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**Physics department**

**College of Education**

**Salahaddin University-Erbil**

**Subject: Laser Physics**

**Course Book – (Third Year Student)**

**Lecturer's name: Dr. Runas Y. Sula**

**Academic Year: 2022/2023**

Course Book

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| **1. Course name** | Laser Physics |
| **2. Lecturer in charge** | Dr. Runas Y. Sula |
| **3. Department/ College** | **Physics, Education** |
| **4. Contact** | e-mails: **runas.sula@su.edu.krd**  |
| **5. Time (in hours) per week** | Theory**: 2 Hours** |
| **6. Office hours** | **Sunday: Group A From**  10.30 To 12.30**Group B From**   |
| **7. Course code** |  |
| **8. Teacher's academic profile**:  |
| **9. Keywords** |  |
| **10. Course overview:** The course aims at introducing phenomena and the fundamental principles of Laser using the mathematical skills (especially vector calculus) you learnt from other courses. Emphasis is put on both the understanding of the physical meanings of the mathematical descriptions. Examples will be provided both in class and in homework so as to help you acquire the analytical skills. Some computer skills of doing symbolic calculations will also be introduced. Mini-projects and their presentation allow you to have an in-depth and collaborative exploration of selected topics beyond the scope of the lectures. |
| **11. Course objective:**  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. 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:** Students must be **on** **time** for class and should **refrain** from leaving and **re-entering** the classroom during lecture. If a student has a **legitimate** reason for being **excused** early from class, then **he** or **she** should discuss this with **me** before class.  Cell **phones** may **not** be used during **class** (no texting) and should be **silent**. **Laptops** may not be used for anything other than taking **notes**. It is important that you refrain from **excessive** talking during lecture as a **courtesy** to your fellow students. |
| **13. Forms of teaching:**   Different forms of **teaching** will be used to come across with objectives of the course. **Power** point presentations for the head titles, definitions, graphs and many useful illustrations with summary at the end of each chapter will be presented and discussed.  **There** will be also classroom discussions and the lecture will cover enough information about the description of the **subjects**, solution of many **examples**, analysis and **derivation** for all necessary equations and **proving** theorems and many problems are presented as a home work for improving student abilities.  **Question Bank (Homework):** problems will be **solved** and **discussed** weekly to improve the student’s ability for understanding materials to let the chance for practicing on several aspects of the course in the classroom. |
| **14. Assessment scheme:**  Attaining the **requirements** set to succeed in this study subject requires developing a **mathematical** sense, related to this topic, based on emergent analytical and problem solving skills and memorizing topics cannot secure success.  In this system the **maximum** mark is **(100%)**. The grading system is based on the summation of two categories of **evaluations**: **First**, **(40%)** of the **mark** is based on the **academic** year effort of the student which includes:* **32%** for **two** semester examinations, (**16% X 2)** = **32%**, for each semester **16%**.
* **4%** for quizzes.
* **4%** for solving home works (Question Mark).

 **Second**, **(60%)** of the **mark** is based on **final** examination that is comprehensive for the whole of the study material **reviewed** during the academic **year** and it usually occurs during the month of **June**‌  At the **end** of the **evaluation** process, if the students could not **secure** a minimum of **(50%),** they are given a **chance** to **repeat** the **final** exam in **September** and they should be able by then to **equal** or **exceed** the **(50%)** limit otherwise they will have to **repeat** this **subject** during the **next** academic year if it did not **contradict** with the **administrative** regulations. |
| **15. Student learning outcome:** The due dates for submitting the homework assignments are one week from the date of assignment. No late submission will be accepted.Your problem solutions must include the detailed steps (not just the final answer):(**a**) A diagram, where appropriate,(**b**) Symbolic identification of the given and unknown quantities,(**c**) Identification of the definition, concept, or law used to solve the problem,(**d**) Algebraic solution of the problem.Important - correct final answer without the required steps will not be awarded full marks.Your work must be neat and well organized.Some organizational tips:- Write your name in capital letters, so that you will be credited for your    homework- If you use lined paper, use alternate lines. Otherwise, the work is too    cramped and difficult to read.- Write on one side of the paper only.- Start each problem on a new sheet of paper. This allows you to easily    amend your work and to not get stuck with the need to squeeze lots of    material into a small space. Allow for margins at the top, bottom and    sides of the page.- Number your pages and staple your work together prior to submission.Working in groups is a valuable way to learn physics, but the work you submit for grading must be your own. |
| **16. Course Reading List and References‌:**1. **"Lasers and their application"**, **1979**,by **M.J. Beesely**,London**.**
2. **Principles of lasers**, **1982**,by **O. Svelto plenum**,press New York**.**
3. **Laser physics**, **1983**,by **L.V. Tarasov MIR**,publishers, Moscow**.**
4. **Lasers principles and application**, **1987**,by **J. Wilson**,London**.**
5. **The laser guide book**, **1992**, by **Jeff Hecht**,second edition**.**
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| **17. The Topics:** | Dr. Runas Y.Sula |
| **Chapter One: Introduction****1 Weeks**  | **1.1: Historical Preview****1.2:1: Electromagnetic Radiation****1.2.2:**[**Electromagnetic Radiation in vacuum**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-1/F1s1t1p1.htm)**1.2.3:**[**Electromagnetic Radiation in Matter**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-1/F1s1t2p1.htm)**1:3: Refraction of Light Beam - Snell Law****1.4: Properties of Laser Radiation****1.5: Electromagnetic Wave Classification** |
| **Chapter Two:** [**Lasing Processes**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-2/F2s0p1.htm)**3 Weeks**  | **2.1: Bohr Model of the Atom****2.2: Photons and the Energy Diagrams** **2.3: Absorption of Electromagnetic Radiation****2.4: Decay Rate****2.5: Relative Population (**$\frac{N\_{2}}{N\_{1}}$**)****2.6: Population Inversion****2.7: Stimulated Emission****2.8: Rate Equations for Spontaneous Emission****2.9: Energy Level Diagram****2.10: Loss and Gain in Laser****2.11: Three Level System Laser****2.12: Four Level System Laser** |
| **Chapter Three:** [**Laser**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-2/F2s0p1.htm) **System****1 Weeks**  | **3.1: Introduction****3.2: The Laser Active Medium****3.3: The Excitation Mechanism****3.4: Feedback Mechanism****3.5: Output Coupler** |
| **Chapter Four: Optical Cavity and Laser Modes****3 Weeks**  | **4.1: Standing Waves in a Laser****4.2: Longitudinal Modes in a Laser****4.2.1: The Number of Longitudinal Optical Modes****4.2.2: Difference between Adjacent Longitudinal Modes****4.2.3: The importance of Longitudinal Optical Modes at the Output of the Laser****4.3: Transverse Modes of a Laser****4.3.1: Shape of Transverse Electromagnetic Modes****4.3.2: Control of the Transverse Modes of the Laser****4.3.3: Characteristics of the Basic Transverse Mode (TEM00) of the Laser****4.4: Optical Cavity****4.4.1 Specific Laser Optical Cavities****4.4.2: Stability Criterion of the Cavity** |
| **Chapter Five: Amplification in a Laser - Laser Gain****3 Weeks**  | **5.1: Fluorescence Line Shape of the Laser****5.2:** [**Amplification in a Closed Loop Path between the Mirrors of the Optical Cavity**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-5/F5s2p1.htm)**5.3: Summary of Chapter 5****5.4: Coherence of Light** |
| **Chapter Six: Laser Types and Their Characteristics****2 Weeks** | [**Laser Type’s Introduction**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s0p1.htm)[**6.1: Gas Lasers**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s1p1.htm)**:****6.1.1:**[**Helium-Neon Laser (He-Ne)**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s1t1p1.htm)**6.1.2:**[**Metal Vapor Laser (Copper, Gold)**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s1t2p1.htm)**6.1.3:**[**Helium Cadmium Laser (He-Cd)**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s1t3p1.htm)**6.1.4:**[**Argon Ion Laser (Ar+)**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s1t4p1.htm)**6.1.5:**[**Krypton Laser (Kr+)**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s1t5p1.htm)**6.1.6:**[**Carbon Dioxide Laser (CO2)**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s1t6p1.htm)**6.1.7:**[**Nitrogen Laser (N2)**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s1t7p1.htm)**6.1.8:**[**Excimer Laser**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s1t8p1.htm)**6.1.9:**[**Chemical Laser**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s1t9p1.htm)**6.1.10:**[**Far Infra-Red Laser (FIR)**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s1t10p1.htm)**6.2:**[**Solid State Lasers**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s2p1.htm)**:****6.2.1:**[**Ruby Laser**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s2t1p1.htm)**6.2.2: [Neodimium YAG and Nd Glass Laser](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s2t2p1.htm%22%20%5Ct%20%22_top)****6.2.3:**[**Alexandrite Laser**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s2t3p1.htm)**6.2.4: [Color Center Laser](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s2t4p1.htm%22%20%5Ct%20%22_top)****6.2.5:**[**Titanium Sapphire Laser**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s2t5p1.htm)**6.3:**[**Diode Lasers**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s3p1.htm)**6.4:**[**Dye Laser (Liquid)**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s4p1.htm)**6.5:**[**Special Lasers**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s5p1.htm)**6.5.1:**[**Free Electron Laser (FEL)**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s5t1p1.htm)**6.5.2:**[**X-Ray Laser**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-6/F6s5t2p1.htm) |
| **Chapter Seven: Laser Characteristics of Laser Radiation****3 Weeks** | **Laser Radiation Properties:****7.1: Radiometry and Measurement of Electromagnetic Radiation****7.2: Spatial Energy Distribution at the Laser Output** **7.3: Laser Beam Divergence and Focusing Capability****7.3.1: Divergence of Laser Beam (Beam Divergence )****7.3.2: Near Field and Far Field of a Laser Beam****7.3.3: Rayleigh Range****7.3.4: Diffraction through a Circular Hole****7.3.5: Fresnel Number****7.3.6: Beam Focusing****7.4:**[**Special Mechanisms for creating Pulses ("Q" switch and Mode Lock)**](https://perg.phys.ksu.edu/vqm/laserweb/Ch-7/F7s4p1.htm)**7.4.1: Q switched Lasers****7.4.2: Mode Locked Lasers****7.4.3: Summary of Periodic Laser Pulses** |
| **Chapter Eight: Laser Applications****2 Weeks** | **9.1: Industrial Applications****9.2: Medical Applications****9.3: Military Applications****9.4: Daily applications****9.5: Scientific/Research Applications****9.6: Special Applications** |
| **Chapter Nine: Laser Safety****2 Weeks** |  |
| **18. Practical Topics (If there is any)** | Not Exist |
| **19. Examinations:** Different types of questions will be provided to the student as an exercise and also in examinations such as given them in the question banks which contain each of the following ones:1. Mathematical **derivation** and **explanation** questions for different subjects in calculus are provided.
2. Mathematical **calculation questions** for different algebraic and analytical calculus subjects also given to them.
3. **Multiple** **choices** questions for every subject that are given in calculus topics are also provided to them.
4. Finally the **true** and **false** questions are also given to them for several mathematical subjects.

Each of these mentioned question types will be seen clearly in the question banks that are given to the quality assurance committee of our physics department.  |
| **20. Extra notes:** Due to a number of **unforeseen** reasons that may lead to the **shifting** of the academic year **program**, it may be subjected to **modifications**. Also extra **curriculum** hours may be **needed** to cover all the **topics** mentioned above. The students shall be **notified** of the **changes** if and when they may **occur**. |
| **21. Peer review**  |