MCC046 – Photonics and Lasers – 2020
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 at the following link:

The course home page is in Pingpong, here:

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,

Calculation exercises

These tutorials will mainly focus on exam-level calculations and problem solving.

Numerical tutorials

The theory and practice of numerical simulations in photonics will be taught at these tutorials, with this knowledge then put to use in MATLAB home assignments. Each home assignment, correctly solved and handed in on time (which is on next week's num exercise), will render a bonus point on the exam.

Ethics seminar

Ethical issues will be addressed in one seminar, where photonics subject matter and real life career settings form the basis for analysis of ethical dilemmas. A written essay on a relevant 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

All classes will be held in room A820 "Fasrummet" in the MC2-building, 8th floor.
Times are: Mondays 10-12, and Wednesdays 10-12, 13-17, with some exceptions. A detailed schedule is provided last in this document.

Textbook

Textbook: B.E.A. Saleh and M.C. Teich: Fundamentals of Photonics, 2nd ed., 2007, Wiley. Available from the Chalmers bookstore "Store" (previously named "Cremona"). Also available in print or as an e-book from the Chalmers library.

Alternative textbooks available online for free are

Daniel A. Steck, Classical and Modern Optics, available online at

J. Peatross and M. Ware, Physics of Light and Optics, 2015 edition, available at http://optics.byu.edu

These books give alternative presentations on some 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 Saleh-Teich, 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 obligatory 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 a 4-hour exam. Please remember to sign up before the deadline.

One bonus point is awarded for each home assignment and for the lab report, if they are correct and handed in on time. You can get maximum 4 bonus points.

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.

Allowed material at the written exam:

1. Course book “Fundamentals of photonics”, first or second edition by B.E.A. Saleh and M.C. Teich.

2. Lecture notes, downloaded and printed from the course homepage.

3. Numerical tutorial notes, downloaded and printed from the course homepage.

4. Manuals for the laboratory exercises.

5. Handbooks “Physics Handbook” and “Beta Mathematical Handbook”

6. Basic calculator approved by Chalmers

Notice that this material may contain handwritten short notes, markings and indexing, but must not include solved problems.

Grading Criteria

The grading is calculated by the following scheme, after adding bonus points (max 4) to the "raw" exam points, to obtain a sum x:

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

$24 \leq x < 36$: grade 3

$36 \leq x < 48$: grade 4

$48 \leq x \leq 64$: grade 5

The bonus points are valid for all three exams connected with this year's course.

Contact Information

Teachers can be contacted through e-mail with first name dot surname at chalmers dot se.

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

Week	Date 2020	Time	Topic	Activity	Teacher	Hand in
1	Mon. Jan. 20	9-10	Intro: Goals, Activities, Schedule, Examination	Lecture 1	MK	
		10-12	Ray Optics	Lecture 2	MK	
	Wed. Jan. 22	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. 27	10-12	Beam Optics	Lecture 4	MK	
	Wed. Jan. 29	10-12	Optical Resonators	Lecture 5	JG	
		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. 3	10-12	Lasers, mode-locking, laser safety	Lecture 6	MK	
	Wed. Feb. 5		CHARM - No activities			Ethics Essay in
4 Lab 1 MJ/KT	Mon. Feb. 10	10-12	Fourier Optics	Lecture 7	JG	
	Wed. Feb. 12	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. 17	8-10	Diff, Imaging, Hologr.	Lecture 8	MK	
		10-12	Matrix Methds	Numerical 4	JG	
	Wed. Feb. 19	10-12	Electromagnetic Optics	Lecture 9	MK	
		13-15	Diffr., imaging, EM , Polarization	Exercise 4	OH	
		15-17	Polarization	Lecture 10	MK	3: FDTD (MJ)
6 Lab 2 MJ/KT	Mon. Feb. 24	10-12	Waveguides and Optical Fibers	Lecture 11	MK	
	Wed. Feb. 26	10-12	Coherence, Photons and Atoms	Lecture 12	MK	
		13-15	Polarization, WGs + Fibers	Exercise 5	OH	
		15-16	Final, FDTD+Matrix Methods	Numerical 5	JG	4: Matrix Methods (MJ)
7 Lab 2 MJ/KT	Mon. Mar. 2	10-12	Amplification and Lasers	Lecture 13	MK	
	Wed. Mar 4	10-12	Laser oscillations, dynamics, Q-switching, course summary	Lecture 14	MK	
		13-15	Coherence, Photons and Atoms	Exercise 6	OH	
8	Mon. Mar. 9	10-12	Amplifiers and Lasers	Exercise 7	OH	
	Wed. Mar. 11	10-11	Guest lecture, Anders Larsson		JG	
		13-15	Old Exam problems	Exercise 8	OH	
9	Mon. Mar. 16	14-18	Exam			
	Tue. June 9	14-18	Re-exam			
	Thu. Aug 20	-	Re-exam, Contact examiner			