

Course Syllabus

PHOT 451 Microscale optical systems design

2025-2026 Fall

Instructor

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Office hours: Friday, 9:00 – 17:00 (via appointment)

Teaching Assistants

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Office hours: TBA

Course Schedule

Monday 08:45 – 12:30 F-building, D5

Course Fundamentals

Course Description

This course is aimed at numerical modeling and design of micro-scale optical systems. At first, the design of small-scale optical components such as micro-lenses, objectives, prisms, gratings, optical interconnects, optical switches, micro-rings, fiber couplers, wave length splitters, etc. The models will touch upon concepts such as: validity of methods and approximations under subwavelength-sized structures, wave-mixing, deviations from paraxial approximation in microlenses, aberrations in large and microscale systems, attenuation, stray light, loss of light, and scattering. Throughout the course numerical methods based on raytracing, finite-difference, and modal methods will be applied to model and design the optical systems. For this, well-known software packages such as ANSYS Lumerical (and to a lesser extent Zemax) will be used.

Course Objectives (Learning Outcomes)

At the end of the course, you should be able to:

1. Understanding the working of basic optical components at the micro-scale.
2. Being able to model optical systems comprising multiple optical components

3. Understand what model (order of aberrations, raytracing or full wave models) is appropriate for different micro-scale optical systems.
4. Understanding the differences and similarities between macro and micro-scale design constraints when downscaling to subwavelength optical components
5. Being able to model and optimize microscale optical components by utilizing numerical methods (finite difference and finite element solvers).
6. Ability to design practically applicable microscale systems employing widely used raytracing, finite difference and modal based software packages.

Prerequisites

PHOT 201 and PHOT 202 (Fundamentals of Optics and Photonics I & II) or equivalents are prerequisites for this course.

Textbooks

Course Textbooks:

Jürgen Jahns, Stefan Helfert, **Introduction to Micro- and Nanooptics**, Wiley (2012)

S. Sinzinger, J. Jahns, **Microoptics**, 2nd edition Wiley (2003)

Supplementary Materials:

S. Bhattacharya, **Introduction to Ray, Wave, and Beam Optics with Applications**, IOP (2024)

R. Siew, **Modern Classical Optical System Design**, IOP (2024)

B.C. Kress, P. Meyrueis, **Applied Digital Optics**, Wiley (2005)

Supplementary Materials for Numerical calculations:

[Youtube channel on design of optical systems](#) using Zemax

[Python API for Lumerical](#)

[ZOS-API for Zemax](#) (connect via MATLAB, Python, C#, and C++)

Course website and announcements

You will find all announcements relevant to the course (homework, grades, etc.) on MS-Teams. Some course materials will also be made available via [Michaël Barbier's webpage](#). Syllabus and course schedule may be subject to change during the semester.

Class structure

Course material will be presented on the whiteboard and on the screen. Practical sessions will require the students to use a computer with ANSYS installed. All lecture notes and class materials can be reached from Teams.

Course schedule (tentative)

Week 1	Introduction to micro-scale optical components
Week 2	Light propagation in free space
Week 3	Geometric optics and raycasting
Week 4	Diffraction limit & Abberations
Week 5	Quiz + Beam propagation
Week 6	Refractive optical elements Microlenses
Week 7	Blazed Fresnel lenses
Week 8	Digital lenses
Week 9	Diffraction optical elements
Week 10	Quiz + Wave guides and beam propagation
Week 11	Wave mixing
Week 12	Gratings, periodic structures
Week 13	photonic crystals
Week 14	Whole optical system optimization
Week 15	Final exam
Week 16	Final exam

Course Policies

Attendance and class behavior

Students who attend the lecture are expected to actively participate (in listening, taking notes, understanding, problem solving sessions, etc.).

Homework assignments

A project will be assigned during the term. This project can be performed with help from others (fellow students, course instructors, etc.), but the project should have unique simulation files/results and presentation.

Quizzes

Two quizzes will be given during specific lectures (see dates below). You will have one hour to complete the quizzes.

Examinations and Grading

You will have two quizzes, one project presentation, and a final exam. The quizzes/final exam are closed-book and exist out of open questions and problems which can be answered using pen and paper. If you miss one of the quizzes without a valid excuse, a zero will be averaged into your grade. If you have a valid excuse (i.e., an official certified medical report), you will receive a make-up exam at the end of the semester.

Your final grade is the weighted average of your project, midterm and final exam grades, according to following weights (tentative):

- Quizzes: 30% (2 x 15%)
- Project presentation: 30%
- Final exam: 40%

If your final exam score is higher than your score for the weighted quizzes and final, then you will receive the final exam mark weighted with 70% ignoring the quizzes (you will get the maximum of the two).

Examination Dates (tentative)

Quiz 1: Monday 27.10.2025

Quiz 2: Monday 01.12.2025

Final exam (all topics): date TBA

Disabilities

Students with certified disabilities requiring special accommodation are urged to contact the instructor at the beginning of the semester so that suitable arrangements may be made.

Academic Integrity

Students who violate University rules on academic dishonesty are subject to disciplinary penalties, including the possibility of failure in the course and/or suspension from the University. Forms of academic dishonesty include copying the reports of homework assignments (from a fellow student or internet), cheating on exams, use of unauthorized materials for exams, and changing solutions to returned assignments and exams.