Optics and Optical Design

FAFF01 – FYST43

Cord Arnold / Olle Lundh

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Photonics

Photonics = science and technology of generating and controlling photons. The science of photonics includes the emission, transmission, amplification, manipulation, detection and utilization of light.

Important photonics industry branches:

- Information and communication
- Lighting
- Laser
- Manufacturing
- Security
- Space and defense
- Life science and health care
- …

Recent Nobel prices for photonics:

2018:

- A. Ashkin: Optical tweezers
- G. Mourou and D. Strickland: Chirped pulse amplification

2014:

- I. Akasaki, H. Amano and S. Nakamura: Blue LEDs
- E. Betzig, S.W. Hell and W.E. Moerner: Super-resolution microscopy

2009:

- C.K. Kao: Potential of optical fibers
- W.S. Boyle and G.E. Smith: CCD sensors

Photonics program

- **Engineering**
- **Communication**
- **Diagnostics**
- **Devices and components**

Specialisation E, F,

Master program

Exchange student program

http://www.atomic.physics.lu.se/education/photonics/

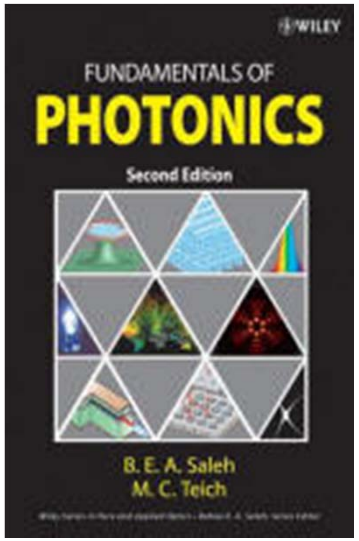
Photonics / Engineering

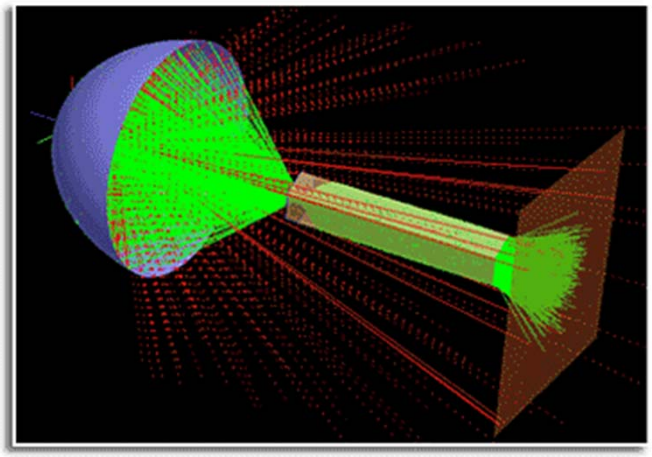
Four courses

Optics & optical design **C. Arnold / O. Lundh**	**7.5**	**FAFF01** **FYST43**	**G2**	**HT1: First period, autumn**
Lasers **O. Lundh, J. Larsson**	**7.5**	**FAFN01** **FYSN14**	**A**	**HT2: Second period, autumn**
Optoelectronics and optical communication **D. Hessman, C. Arnold**	**7.5**	**FFFN25** **FYST50**	**A**	**VT1: First period, spring**
Advanced lasers and optics **J. Larsson / C. Arnold**	**7.5**	**FAFN10** **FYST32**	**A**	**VT2: Second period, spring**
Medical Optics **C. Arnold / E. Berrocal**	**7.5**	**FAFN35** **FYST22**	**A**	**HT2: Second period, autumn**

KFS Studentbokhandel

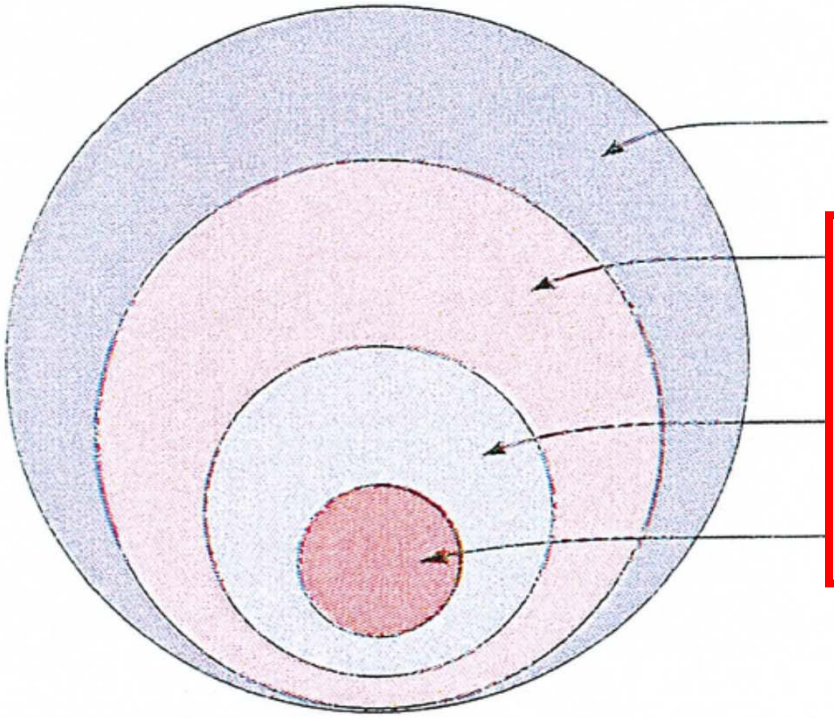
Course book:
Fundamentals of Photonics, 2nd Edition
Bahaa E.A. Saleh, Malvin C. Teich
ISBN: 978-0-471-35832-9





Ray tracing project (FRED software) in all courses.

Course content



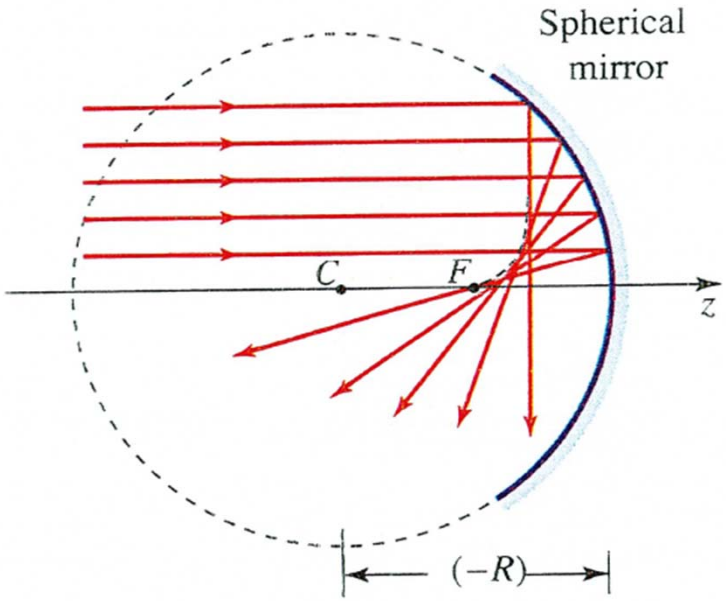
Quantum Optics

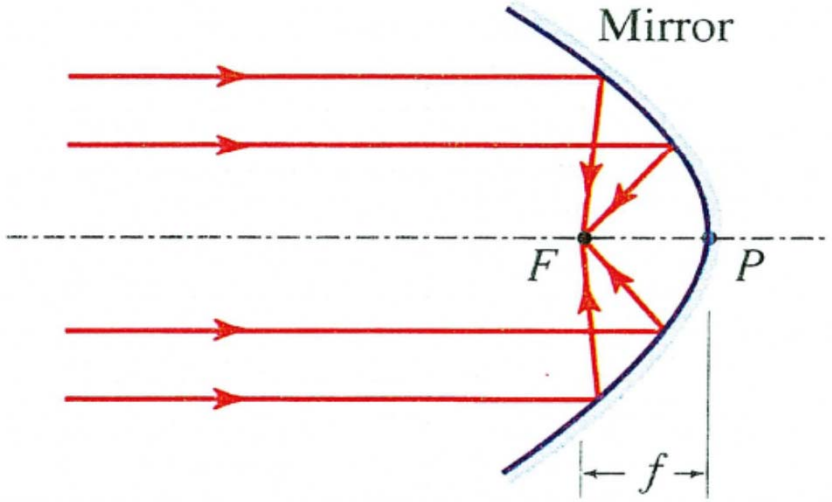
Electromagnetic Optics — Polarization Optics; Optics of layered media

Wave Optics — Fourier Optics

Ray Optics

Ray optics - Examples

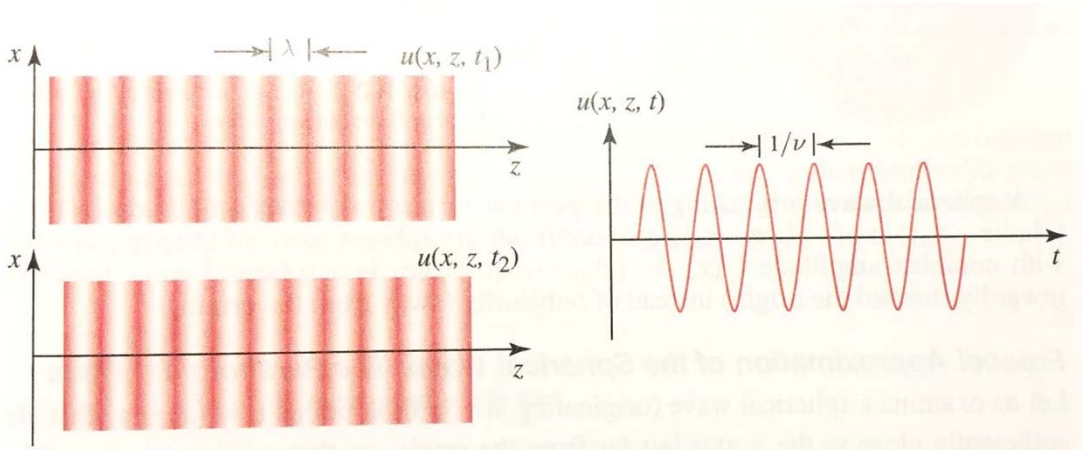




Main concepts:

- Basic optical components
- Basics of optical systems
- Background of optical design

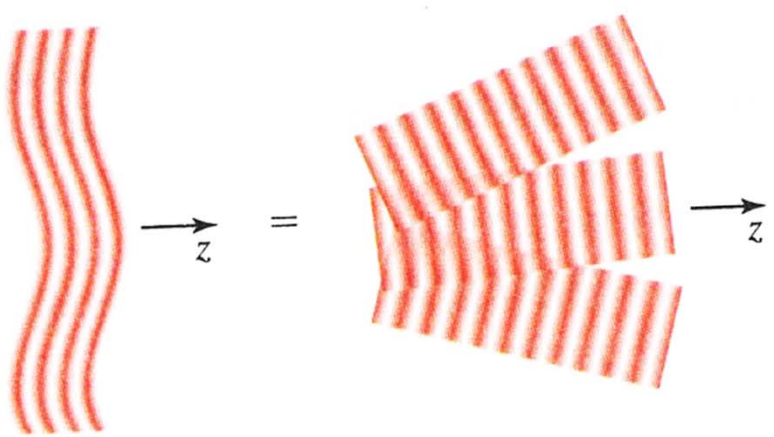
Wave optics

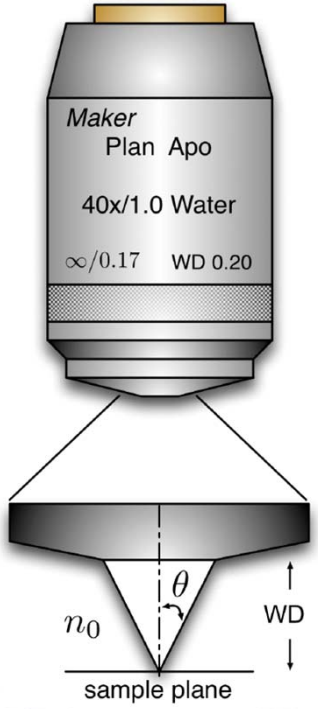


https://www.ligo.caltech.edu/LA/page/what-is-interferometer

Main concepts:
- Interference
- Diffraction

Fourier optics



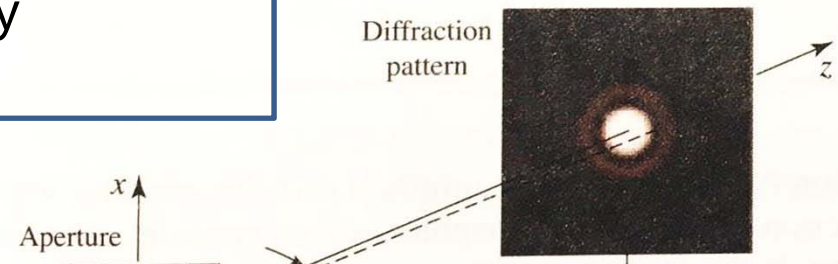


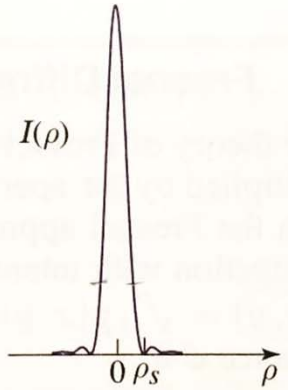
Main concepts:
- Wave front decomposition
- Spatial frequency
- Diffraction limit

$$\theta = 1.22\frac{\lambda}{D}.$$

$$\Rightarrow \theta \approx 1.22\,\lambda/D \quad (4.3\text{-}9)$$

Airy Disk Half Angle





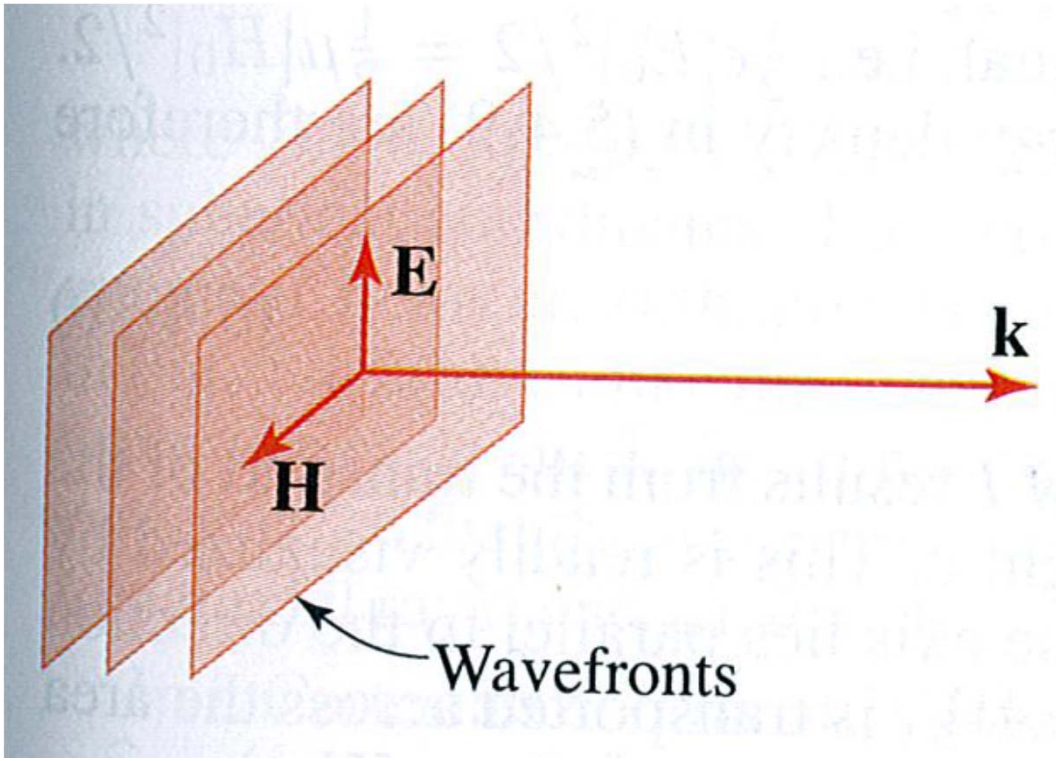
Electromagnetic optics

$$\nabla \times \mathcal{H} = \frac{\partial \mathcal{D}}{\partial t}$$

$$\nabla \times \mathcal{E} = -\frac{\partial \mathcal{B}}{\partial t}$$

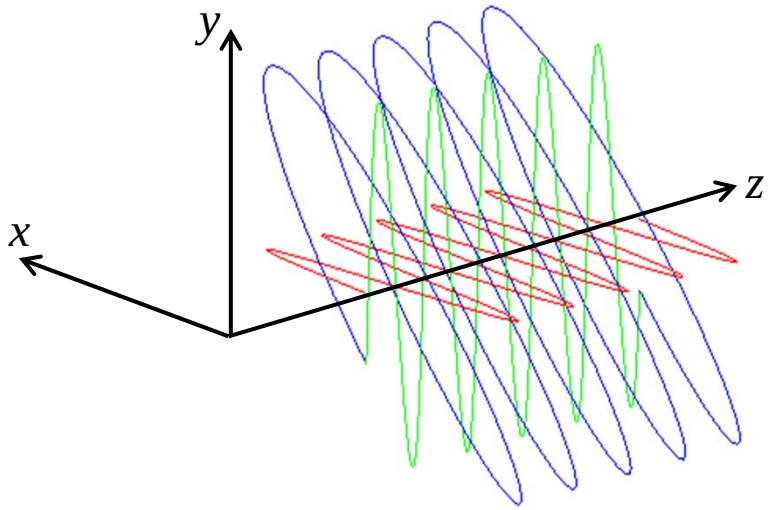
$$\nabla \cdot \mathcal{D} = 0$$

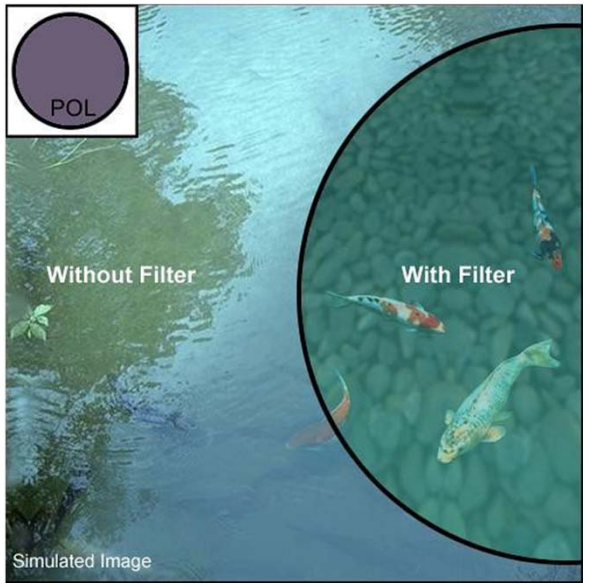
$$\nabla \cdot \mathcal{B} = 0.$$



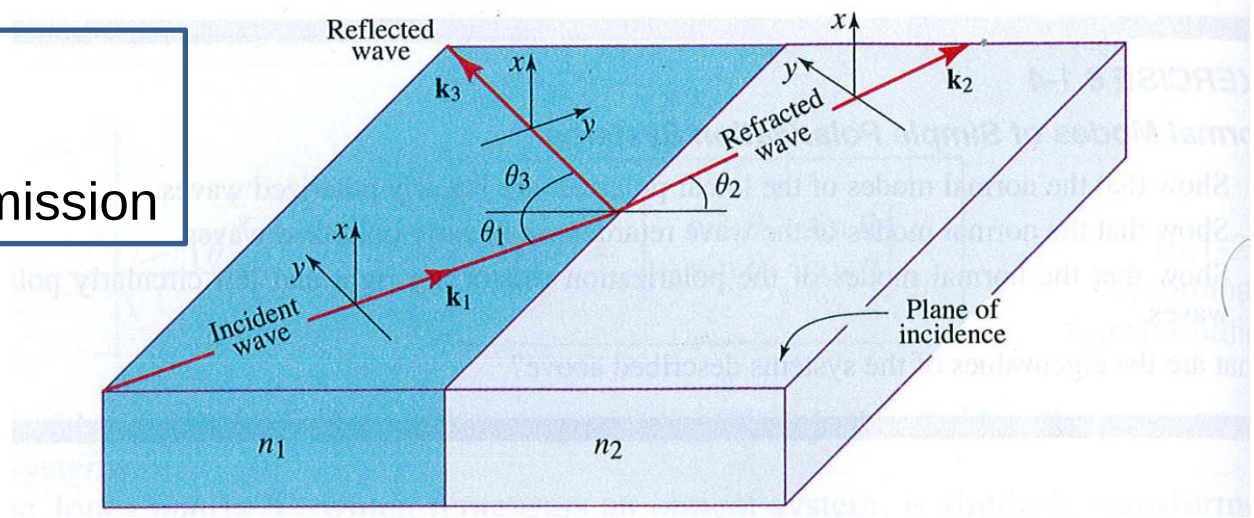
Main concepts:
- EM-fields are vectorial
- Dispersion

Polarization optics

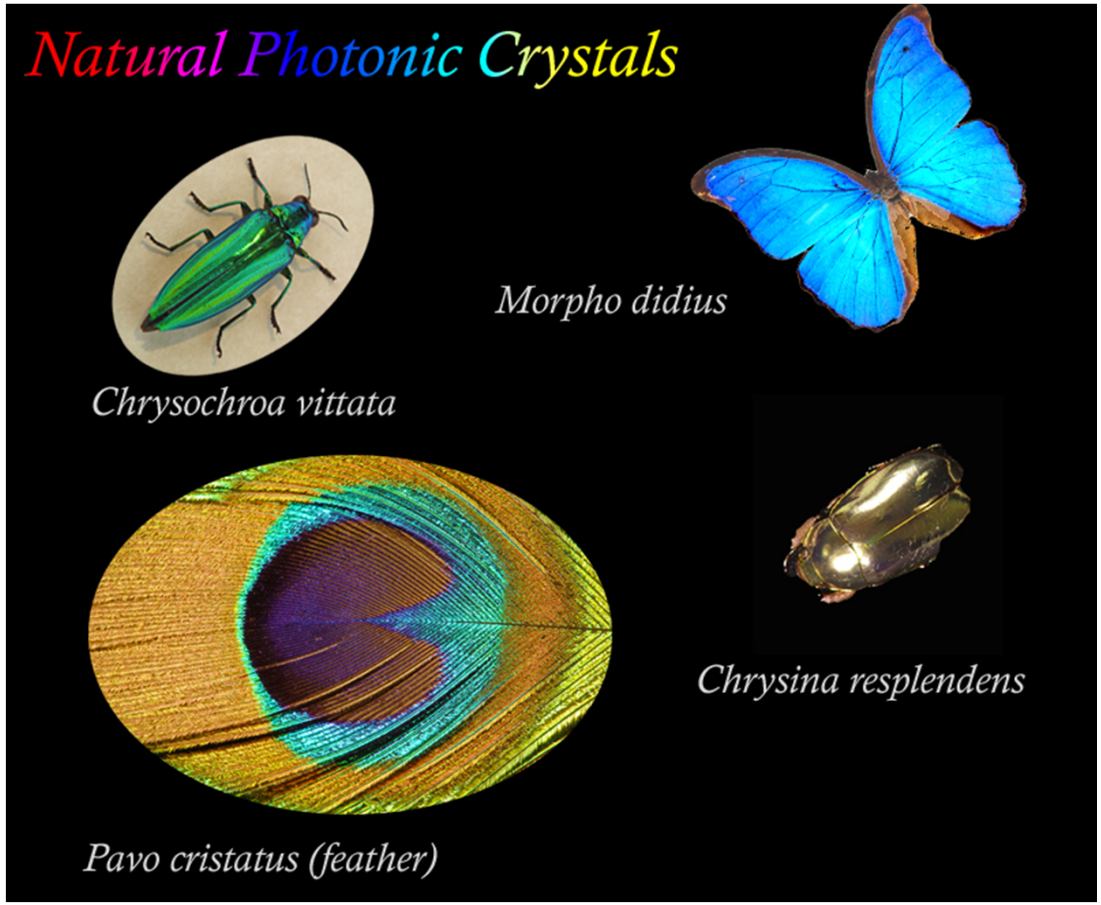


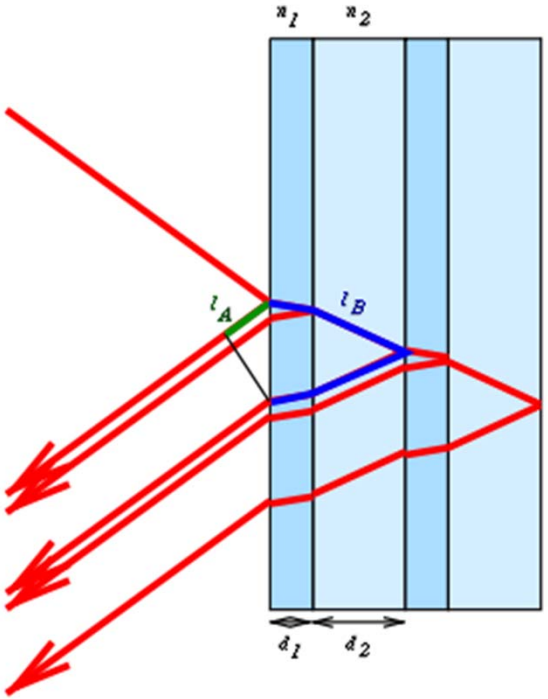


Main concepts:
- Polarization
- Reflection and transmission



Optics of layered media





Main concepts:

- The power of multiple interference
- Optical coatings

Structure

Lectures: (Cord Arnold, Olle Lundh) 13-15 Mon, 10-12 Thu

Exercises: (Cord Arnold, Olle Lundh) 13-15 Fri (usually) Schedule

Ray tracing project: (Hugo Laurell)

3 Laboratory exercises:

- Interferometry: Jonas Björklund-Svensson, Ivan Sytcevich
- Fourier Optics: Hugo Laurell, Kristoffer Svendsen
- Polarization: David Busto, Hafsa Syed

Written Exam

Aims

- **Aim:** The course aims at building knowledge about the basic principles of optics and practical knowledge on optical design, with the help of a ray tracing program.
- **Learning outcomes**
  - Knowledge and understanding: For a passing grade the student must
    - have a good knowledge of optics that allows her/him to design and build industrial optical applications.
    - be able to understand why and when a given optical problem can be solved with ray optics, wave optics or electromagnetic optics.
    - be able to understand important concepts, such as polarization, diffraction, interferometry, holography.
  - Competences and skills: For a passing grade the student must
    - be able to do alignments and measurements in optics.
    - be able to calculate propagation of light through optical components.
    - be able to perform optical designs.
    - be able to search and acquire knowledge from references within the field.
    - have an increased competence in presenting in writing and orally an accomplished project.
  - Judgement and approach: For a passing grade the student must
    - have an increased experience of working in groups of two or four persons towards a common goal.

Course web page (not preferred)

www.atomic.physics.lu.se/education/elective-courses/faff01-fyst43-optics-and-optical-design/

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Photonics

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- FAFN05-FYST21 Light-Matter Interaction

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FAFF01-FYST43 Optics and Optical Design

About the course

The course "Optics and optical design" teaches the basic principles of optics and gives practical knowledge on optical design, with the help of a ray tracing program.

It is a course with level G2 optional for F4, E4, N4, Pi4, also open to students of the Science faculty.

First lecture 2018, Monday September 3rd, 13:15 in H322.

Course content:

Optics and optical design includes ray optics (incl. matrix formulation), wave optics, Fourier optics, electromagnetic optics incl. polarization and the optics of layered media (incl. matrix formalism) with a short introduction to photonic crystals.

ADMINISTRATIVE INFO

Course code Science Faculty: FYST43

University credits: 7.5 ECTS

Term: Fall 1

Grading scale: TH

Level: G2

Language of Instruction: English

Course Teachers: Cord Arnold & Olle Lundh

Recommended prerequisites: Basic courses in mathematics and physics

Assessment: Written exam. Three mandatory laboratory exercises with report. Ray tracing project.

Lectures: 26 h

Exercises: 12 h

Laboratory work: 15 h

Live@Lund (preferred)

https://liveatlund.lu.se/departments/Physics/FAFF01/FAFF01_2018HT_100_1_NML__1281

Cord Arnold Sign Out

Live@Lund

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FAFF01-FYST43 - Optics and Optical Design

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It is a course with level G2 optional for F4, E4, N4, Pi4, also open to students from the Science faculty and the Photonics master program.

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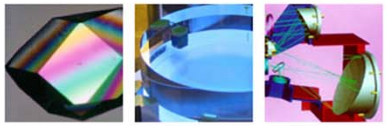

Important notice:

This course uses both Live@Lund as well as the original course web page. At this moment, most of the information can be found on our original course page. During the course, all the lecture notes, exercises, solutions, etc. will be posted at Live@Lund (Check the Lesson plan section). Also, signing up for the laboratory exercises and handing in the reports will happen on the Live@Lund page.

Important links:

- Course literature
- Ray tracing project
- Instructions to laboratory exercises
- Information about the exam

Course Announcement

Course registration procedure

- All students must apply for a course in advance of the course start, i.e. in advance of today!
  - Nfak: antagningen.se
- We can generally not just offer places, if students just show up at the course start.
- But, there usually is the possibility for ”late” application.
  - Nfak: antagningen.se (one week after course start!)
  - LTH: Contact administration
- …

Course registration procedure

- All students (not PhD) must self register (this not the same as applying for the course!) through Studentportalen (student.lu.se) .
- This only works, if you have applied before!
- Self-registration closes:
  - 8/9 (N-fak, be fast with late application!)
  - 22/9 (LTH)

Important people and addresses

- Teaching administrator LTH: Eskil Fredriksson (H334)
- Teaching administrator N-fak: Stina Loo (H333)
- **studentadministration@fysik.lu.se (EF och SL)**
- Study director Charlotta Nilsson (H336)
- **studierektor@fysik.lu.se (CN)**
- **Always put me in copy.**

End of the introduction

Good luck with the course