



University of Al Ameer



Faculty of Health and Medical Technologies

Department of

Cosmetics and Laser Technologies

Laser Physics

Course Description

Course Information

Course Information				
Course Title	Laser Physics	Course Delivery		
Course Code		Method	H/Week	Frequency
Credits		Theory	2	15 weeks
Course Type	Quarterly	Online Lecture		
Course Level	1	Lab	2	15 weeks
Semester of Delivery	Second Semester	Tutorial		
Administering Department	Cosmetics and Laser Technologies	Practical		
Instructor	Dr. Hayder H. Al-Aaraji	Seminar		
Version Number		Faculty	Health and Medical Technologies	
		E-mail	hayder.aaraji@alameed.edu.iq	
		Scientific Committee Approval Date	Version Number	

Brief Description

Course Objective, Learning Outcomes and Indicative Contents

Course Objective	<ol style="list-style-type: none"> 1. Understand the nature of electromagnetic radiation, refraction, and laser properties. 2. Learn lasing processes, including photon interactions, population inversion, and amplification. 3. Differentiate laser types (e.g., gas lasers) and their excitation mechanisms. 4. Analyze laser system components, operation principles, and radiation control methods. 5. Apply laser physics to cosmetology and medical treatments while ensuring safe usage.
Course Learning Outcomes	<p style="background-color: yellow;">/*Important: Write at least 6 Learning Outcomes, better to be equal to the number of study weeks. MUST be SMART (Specific, Measurable, Achievable, Relevant, and Time-bound)*/</p> <ol style="list-style-type: none"> 1: Explain the fundamental principles of electromagnetic radiation, wave propagation, reflection, and refraction, and correctly solve related conceptual and numerical problems with at least 70% accuracy by the end of Week 2. 2: Describe the physical properties of laser radiation and distinguish them from ordinary light sources by identifying coherence, monochromaticity, directionality, and intensity characteristics by the end of Week 4. 3: Analyze laser generation processes, including stimulated absorption, spontaneous emission, stimulated emission, population inversion, and optical amplification, and accurately interpret related energy-level diagrams by the end of Week 6. 4: Compare major laser types, particularly gas lasers and solid-state lasers, and evaluate their excitation mechanisms, operational characteristics, and practical applications through written assignments and examinations by the end of Week 8. 5: Evaluate the functions of key laser system components, including the active medium, pumping source, optical resonator, and beam-control devices, and explain their roles in laser operation by the end of Week 10. 6: Apply laser physics principles to cosmetology and medical technologies by selecting appropriate laser parameters, identifying potential hazards, and recommending safe operating procedures in case-based assessments by the end of Week 12.
Indicative Contents	<p>Theory Lectures</p> <p style="background-color: yellow;">/*Learning concepts of each theoretical lecture or groups of lectures. [Reference]*/</p>

Lecture 1: Electromagnetic Radiation in Vacuum and Matter

Reference: Silfvast, W. T. Laser Fundamentals, 2nd Edition, Cambridge University Press.

- Nature and characteristics of electromagnetic radiation.
- Propagation of electromagnetic waves in vacuum.
- Interaction of electromagnetic radiation with matter.

Lecture 2: Refraction of Light Beam – Snell's Law

Reference: Hecht, E. Optics, 5th Edition, Pearson.

- Refractive index and optical media.
- Snell's Law and light propagation across interfaces.
- Applications of refraction in optical systems.

Lecture 3: Properties of Laser Radiation

Reference: Siegman, A. E. Lasers, University Science Books.

- Monochromaticity of laser light.
- Coherence and directionality.
- Brightness and low beam divergence.

Lecture 4: Lasing Processes and Atomic Models

Reference: Silfvast, W. T. Laser Fundamentals, 2nd Edition.

- Bohr model of the atom.
- Photon concept and energy quantization.
- Atomic energy-level diagrams.

Lecture 5: Absorption and Spontaneous Emission

Reference: Svelto, O. Principles of Lasers, 5th Edition.

- Absorption of electromagnetic radiation.
- Mechanism of spontaneous emission.
- Relationship between atomic transitions and radiation.

Lecture 6: Population Inversion and Amplification

Reference: Svelto, O. Principles of Lasers, 5th Edition.

- Decay rate and excited-state lifetime.
- Population at thermodynamic equilibrium.
- Population inversion, stimulated emission, and optical amplification.

Lecture 7: Three-Level and Four-Level Lasers

Reference: Silfvast, W. T. Laser Fundamentals, 2nd Edition.

- Structure of three-level laser systems.
- Structure of four-level laser systems.
- Comparison of efficiency and operation between both systems.

Lecture 8: Components of the Laser System

Reference: Siegman, A. E. Lasers.

- Laser active medium and its characteristics.
- Excitation mechanisms and atomic collisions.
- Feedback mechanism and output coupler functions.

Lecture 9: Operation of a Laser System

Reference: Svelto, O. Principles of Lasers, 5th Edition.

- Laser gain and amplification process.
- Fluorescence line shape and linewidth.
- Factors affecting laser performance.

Lecture 10: Gain Curves and Loop Gain Calculations

Reference: Siegman, A. E. Lasers.

- Gain curve and fluorescence line broadening.
- Loop gain calculations with and without losses.
- Threshold gain requirements for laser oscillation.

Lecture 11: Continuous-Wave and Pulsed Lasers

Reference: Silfvast, W. T. Laser Fundamentals, 2nd Edition.

- Saturation gain in continuous-wave lasers.
- Principles of pulsed laser operation.
- Comparison between CW and pulsed laser systems.

Lecture 12: Gas Lasers and Laser Resonators

Reference: Svelto, O. Principles of Lasers, 5th Edition.

- Types and characteristics of gas lasers.
- Excitation methods and classification of gas lasers.
- Common laser resonators and selective mirror coatings.

Lecture 13: Control of Laser Radiation Properties

Reference: Hecht, E. Optics, 5th Edition.

- Methods for controlling laser radiation properties.
- Resonator design and mode selection.
- Selective cavity mirror coatings and beam optimization.

Learning and Teaching Strategies

Strategies

- 1- Interactive lectures to explain fundamental concepts of laser physics and electromagnetic radiation.
- 2- Problem-solving sessions to develop analytical and quantitative skills related to laser systems.
- 3- Multimedia presentations and simulations to illustrate laser operation and optical phenomena.
- 4- Guided discussions and question-and-answer activities to enhance student engagement and critical thinking.
- 5- Formative assessments, quizzes, and assignments to monitor student progress and understanding.

Course Evaluation

		Time Number	Weight (Marks)	Week Due															Relevant Learning Outcome										
				W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	LO1	LO2	LO3	LO4	LO5	LO6	LO7	LO8	LO9	LO10	
Formative	Quizzes	4	5%	●				●				●			●			●	●		●								
	Report	-	-																										
	Lab Report	12	15%		●	●	●	●	●	●		●	●	●	●	●		●	●	●	●	●	●						
	Project	-	-																										
	Online Assig.	-	-																										
	Onsite Assig.	3	20%				●				●			●				●	●	●	●	●	●						
	Seminar	-	-																										
Summative	Mid. Exam T	1	25%							●							●	●	●	●	●	●							
	Mid. Exam L	1	15%							●							●	●	●	●	●	●							
	Mid. Exam P	-	-																										
	Final Exam T	1	35%	Week 16															●	●	●	●	●	●					
	Final Exam L	1	25%																●	●	●	●	●	●					
	Final Exam P	-	-																										
Total assessment			100%																										

Delivery Plan (Weekly Syllabus)

	Material Covered
Week 1	Electromagnetic Radiation, Electromagnetic Radiation in Matter. Electromagnetic Radiation in vacuum
Week 2	Refraction of Light Beam - Snell Law:
Week 3	Properties of Laser Radiation, Monochromaticity. Directionality Coherence,.
Week 4	low divergent angle ,brightness
Week 5	Lasing processes, Bohr model of the atom, Photons and the energy diagrams,
Week 6	Absorption of electromagnetic Radiation Spontaneous emission of electromagnetic Radiation,
Week 7	Decay Rate, Population at Thermodynamic Equilibrium Population Inversion, Stimulated Emission , Amplification
Week 8	Three Level Laser, Four Level Laser
Week 9	The Laser System, The laser active medium: The excitation mechanism , Collisions with atoms, Feedback Mechanism, Output Coupler
Week 10	Operation of a Laser System - Interactive Applets: Laser Gain Fluorescence line shape of the laser, Fluorescence Linewidth.
Week 11	Laser Gain Curve Broadening the Fluorescence line, Loop Gain, Calculating Loop Gain (G_L) Without Losses, Calculating Loop Gain (G_L) With Losses,
Week 12	Calculating Gain Threshold (G_L) _{th} , Saturation Gain in a Continuous Wave Laser, Pulsed Laser
Week 13	Different Laser Types and their Characteristics, Gas Lasers, Excitation of a gas laser , Groups of Gas Lasers, Controlling the laser radiation properties, Some Common Laser Resonators. Selective coating on the cavity mirrors.
Week 14	Controlling the laser radiation properties, Some Common Laser Resonators. Selective coating on the cavity mirrors
Week 15	The end of the second course exam

Delivery Plan (Weekly Lab. Syllabus)

Delivery Plan (Weekly Lab. Syllabus)	
	Material Covered
Week 1	<p>Introduction to Laboratory Safety and Equipment</p> <ul style="list-style-type: none"> • Overview of laser safety regulations • Proper handling of laser devices and optical instruments • Laboratory safety procedures and emergency protocols
Week 2	<p>Electromagnetic Radiation and Light Behavior</p> <ul style="list-style-type: none"> • Observing light propagation in different media • Measuring refraction using Snell's Law • Demonstrating total internal reflection
Week 3	<p>Properties of Laser Radiation</p> <ul style="list-style-type: none"> • Experimenting with laser coherence and monochromaticity • Measuring laser beam divergence • Analyzing laser brightness and intensity distribution
Week 4	<p>Understanding Lasing Processes</p> <ul style="list-style-type: none"> • Demonstrating photon absorption and emission • Visualizing population inversion using simulated models • Measuring spontaneous and stimulated emission rates
Week 5	<p>Laser Gain and Amplification</p> <ul style="list-style-type: none"> • Understanding laser amplification through practical setup • Measuring gain in different laser media • Observing the effects of population inversion on laser operation
Week 6	<p>Three-Level and Four-Level Laser Systems</p> <ul style="list-style-type: none"> • Comparative study of three-level vs. four-level laser systems • Demonstration of energy level transitions in a practical setup • Measuring output efficiency of different laser types

Week 7	<p>Laser Active Medium and Excitation Mechanisms</p> <ul style="list-style-type: none"> • Investigating the behavior of various laser active media • Demonstrating different excitation techniques (optical, electrical) • Studying collisions with atoms in the laser medium
Week 8	<p>Laser Feedback Mechanisms and Resonators</p> <ul style="list-style-type: none"> • Exploring the function of cavity mirrors in laser systems • Measuring reflection and transmission of laser beams • Demonstrating selective coatings on resonator mirrors
Week 9	<p>Laser Gain and Line Shape Measurement</p> <ul style="list-style-type: none"> • Measuring fluorescence linewidth of a laser • Observing spectral broadening in different laser media • Analyzing the gain curve of laser systems
Week 10	<p>Laser Output Control and Threshold Calculations</p> <ul style="list-style-type: none"> • Calculating loop gain with and without losses • Determining gain threshold for laser operation • Experimenting with saturation gain in CW and pulsed lasers
Week 11	<p>Different Types of Lasers and Their Characteristics</p> <ul style="list-style-type: none"> • Practical demonstration of gas, solid-state, and semiconductor lasers • Measuring the emission spectra of different laser types • Comparing efficiency and application of various laser systems
Week 12	<p>Pulsed and Continuous-Wave Laser Systems</p> <ul style="list-style-type: none"> • Experimenting with pulsed laser generation techniques • Observing the effect of pulse duration on laser output • Measuring power variations in CW vs. pulsed lasers
Week 13	<p>Controlling Laser Radiation Properties</p> <ul style="list-style-type: none"> • Demonstrating beam shaping and focusing techniques • Experimenting with power modulation and beam stability • Implementing different methods for controlling laser output
Week 14	<p>Laser Applications in Cosmetology and Medical Fields</p> <ul style="list-style-type: none"> • Hands-on demonstration of laser-tissue interaction • Observing laser effects on different skin and tissue models • Understanding practical aspects of laser hair removal and skin treatments
Week 15	<p>Final Project and Practical Examination</p> <ul style="list-style-type: none"> • Conducting a laser system performance analysis • Applying acquired knowledge to a real-world laser application <p>Practical assessment and review session</p>

Learning and Teaching Resources

	Title or Address	Available in the Library?
Required Texts	Silfvast, W. T. Laser Fundamentals, 2nd Edition, Cambridge University Press.	Yes
	Hecht, E. Optics, 5th Edition, Pearson.	Yes
	Siegman, A. E. Lasers, University Science Books.	Yes
	Svelto, O. Principles of Lasers, 5th Edition.	Yes
Recommended Texts	Dr. Hayder H. Al-Aaraji. Given Lectures, 2026.	No
	Dr. Hayder H. Al-Aaraji. Given Lectures, 2026.	No
	Dr. Hayder H. Al-Aaraji. Given Lectures, 2026.	No
	Dr. Hayder H. Al-Aaraji. Given Lectures, 2026.	No
Websites	https://www.youtube.com/watch?v=KiJi8yqB_Rg	
	https://www.youtube.com/watch?v=btNvr8KAQyM	
	https://www.nature.com/articles/s41598-021-83701-3	
	https://www.youtube.com/watch?v=ovT8IRAkFME	
	https://www.youtube.com/watch?v=FBK_3t0HsU4	

Grade Policy

Class Participation	Required/ Done
Quizzes	Required/ Done
Report	
Lab Report	Required/ Done
Project	
Online Assig.	
Onsite Assig.	Required/ Done
Seminar	
Mid. Exam Theory	Required/ Done
Mid. Exam Lab.	Required/ Done
Mid. Exam Practical	
Final Exam Theory	Required/ Done
Final Exam Lab.	Required/ Done
Final Exam Practical	

Grading Scheme

Group	Grade	التقدير	Marks %
Success Group (50 - 100)	A – Excellent	امتياز	90 - 100
	B - Very Good	جيد جدا	80 - 89
	C - Good	جيد	70 - 79
	D - Satisfactory	متوسط	60 - 69
	P - Pass	مقبول	50 - 59
Fail Group (0 – 49)	Conditional Pass	راسب (قيد القرار)	(45-49)
	F – Fail	راسب	(0-44)

University Policy
