AN INTRODUCTION TO LASER PHYSICS AND APPLICATIONS

COURSE OUTLINE

Responsible: Konstantinos Petridis

1. GENERAL			
SCHOOL	School of Engineering		
ACADEMIC UNIT	Department of Electronic Engineering		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	MEN1.2	**SEMESTER**	2nd
COURSE TITLE	An Introduction to Laser Physics and Applications		

INDEPENDENT TEACHING ACTIVITIES if credits are awarded for separate components of the course	**WEEKLY TEACHING HOURS**	**CREDITS**
	2	4
Total	**2**	**4**

COURSE TYPE general background, special background, specialised general knowledge, skills development	Theoretical
PREREQUISITE COURSES	There are no prerequisites for this course
LANGUAGE OF INSTRUCTION and EXAMINATIONS	English
OFFERED TO ERASMUS STUDENTS	Yes (in English) — Spring Semester
COURSE WEBSITE (URL)	

2. LEARNING OUTCOMES

Learning outcomes

- Explain the fundamental principles of light–matter interaction, including absorption, spontaneous emission, and stimulated emission.
- Describe the conditions required for laser operation, including population inversion, optical amplification, and feedback.
- Explain the basic characteristics of laser radiation, including coherence, monochromaticity, directionality, intensity, and polarization.
- Analyze the operation of optical resonators and describe the formation of longitudinal and transverse modes.
- Understand continuous-wave and pulsed laser operation.
- Distinguish between different types of lasers, including solid-state, gas, semiconductor, fiber, and dye lasers.
- Communicate the principles and applications of laser technology through technical reports, problem-solving activities, and oral presentations.

General Competences

- Applying the fundamental principles of light–matter interaction, including absorption, spontaneous emission, and stimulated emission.
- Explaining the physical conditions required for laser operation, including population inversion, optical gain, and feedback.

- Identifying the main components of a laser system and evaluating their functions.
- Distinguishing among solid-state, gas, semiconductor, fiber, and dye lasers.
- Analyzing the main properties of laser radiation, including coherence, monochromaticity, directionality, intensity, and polarization.
- Interpreting the operation of optical resonators and the formation of longitudinal and transverse modes.
- Calculating fundamental laser parameters, including wavelength, frequency, photon energy, optical power, intensity, beam divergence, and pulse energy.
- Differentiating between continuous-wave, pulsed, Q-switched, and mode-locked laser operation.

3. SYLLABUS

The course will contain the following topics:

- The three fundamental processes to generate light: absorption, spontaneous emission, and stimulated emission.
- The properties of laser light.
- The three building blocks of a laser device: Pump Source, Medium, and an Optical Amplifier.
- Types of Pumping Sources and related laser systems.
- What do we define as the threshold point? What is population inversion, and how many energy states do we need to achieve population inversion?
- Types of optical amplifiers. The stability/loss diagram.
- Longitudinal and Transverse laser modes.
- The saturation mechanism. The various spectral broadening mechanisms.
- How to generate laser pulses: the Q-Switching and Mode-Locking Techniques.
- Controlling the polarization of the laser light.
- Applications of laser light in medicine, environment, and military areas.

4. TEACHING and LEARNING METHODS - EVALUATION

DELIVERY Face-to-face, Distance learning, etc.	- Synchronous lecture sessions and attention of seminars in a hybrid format.
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY Use of ICT in teaching, laboratory education, communication with students	• Use of the Zoom platform • Use of a Learning Management System to download the lecture sessions, respond to your assignments, and upload your homework. • Use of the Mentimeter tool for polling activities during the lecture sessions. • Use of the Kahoot tool for understanding the outcomes of each session.
TEACHING METHODS The manner and methods of teaching are described in detail.	

Activity	**Semester workload**
Lectures	25
Homework & Assignments	75
Final Exam	2
Course total	**102**

STUDENT PERFORMANCE EVALUATION Description of the evaluation procedure	• Active Participation: 50% • Homework: 30% • Final Exam: 20% The students should be engaged in all of the above assessment processes.

5. ATTACHED BIBLIOGRAPHY

- Lecturer's teaching notes.
- LASERS by Siegman