- Spherical aberration
- RMS OPD
- PSF airy diameter (diffraction spot size)
- Strehl ratio

Question 2: ABCD propagation

Consider a thick plano-convex lens with surface curvature radii $R_1 = \infty$ and $R_2 = -20$ micron. The lens has a clear diameter of 20 micron and thickness of $d = 10$ micron.

(a) Use the transfer matrix method (ABCD matrices) to calculate an expression for the focal length of the lens.
(b) Derive how the focal length of the lens scales with the thickness d of the lens. Sketch this.

Question 3: Laser beam propagation

Consider a laser beam with wavelength $\lambda = 1000$ nm, beam width $w_0 = 2$ micron. Put a thin lens at distance 100 micron from the beam waist position to collimate the beam over a longer distance.

(a) What is the focal length of the thin lens? What is the beam width: w_0' after collimation? Sketch the beam.
(b) After being collimated the beam encounters a circular detector with diameter 10 micron. Calculate the power ratio detected.