# Department of Physics

# College of Education

# University of Salahaddin

# Subject: Course Book of PhD. stage

# Lecturer's name: Assist. Proof. Dr.Nahlah Q.Mohammed

# Academic Year: 2020/2021

| | |
|---|---|
| **1. Course name** | **Optical Communications** |
| **2. Lecturer in charge** | **Assist. Proof. Dr. Nahlah Q. Mohammed** |
| **3. Department/ College** | **Physics /Science** |
| **4. Contact** | **e-mail:nahlah.mohammed@su.edu.krd<br>Tel:+9647504492717** |
| **5. Time (in hours) per week** | **3 hr.** |
| **6. Office hours** | **Every day (9 AM- 3 PM)** |
| **7. Course code** | |
| **8. Teacher's academic profile** | https://academics.su.edu.krd/nahlah.mohammed |
| **9. Keywords** | **Optical communication, Optical fiber communication, Laser sources, WDM, Detectors, Amplifiers** |

**10. Course overview:**

**Optical and optical fiber communication is a method of transmitting information from one place to another by sending pulses of light through an optical fiber. The light forms an electromagnetic carrier wave that is modulated to carry information. Fiber is preferred over electrical cabling when high bandwidth, long distance, or immunity to electromagnetic interference are required. This type of communication can transmit voice, video, and telemetry through local area networks, computer networks, or across long distances. Optical fiber is used by many telecommunications companies to transmit telephone signals, Internet communication, and cable television signals. Researchers at Bell Labs have reached internet speeds of over 100 peta bit ×kilometer per second using fiber-optic communication. The process of communicating using fiber-optics involves the following basic steps: 1. creating the optical signal involving the use of a transmitter, usually from an electrical signal 2. relaying the signal along the fiber, ensuring that the signal does not become too distorted or weak 3. receiving the optical signal 4. converting it into an electrical signal**

**11. Course objective:**

- The course will give students a better understanding of a number of optical communication 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, study transmitter and receiver of optical communication system, Sources, detectors, WDM, Amplifiers. 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, analyser , 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 one closed book exams at the semester besides other assignments quizzes exam. The exams have 20 marks, the quizzes have 5 marks, Article review have 15 marks, presentation and seminar have 10 marks There will be a final exam on 50 marks. So that the final grade will be based upon the following criteria:

one semester exams, Quizzes and assignments,
article review, presentation and seminar : 50%
Final exam: 50%

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 optical communication system topics, Study the Electromagnetic theory, Study laser physics and its characteristics, increase your knowledge on the effects and characteristics of different kinds of lasers material, Understand the different applications of lasers, study optical fiber communications, study ray theory, optical fiber cables and connectors. 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 optical communication instruments.

**16. Course Reading List and References:**

1/ lasers and their application by M.J. Beesely London (1979).
2/ Optical Fiber Communication, by John M. Senior (2009) 3rd Edition.

3/ principles of lasers, by O. Svelto plenum press New York (1982).
4/ Optical Fiber Communication by Gerd Keiser (2008) 4th Edition.

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

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

7/ 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 |
|---|---|
| **1. Introduction - Laser Radiation and its properties.**<br>1.1 Electromagnetic radiation - in vacuum and in matter<br>1.2 Properties of laser radiation - Monochromaticity, **Directionality, Coherence.**<br>**2. Introduction of Fiber Optics**<br>**3. Laser Mechanism.**<br>2.1 Bohr model of an atom.<br>2.2 Photons and Energy levels diagrams.<br>2.3 Absorption of electromagnetic radiation.<br>2.4 Spontaneous emission of electromagnetic radiation.<br>2.5 Thermodynamic equilibrium.<br>2.6 Population inversion.<br>2.7 Stimulated emission.<br>2.8 Rate equations.<br>2.9 Stimulated transitions.<br>2.10 Amplification.<br>2.11 3 level laser.<br>2.12 4 level laser. | Assist . Proof. Dr. Nahlah Qader Mohammed |

**4. Laser system.**

3.1 Active medium.

3.2 Excitation mechanism.

3.3 Feedback mechanism.

3.4 Output coupler.

3.5 Interactive Demonstration.

**4. Optical cavity and oscillation modes.** 4.1 Standing waves.

4.2 Longitudinal modes in a laser.

4.3 Transverse modes in a laser.

4.4 Optical Cavity.

**5. Amplification - Laser Gain.**

**6. Optical fiber waveguides**

**7. Transmission characteristics of optical fiber**

**8. Optical Sources**

**9. Optical Detectors**

**10. Direct detection receiver performance**

**11. Optical amplifier**

**12. Optical fiber system**

**13. Optical fiber measurements**

**14. Optical network**

**18. Practical Topics (If there is any)**

**19. Examination** **Type of questions for laser Examination**

many colours in their spectra.

**5-** The number of spontaneous emission is dependent on the population of state i.e;

$$\left(\frac{d N_2}{d t}\right)_{sp} = N_1 A_{12}$$

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:

$$He(2^1S)^* + Ne \rightarrow He(1^1S) + Ne(3p)^*$$

$$He(2^3S)^* + Ne \rightarrow He(1^1S) + Ne(2p_4)^*$$

**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 1and 0.95 respectively, resonator length of laser is 50 cm, loss coefficient is $1.2x10^{-4}$ $cm^{-1}$. Calculate:

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

**20. Extra notes:**

**21. Peer review**