Department of Physics

College of Education

Salahaddin University-Erbil

Subject: Laser

Course Book – (Year 3)

Lecturer's name:

Assist. Prof. Dr. Saman Q. Mawlud

(PHD Nanoglass Materials Science)

Academic Year: 2023/2024

Course Book

1. Course name	**Laser**
2. Lecturer in charge	**Dr. Saman Qadir Mawlud**
3. Department/ College	**Physics/Science**
4. Contact	**e-mail: saman.maulud@uor.edu.krd** **Tel:009647504789074**
5. Time (in hours) per week	**Theory: 2** **Practical: 0**
6. Office hours	**Thursday from 9:00-11:00 AM or by an appointment**
7. Course code	
8. Teacher's academic profile	https://academics.su.edu.krd/saman.mawlud
9. Keywords	**Laser Physics, Concepts and Applications** **Laser Characteristics**

10. Course overview:

This course is titled “Laser” but could as well have been titled “Laser Principles”. It is an introductory course in lasers, so in fact there is more “Laser Principles” in it. The chief purpose is for students to obtain a solid understanding of the basic principles of lasers and to be familiar with the operation of most common laser types. The course is taught in the classical approximation so a knowledge of quantum mechanics is not required.

11. Course objective:

The goal of this course is to provide B Sc. students with knowledge and understanding of fundamental aspects of laser physics and engineering of lasers of all kinds, including fundamental physics of stimulated emission process and laser amplifiers, optical resonators, characteristics of laser radiation and methods for controlling it.

The aim of the course is that the student shall:

- have acquired a thorough understanding of the theory of modern laser physics
- be able to describe in detail the inherent behavior and functionality of the many different types of modern lasers
- have acquired a deep understanding of the detailed properties of coherent laser light
- be able to formulate reasonably complicated problems in laser physics and provide solutions to the same

12. Student's obligation

A list of additional useful problems will be given to help the student further sharpen your understanding of the subject and your problem solving skills. The students are required to do these problems, although you may find it useful to do so. Because this subject is One course, so that the

students are required to do at least two closed exams during this semester besides other assignments and each student must prepare full report at the end of the year. All exams have marks, full report also has marks, the classroom activities count marks and mark for attendance too.

13. Forms of teaching

Our lecture is depending directly on showing the strong point in the lecture via data show depending on the power point program… and solve problem on the white board with the students.

14. Assessment scheme

All exams have 20 marks, full report has 5 marks, the classroom activities count (Homework) has 10 and for Quiz 5 Marks. So that the final grade will be based upon the following criteria:

- Mid- semester exam: 30%
- Homework, Classroom participation and assignments: 5%
- Quiz: 5%
- Final Exam: 60%

15. Student learning outcome:

Laser physics plays a very important role in the physics field. During the years of experience of teaching laser physics, I have notices that students generally find it easier to learn its underlying ideas than to handle the practical aspects of the formalism. What is true is that the students at the Physics department who were all selected after a stiff entrance examination, and whose ambitions in life were diverse in science, in industry, in business, in high public office all had to follow this introductory physics course. As a consequence, the challenge was to try to get them interested in the field whatever their future goals were. Of course, laser is an ideal subject because one can be interested in it for a variety of reasons, such as the physics itself, the mathematical structure of the theory, its technological spinoffs, as well as its philosophical or cultural aspects. So the task was basically to think about the pedagogical aspects, in order to satisfy audiences that went up to many students during the last 10 years.

16. Course Reading List and References:

Books: There are many good introductory texts on Laser, for example:

- An Introduction to Lasers and Their Applications: Donald C. O'Shea -Addison-Wesley
- Optoelectronics: An Introduction /J. Wilson, J.F.B. Hawkes /Englewood Cliffs; London: Prentice-Hall
- Principles of Lasers: Orazio Svelto / Springer
- Magazines and review (internet)

17. The Topics:

Lecture 1: Introduction, history, properties of laser light

Lecture 2: Blackbody radiation, Planck's theorem

Lecture 3: Absorption, spontaneous & stimulated emission

Lecture 4: Line broadening mechanisms, homogeneously broadened lines

Lecture 5: inhomogeneously broadened lines

Lecture 6: The laser Saturation effects

Lecture 7: The laser Saturation of inhom. broadened lines, spectral hole burning

Lecture 8: The laser Energy levels: atoms, molecules, solid-state

Lecture 9: The laser 2, 3, and 4-level lasers

Lecture 10: The laser Continuous wave operation, optimum output coupling

Lecture 11: Light interaction with matter

Lecture 12: Modes in lasers Paraxial beams, modes, ABCD matrices, resonator stability

Lecture 13: Modes in lasers Gaussian beams, higher order modes

Lecture 14: Modes in lasers Passive resonators, stability

Lecture 15: Modes in lasers multiple modes, unstable resonators, Fabry-Perot interferometer

Lecture 16: Modes in lasers Longitudinal modes

Lecture 17: Pumping Electrical and optical pumping

Lecture 18: Pulsed lasers Transient behavior, relaxation oscillation

Lecture 19: Pulsed lasers Q-switching

Lecture 20: Pulsed laser Mode-locking

Lecture 21: Measurement of laser dynamics

Lecture 22: Semiconductor lasers: Electronic structure of semiconductors

Lecture 23: Semiconductor lasers: Gain in semiconductors

Lecture 24: Semiconductor lasers: Semiconductor diodes, quantum well lasers and VCSELs

Lecture 25: Solid-state lasers

Lecture 26: Laser types Crystalline, glass, fiber, gas lasers

18. Practical Topics (If there is any)

In this section The lecturer shall write titles of all practical topics he/she is going to give during the term. This also includes a brief description of the objectives of each topic, date and time of the lecture

19. Examinations:

Q1\ choose the correct answer:

1. What does the acronym LASER stand for?
   a) Light Absorption by Stimulated Emission of Radiation
   b) Light Amplification by Stimulated Emission of Radiation
   c) Light Alteration by Stimulated Emission of Radiation
2. What does the acronym MASER stand for?
   a) Microwave Amplification by Stimulated Emission of Radiation
   b) Molecular Absorption by Stimulated Emission of Radiation
   c) The name of Albert Einstein's dog
3. What is one way to describe a Photon?
   a) Solid as a rock
   b) A wave packet
   c) A torpedo
4. Which laser is considered "eye safe"?
   a) Laser bar-code scanners
   b) The eximer laser
   c) Communications lasers
5. Most lasers are electrically inefficient devices.
   a) True
   b) False
6. Chemical lasers use____ to produce their beams.
   a) Excessive amounts of electrical power
   b) Small amounts of electrical power
   c) No electrical power

Q.2\ Calculate the ratio of the population inversion (N_2 / N_1) for the two energy levels E_2 and E_1 when the material is at room temperature (300^0K), and the difference between the energy levels is 0.5 eV. What is the wavelength of a photon which will be emitted in the transition from E_2 to E_1?

When substituting the numbers in the equation, we get:

$$\frac{N_2}{N_1} = \exp\left(-\frac{E_2 - E_1}{k_B \cdot T}\right) = \exp\left[-\frac{(0.5 \cdot eV) \cdot \left(1.6 \cdot 10^{-19} \cdot \frac{J}{eV}\right)}{\left(1.38 \cdot 10^{-23} \cdot \frac{J}{K}\right) \cdot (300K)}\right]$$

$= 4 * 10^{-9}$

To calculate the wavelength:

$$\lambda = \frac{h \cdot c}{\Delta E} = \frac{(6.626 \cdot 10^{-34} \cdot J \cdot sec) \cdot \left(3.10^{8} \cdot \frac{m}{sec}\right)}{(0.5 \cdot eV) \cdot \left(1.6 \cdot 10^{-19} \cdot \frac{J}{eV}\right)} = 2.48 \cdot \mu m$$

This wavelength is in the Near Infra-Red (NIR) spectrum.

20. Extra notes:

- Google Classroom Web site:
  https://classroom.google.com/c/MTU2NzQyNzAyMDcw?cjc=i4dkbuq

This site will reflect latest changes and contain homework and reading assignments. Slides used for classes will be available for download before each class. If you want a hard copy of the slides, print them. You are required to read the notes prior to class.

- Per university policy and classroom etiquette; mobile phones, iPods, etc. must be silenced during all classroom lectures. Those not heeding this rule will be asked to leave the classroom immediately so as to not disrupt the learning environment. Please arrive on time for all class meetings. Students who habitually disturb the class by talking, arriving late, etc., and have been warned may suffer a reduction in their final class grade.

21. Peer review

This course book has to be reviewed and signed by a peer. The peer approves the contents of your course book by writing few sentences in this section.

(A peer is person who has enough knowledge about the subject you are teaching, he/she has to be a professor, assistant professor, a lecturer or an expert in the field of your subject).

ئەم کۆرسبووکە دەبێت لەلایەن هاوەڵێکی ئەکادیمیەوە سەیر بکرێت و ناوەڕۆکی بابەتەکانی کۆرسەکە پەسەند بکات و جەند ووشەیەک بنووسێت لەسەر شیاوی ناوەڕۆکی کۆرسەکە و واژووی لەسەر بکات.

هاوەڵ ئەو کەسەیە کە زانیاری هەبێت لەسەر کۆرسەکە و دەبیت پلەی زانستی لە مامۆستا کەمتر نەبێت.