MICRO-422

# Lasers: theory and modern applications

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| Cursus | Sem. | Type |
|---|---|---|
| Electrical and Electronical Engineering | MA1, MA3 | Opt. |
| Ing.-phys | MA1, MA3 | Opt. |
| Microtechnics | MA1, MA3 | Opt. |
| Photonics minor | H | Opt. |
| Photonics | | Opt. |
| Physicien | MA1, MA3 | Opt. |

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| Language of teaching | English |
| Credits | 4 |
| Session | Winter |
| Semester | Fall |
| Exam | Written |
| Workload | 120h |
| Weeks | 14 |
| **Hours** | **4 weekly** |
| Lecture | 3 weekly |
| Exercises | 1 weekly |
| **Number of positions** | |


## Summary

This course gives an introduction to Lasers by both considering fundamental principles and applications. Topics that are covered include the theory of lasers, laser resonators and laser dynamics. In addition to the basic concepts, a variety of interesting laser systems and applications are covered


## Content

1. Introduction (Overview: History of the laser, Market application, Nobel Prizes,)- demo laser printer.
2. Basics of resonators and Gaussian beam optics.
3. Principle of laser operation: Lorentz model, dispersion theory.
4. Principle of laser operation: Laser oscillation, threshold, coherence.
5. Semiconductor and photonic nanostructured lasers
6. Laser dynamics : Laser oscillation, laser line-width, coherent population oscillations - AM, PM Noise.
7. (Gas and ) Solid state lasers Optical fibers
8. Fiber laser and amplifiers Optical fibers
9. Ultrafast lasers, Femtosecond laser Frequency Metrology, Mode locked lasers, autocorrelation, FTIR
10. Ultrafast lasers, Femtosecond laser Frequency Metrology, Mode locked lasers
11. Detection of laser light (detector basics)
12. Optical parametric oscillators (OPO), Raman Lasers
13. Tools of laser light manipulation

## Learning Prerequisites

### Important concepts to start the course

This course requires an understanding of introductory physics in wave theory (incl. complex numbers) and familiarity with Maxwell equations and electromagnetism.

## Learning Outcomes

By the end of the course, the student must be able to:

- Able to compute absorption cross-section
- explain in details YAG, He-Ne, Ti-saphirre, external cavity lasers, fiber lasers
- Know shot and thermal noise, laser linewidth, relaxation oscillation
- know passive and active modelocking, methods to caracterize pulse duration
- Know phase matching, method to obtain phase matching
- know parametric gain, singly and doubly resonant lasers

## Teaching methods

2 hours of class + 1 hour of exercises
Part of the class will be given via MOOC videos.

## Assessment methods

The course grading is based on a final written exam which counts for 80% of the grade and two quizzes during the semester which count for 20% of the grade.

Homework will be given every week. Solutions will be handed out. The quizzes questions are drawn from the class and from the exercises.

## Resources

### Bibliography

Main text book:
Milonni, Eberly "Laser Physics" (Wiley Interscience)
Additional chapters will be selected from:
Saleh, B. E. A., and M. C. Teich. Fundamentals of Photonics. New York, NY: John Wiley and Sons, 1991. ISBN: 0471839655.
Yariv, A. Optical Electronics in Modern Communications. 5th ed. New York, NY: Oxford University Press, 1997. ISBN: 0195106261.Amnon Yariv "Quantum Electronics" (Wiley)

### Ressources en bibliothèque

- Quantum Electronics / Yariv
- Fundamentals of Photonics / Saleh
- Optical Electronics in Modern Communications / Yariv
- Laser Physics / Milonni

### Notes/Handbook

Polycopié:
"Theory and applications of lasers" by Tobias J. Kippenberg and Christophe Moser (available as pdf on Moodle)

### Moodle Link

- https://go.epfl.ch/MICRO-422