MCC046 – Photonics and Lasers – 2021
Course PM

Obligatory course within the Master Program Wireless, Photonics and Space Engineering (MPWPS)

Course Plan and home page

The course plan is the official document describing this course and can be found in Canvas for those signed up for the course.

Credits:

This course gives 7.5 credits, and is recorded as a single course element in the Ladok system.

Aim:

The aim of the course is to provide the student with an up to date knowledge of concepts and techniques used in modern photonics. Different physical models for light propagation are discussed, and they are implemented using modern numerical methods. A wide area of optical phenomena and applications, from magnifying glasses and blackbody radiation, to lasers and the blue-ray readout head, is covered. The focus is on width rather than depth, which makes the course a good background for further in-depth studies in the field of photonics.

Course specific prerequisites

Basic knowledge of physics, electromagnetic fields, and numerical work with MATLAB software.

Learning Goals

After completion of this course the student should be able to:

1. *describe* the four theories/models of light and *apply* the appropriate theory for a given optical problem
2. *implement* the relevant model analytically and numerically, and use numerical software (e.g. MATLAB) to perform simulations of various optical systems.
3. *discuss* and *apply* the theory of interaction of light with matter
4. *describe qualitatively and quantitatively*
   - ray propagation in lenses and mirrors
   - propagation and diffraction of Gaussian beams of light
   - Fourier decomposition and analysis of light in terms of plane waves
   - imaging, holography and optical waveguides
   - coherence and the statistical properties of light
   - polarization properties of light and how polarization components work
   - how light is generated in a laser
   - various laser types and their applications
   - properties of laser light such as output power, frequency, line width, modes and dynamics
5. *collect and evaluate* experimental data in a photonics laboratory while taking into account laser safety

Learning Activities

Lectures

The main part of the course is the regular Lectures based on slides and whiteboard. Shown slides will be handed out on the website. Also minor experiments/demos and problems will be covered. All lectures will be streamed over Zoom, and in most cases recorded.

Calculation exercises

These tutorials will mainly focus on exam-level calculations and problem solving. Tutorials will be streamed over Zoom and possibly recorded.

Numerical tutorials and home assignments

The theory and practice of numerical simulations in photonics will be taught at these tutorials, with this knowledge then put to use in 4 MATLAB home assignments. The home assignments shall be solved within 1 week and handed via Canvas before the next numerical lecture. They will be corrected and returned within 1 week, and students with insufficient solutions will have one more chance to hand an improved solution. The deadline for all returns is March 31st.

Ethics seminar

Ethical dilemmas will be discussed in an ethics seminar, where a framework for dealing with engineering and real life problems form the basis for analysis. A written essay on a selected ethical dilemma shall be handed in.

Lab exercises

There are 2 compulsory lab exercises (approx 4 h each), that include pre-assignments that should be solved and handed in (individually) via Canvas before the lab. Suitable lab group sizes are 2 or 3, but not alone. Sign up for labs via Canvas. The labs take place on level B4, room B420 in the MC2-building (enter opposite to the Kollektorn lecture hall).

Lab 1 is about free-space Fourier optics, and lab 2 is about building a fiber ring laser.

Schedule and location

All classes will be given in the lecture hall ”Kollektorn”, room A423 in the MC2-building, 4th floor, situated in the far end of the Canyon.
Times are: Mondays 10-12 (lect), and Wednesdays 10-12 (lect) , 13-15 (exercise) 15-17 (num tutorial), with some exceptions. A detailed schedule is provided last in this document. Note that the introduction lecture starts at 9 on Monday morning, Jan 18.

Textbook

Textbook: B.E.A. Saleh and M.C. Teich: *Fundamentals of Photonics, 2nd ed.*, 2007, Wiley. This is available from the Chalmers bookstore “Store” (previously named “Cremona”) or as an e-book at the Chalmers library. A more extensive 3rd edition of this work was released 2019 as a 2-volume set, but it is not necessary for this course. The first edition from 1991 is insufficient and not recommended.

Alternative textbooks available online for free are e.g.: Daniel A. Steck*, Classical and Modern Optics*, available online at http://atomoptics-nas.uoregon.edu/~dsteck/teaching/optics/ as well as from the course web. Also J. Peatross and M. Ware*, Physics of Light and Optics*, 2015 edition, available at http://optics.byu.edu

These books give alternative presentations of much of the course material, even if they cannot fully replace all aspects of *Fundamentals of Photonics*.

Course content and suggested reading list

Reading list refers to the textbook, Fundamentals of Photonics 2nd edition.

Models of Light	Lecture number	Lecture themes	Chapters for central content	Sections for extra studies
Ray Optics	2	Ray Optics	1, 9.1	1.3 C
Wave Optics	3	Wave Optics	2	2.3
	4	Beam Optics	3, 7.1 B	3.2 D, 3.4
	5	Optical Resonators	10	10.2 E, 10.3-4
	6,14	Lasers, mode-locking	15.1, 15.4A,D	
	7	Fourier Optics	4.1-2	
	8	Diffraction, imaging, holography	4.3-5	
Electromagnetic Optics	9	Electromagnetic Optics	5, 9.3	5.5 C-D, 5.7
	10	Polarization, Crystal Optics	6, 7.1	6.3
	11	Optical Waveguides and Fibers	8.1-3, 9.3	8.5 A-B
	12	Coherence	11.1	
Quantum Optics	12	Photon Optics Photon-Atom Interaction	12.1, 12.2 A-B 13.2-4	12.3 13.3 E-F
	13,14	Laser amplifiers and oscillations	14, 15, 17.2-3	14.4 B, 14.5

Examination

The examination of this course includes a list of compulsory activities as well as a written exam. The obligatory activities, detailed under the “assignments” heading, are:

- 2 lab exercises including pre-lab assignments
- 4 numerical home assignments
- 1 ethics essay

The regular written exam will be an online 4-hour exam performed as an assignment in Canvas or possibly as a written exam.

The written exam will be structured in a similar way to the previous 3 years’ exams, with a concept-based part consisting of short questions worth 10 points together, and a more extensive part consisting of problems worth 50 points together, in total 60 points. Examples of such “old” exams will be used in class and available for study on the course homepage.

To get grade 5, the exam must have been passed with more than 60% of the points, plus an oral exam is performed to judge the final grade.

Allowed material at the written exam:

Open-book exam, any handout from the course is allowed, as well as the course textbook.

Grading Criteria

The grading is calculated by the following scheme, given the exam points x:

$0 \leq x < 24$ points: not passed

$24 \leq x < 36$: grade 3

$36 \leq x$: grade 4

$36 \leq x$ and passed oral exam: grade 5

Oral exam

The oral exam is a 20 minute individual discussion with the student on a few randomly selected topics from the course curriculum. The oral exam is planned to be conducted during the exam week, although exact time slot is somewhat flexible to fit individual schedules.

Contact Information

Teachers can be contacted through e-mail via first name dot surname at chalmers dot se, or via Canvas.

Role	Name	Office area
Main course responsibility, lecturer and examiner	Magnus Karlsson	C4
Numerical tutorials, lecturer Correction and support	Johan Gustavsson Ali Mirani, Mehdi Jahed	B4 B4 B4
Calculation exercises	Oskar Helgason	B4
Lab exercises	Mehdi Jahed Krishna Twayana	B4 B4

Academic integrity and honesty

The compulsory moments in the course, including the exam, is to a large extent hand-in assignments. For the learning to be satisfying this assumes *academic integrity and honesty* by the students. This means:

- Hand-in problems are individual. This means that each student should solve the problems, write necessary computer code and report the result without direct help from fellow students or anyone else. However, discussions about general topics related to the hand-in problems are encouraged between students.
- The written exam is individual. Help from others during the exam is strictly prohibited.
- When reporting solutions in writing, *plagiarism*, i.e., copying text from books, Internet or from other sources (like your fellow students) without referring to the source is not an accepted behaviour and is not allowed.
- Students who are suspected not to respect the rules of academic integrity will be reported to the President of Chalmers and possibly face disciplinary actions.

Changes from last year:

- Bonus points have been removed.
- Firm deadline for the Numerical home assignments.
- Passing an oral exam is required to get grade 5.

Week	Date 2020	Time	Topic	Activity	Teacher	Hand-in
1	Mon. Jan. 18	9-10	Intro: Goals, Activities, Schedule, Examination	Lecture 1	MK	
		10-12	Ray Optics	Lecture 2	MK	
	Wed. Jan. 20	10-12	Wave Optics	Lecture 3	MK	
		13-15	Rays and Waves	Exercise 1	OH	
		15-17	Home Assignment Intro - TSM	Numerical 1	JG	
2	Mon. Jan. 25	10-12	Beam Optics	Lecture 4	MK	
	Wed. Jan. 27	10-12	Optical Resonators	Lecture 5	MK	
		13-15	Beams and Resonators	Exercise 2	OH	
		15-16	TSM: Resonator	Numerical 2	JG	1: TSM (AM)
		16-17	Ethics and ethical dilemmas	Seminar 1	MK	
3	Mon. Feb. 1	10-12	Lasers, mode-locking, laser safety	Lecture 6	MK	
	Wed. Feb. 3		CHARM - No activities			Ethics Essay in
4 Lab 1 MJ/KT	Mon. Feb. 8	10-12	Fourier Optics	Lecture 7	MK	
	Wed. Feb. 10	10-12	Diff, Imaging, Holography	Lecture 8	MK	
		13-15	Fourier Optics	Exercise 3	OH	
		15-17	FDTD, Maxwell's Equations	Numerical 3	JG	2: Resonators (AM)
5 Lab 1 MJ/KT	Mon. Feb. 15	10-12	Electromagnetic Optics	Lecture 9	MK	
	Wed. Feb. 17	10-12	Polarization	Lecture 10	MK	
		13-15	Diffr., imaging, EM , Polarization	Exercise 4	OH	
		15-17	Matrix Methds	Numerical 4	JG	3: FDTD (MJ)
6 Lab 2 MJ/KT	Mon. Feb. 22	10-12	Waveguides and Optical Fibers	Lecture 11	MK	
	Wed. Feb. 24	10-12	Coherence, Photons and Atoms	Lecture 12	MK	
		13-15	Polarization, WGs + Fibers	Exercise 5	OH	
		15-17	Final, FDTD+Matrix Methods	Numerical 5	JG	4: Matrix Methods (MJ)
7 Lab 2 MJ/KT	Mon. Mar. 1	10-12	Amplification and Lasers	Lecture 13	MK	
	Wed. Mar 3	10-12	Laser oscillations, dynamics, Q-switching, course summary	Lecture 14	MK	
		13-15	Coherence, Photons and Atoms	Exercise 6	OH	
		15-17	Spare	Lecture 15	MK	
8	Mon. Mar. 8	10-12	Amplifiers and Lasers	Exercise 7	OH	
	Wed. Mar. 10	10-11	Guest lecture, Anders Larsson		MK	
		13-15	Old Exam problems	Exercise 8	OH	
9	Mon. Mar. 15	14-18	Exam			
	Tue. June 9	14-18	Re-exam			
	Aug 2021	-	For re-exam, Contact examiner			