

Ministry of Higher Education and Scientific research



Department of Physics

College of Education

University of Salahaddin

Subject: Course Book of Laser 4th stage

Lecturer's name: Assist. proff. Dr.Nahlah

Q.Mohammed

Academic Year: 2019/2020

1. Course name	Laser
2. Lecturer in charge	Assist. Proff. Dr. Nahlah Q. Mohammed
3. Department/ College	Physics /Science
4. Contact	e-mail:nahlah.mohammed@su.edu.krd Tel:+9647504492717
5. Time (in hours) per week	2 hr
6. Office hours	Every days(9 AM- 3 PM)
7. Course code	
8. Teacher's academic profile	https://academics.su.edu.krd/nahlah.mohammed
9. Keywords	Laser , Diode Laser , nanolaser
10. Course overview:	The course will cover laser texts of selective topics together with print media or internet articles which deal with current laser issues. Instructional strategies attempt to strike a balance between developing the students' ability to cope with laser texts, extending their general academic reading skills, and increasing their basic knowledge and understanding of lasers
11. Course objective:	<ul style="list-style-type: none"> The course will give students a better understanding of a number of lasers topics, the followings are examples but not restricted to: Study the concept principle of atom and its absorption and emissions, Study the laser theory, Study lasers physics and its characteristics, Increase your knowledge on the effects and characteristics of different kinds of lasers material, Understand the different applications of lasers, with some extra topics that will be identified as the course progress.
12. Student's obligation	The students should have presence in all lectures and To get the best of the course, it is suggested that you attend classes as much as possible, read the required lectures, teacher's notes regularly as all of them are foundations for the course. Lecture's notes are for supporting and not for submitting the reading material including the handouts. Try as much as possible to participate in classroom discussions, preparing the assignments given in the course.
13. Forms of teaching	Different forms of teaching will be used to reach the objectives of the course: power point presentations for the lectures including head titles and definitions and summary of conclusions,

classification of materials and any other illustrations. There will be classroom discussions and the lecture will give enough background to solve, analyze, and evaluate problems sets, and different issues discussed throughout the course. in addition to the white board (Students should be use course references).

14. Assessment scheme

The students are required to do two closed book exams at the semester besides other assignments quizzes exam. The exams have 30 marks, the quizzes and the attendance, classroom activities count 10 marks. There will be a final exam on 60 marks. So that the final grade will be based upon the following criteria:

Three semester exams: 30%
Quizzes and classroom participation and assignments 10%
Final exam: 60%

Constructive classroom participation, submitting assignments, and attending class will be evaluated by the lecturer over the semester and used in borderline cases to determine the final grade.

Exams and assignments require analytical work and not just memorization of topics or articles.

15. Student learning outcome:

- The course will give students a better understanding of a number of lasers topics, Study the laser theory, Study lasers physics and its characteristics, increase your knowledge on the effects and characteristics of different kinds of lasers material, Understand the different applications of lasers,
- Students can easily come in for work in the private sectors, e.g. dermatology Lab., etc.
- Today due to the technology students can learn more about the modern laser instruments.

16. Course Reading List and References:

1/ lasers and their application by M.J. Beesely London (1979).

2/ principles of lasers, by O. Svelto plenum press New York (1982).

3/ laser physics by L.V. Tarasov MIR publishers, Moscow (1983).

4/ Lasers principles and application, by J. Wilson London (1987).

5/ The laser guide book, second edition by Jeff Hecht (1992).

And any other lasers textbook published in 21st century.

The core materials of the course consist of the above books, articles from media and internet, and lecture's notes, make sure you read all the materials and prepare well before going for the exams.

Students are encouraged to search for any other materials that may help improve their English language ability in reading, writing, listening and speaking laser texts.

17. The Topics:	Lecturer's name
<p>1. <u>Introduction - Laser Radiation and its properties.</u></p> <p>1.1 <u>Electromagnetic radiation - in vacuum and in matter.</u></p> <p>1.2 <u>Properties of laser radiation - Monochromaticity, Directionality, Coherence.</u></p> <p>2. <u>Laser Mechanism.</u></p> <p>2.1 <u>Bohr model of an atom.</u></p> <p>2.2 <u>Photons and Energy levels diagrams.</u></p> <p>2.3 <u>Absorption of electromagnetic radiation.</u></p> <p>2.4 <u>Spontaneous emission of electromagnetic radiation.</u></p> <p>2.5 <u>Thermodynamic equilibrium.</u></p> <p>2.6 <u>Population inversion.</u></p> <p>2.7 <u>Stimulated emission.</u></p> <p>2.8 <u>Rate equations.</u></p> <p>2.9 <u>Stimulated transitions.</u></p> <p>2.10 <u>Amplification.</u></p> <p>2.11 <u>3 level laser.</u></p> <p>2.12 <u>4 level laser.</u></p> <p>3. <u>Laser system.</u></p>	<p>Assist .Proof. Dr. Nahlah Qader Mohammed</p>

<p>3.1 <u>Active medium.</u></p> <p>3.2 <u>Excitation mechanism.</u></p> <p>3.3 <u>Feedback mechanism.</u></p> <p>3.4 <u>Output coupler.</u></p> <p>3.5 <u>Interactive Demonstration.</u></p> <p>4. <u>Optical cavity and oscillation modes.</u></p> <p>4.1 <u>Standing waves.</u></p> <p>4.2 <u>Longitudinal modes in a laser.</u></p> <p>4.3 <u>Transverse modes in a laser.</u></p> <p>4.4 <u>Optical Cavity.</u></p> <p>5. <u>Amplification in a laser - Laser Gain.</u></p> <p>5.1 <u>Fluorescence line shape.</u></p> <p>5.2 <u>Amplification in a closed loop path between the mirrors of the optical cavity.</u></p> <p>6. Laser types and their characteristics.</p> <p><u>Laser types introduction</u></p> <p><u>6.1 Gas lasers:</u></p> <p><u>Atom Gas:</u></p> <p>6.1.1 <u>Helium-Neon Laser (He-Ne).</u></p> <p><u>Ion Gas:</u></p> <p>6.1.2 <u>Argon Ion Laser (Ar⁺).</u></p> <p><u>Molecular Gas:</u></p> <p>6.1.3 <u>Carbon Dioxide Laser (CO₂).</u></p> <p><u>6.2 Solid State lasers:</u></p> <p>6.2.1 <u>Ruby Laser.</u></p>	
---	--

<p>6.2.2 <u>Neodimium YAG and Nd Glass Laser.</u></p> <p>6.3 <u>Diode Laser (Semiconductor Laser, Injection Laser).</u></p> <p>6.4 <u>Dye Laser (Liquid).</u></p> <p>6.5 <u>Special Lasers:</u></p> <p>6.5.1 <u>X Ray Laser.</u></p> <p>7. <u>Laser Applications.</u></p> <p>7.1 <u>Industrial applications.</u></p> <p>7.2 <u>Medical applications.</u></p> <p>7.3 <u>Military applications.</u></p> <p>7.4 <u>Daily applications</u></p> <p>7.5 <u>Scientific research applications.</u></p> <p>7.6 <u>Special applications.</u></p>	
<p>18. Practical Topics (If there is any)</p>	
<p>19. Examination Type of questions for laser Examination</p> <hr/> <p>Q1) Chose true or false for the following questions and correct the false:</p> <p>1- Stimulated emission is a process of transition of atom from a higher state to a lower one without any outer effect.</p> <p>2-For a symmetrical spherical cavity system the minimum waist is given as:</p> $w_o^4 = \frac{\lambda^2 d^2}{\pi^2} \frac{(1 - g_1 g_2) g_1 g_2}{(g_1 + g_2 - 2g_1 g_2)^2}$ <p>2- Brightness of laser light is a measure for the energy of laser radiation at a point in question, and simply it is the ratio between the output power p_o and the beam waist.</p> <p>4-The laser source of light emit a wide-band of frequency and wavelength so there are many colours in their spectra.</p> <p>5- The number of spontaneous emission is dependent on the population of state i.e;</p> <p>$(d N_2)_{sp} = N_1 A_{12}$</p>	

$d t$

6- In acousto-optic Q-switch, when an acoustic signal is applied to the transducer, light is diffracted out of the intracavity beam and the resonator has a high Quality factor.

7- Q-switching is a simple concept, Energy is stored in the resonator until it reaches a certain level, and then it's released very quickly in a giant pulse.

8- Ruby laser is electrically pumped via first kind collision.

9- The active material in Nd-YAG laser is Nd ion and YAG is as host material.

10- The process of excitation in He-Ne laser is given by the following reaction equations:



Q2) Chose the correct answer for the following questions:

1- In semiconductor laser the principle of lasing emission is due to recombination between electron and

hole in; **A-** conduction band. **B-** valance band. **C-** p-n junction. **D-** all of them.

2- The electromagnetic amplitude which is perpendicular to the direction of propagation of the electromagnetic wave is called;

A- transverse modes. **B-** longitudinal modes. **C-** axial mode. **D-** no each one of them.

3- In homogeneous broadening the response of each individual atom have;

A- the same effect on all the atoms in the ensemble. **B-** the same center frequency. **C-** the same atomic line-shape. **D-** all of them.

4- Sources of radiation losses inside the active medium are;

A-absorption, scattering, transmission by mirror **B-** diffraction through the edges of reflectors

C- both of them . **D-** no each one of them.

5-Consider an optical resonator, having two divergent mirrors M_1 and M_2 , put at distance

d from each other, and having radii of curvature R_1 and R_2 respectively, the stability of this resonator is;

A-stable. B- unstable. C- both of them. D- no each one of them.

6- One of the following is not match, drop it out;

A-He-Ne laser. B- Dye laser. C -Neodymium laser.

7- The principle of Electro Optic Q-switching is;

A- reflection B- refraction C- polarization D- absorption.

Q3) Fill the following blanks:

1- The population inversion equation for three level systems is

2- The line width for this two broadened (collision and natural) distribution can be expressed as.....

3- The reduction in population inversion due to the presence of electromagnetic field is called

4- The equation of mode separation of transverse multi-mode oscillation is written as;

5- ;it is represent the ability of the resonator to store energy.

6- Optical pumping may be or

7- The pumping method helped in solving the problem of increasing pressure in a gas laser.

8- In semiconductor lasers, P-n junction must be doped to work as a good active medium.

Q4) Derive that the number of spontaneous emission to the number of stimulated emission

in any atomic system is equal to the natural distribution of atoms in the same system

Q5)) Plot block diagram for the following process:

1- Population inversion in Four - level systems ;

2- Electro-optic Q-switches;

3- Ar⁺ ion laser device

4- Ruby laser device

Q6) The round trip gain in a laser is 1.136, reflection coefficients of the mirrors are 1 and 0.95 respectively, resonator length of laser is 50 cm, loss coefficient is $1.2 \times 10^{-4} \text{ cm}^{-1}$.

Calculate:

1) the loss factor. 2) the active medium gain. 3) the gain coefficient.

20. Extra notes:

21. Peer review