PHY8254: FUNDAMENTALS OF LASER OPTICS

Effective Term
Semester B 2024/25

Part I Course Overview

Course Title
Fundamentals of Laser Optics

Subject Code
PHY - Physics
Course Number
8254

Academic Unit
Physics (PHY)

College/School
SE

Course Duration
One Semester

Credit Units
3

Level
R8 - Research Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Advanced level course in electromagnetism - PHY3205 or equivalent

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
PHY6254 Fundamentals of Laser Optics

Part II Course Details

Abstract
This course aims at providing students with fundamental knowledge on laser devices and systems. After completing the course, students should be able to understand the basic structures and working principles of laser devices. They will be able

to operate simple laser systems. Students will also learn to select the appropriate types of lasers for innovatively solving practical problems as well as assess the effectiveness and cost/performance merits of various laser systems.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Calculate light characteristics based on EM wave and photons; control them by various effects; interpret atomic and molecular spectra.			x	
2	Evaluate lasers according to several criteria; adopt suitable measures for protection of human health; survey various laser applications.			x	
3	Compute important characteristics of laser systems.			x	
4	Innovatively modify some laser properties; apply gas lasers.			x	
5	Identify state-of-the-art developments in the relevant area and to form opinions on specific issues, and participate in discovery and innovation.		x	x	

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1		Explain key concepts, provide examples and solutions of common problems in laser optics	1, 2, 3, 4	3hr/wk
2		Hands-on demonstration of principle taught in classes	2, 4	0.5hr/wk

Additional Information for LTAs

Scheduled activities: 2 hrs lecture + 1 hr tutorial or 3 hrs studio

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Assignment	1, 2, 3, 4	20	
2	Project presentation & term paper	2	15	
3	Midterm exam	5	15	

Continuous Assessment (%)

50

Examination (%)

50

Examination Duration (Hours)

2

Minimum Continuous Assessment Passing Requirement (%)

0

Minimum Examination Passing Requirement (%)

0

Assessment Rubrics (AR)

Assessment Task

Assignment (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Capable to show a good understanding of the taught materials from solving the given problems.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not given enough efforts or unable to grasp the basic concept.

Assessment Task

Term paper and presentation (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Ability to carry out a literature search and understand

Excellent

(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not given enough efforts or unable to grasp the basic concept.

Assessment Task
Midterm (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
Ability to solve common laser optics problems.

Excellent
(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not given enough efforts or unable to grasp the basic concept.

Assessment Task
Exam (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
Ability to grasp the concept of the taught materials and to solve common laser optics problems.

Excellent
(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not given enough efforts or unable to grasp the basic concept.

Assessment Task
Assignment (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
Capabletoshowagood understanding of the taught materials from solving the given problems.

Excellent
(A+, A, A-) High

Good
(B+, B) Significant

Marginal
(B-, C+, C) Basic

Failure
(F) Not given enough efforts or unable to grasp the basic concept.

Assessment Task
Term paper and presentation (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
Ability to carry out a literature search and understand

Excellent
(A+, A, A-) High

Good
(B+, B) Significant

Marginal
(B-, C+, C) Basic

Failure
(F) Notgivenenough efforts or unable to grasp the basic concept.

Assessment Task
Midterm (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
Ability to solve common laser optics problems.

Excellent
(A+, A, A-) High

Good
(B+, B) Significant

Marginal
(B-, C+, C) Basic

Failure
(F) Notgivenenough efforts or unable to grasp the basic concept.

Assessment Task
Exam (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
Ability to grasp the concept of the taught materials and to solve common laser optics problems.

Excellent
(A+, A, A-) High

Good
(B+, B) Significant

Marginal
(B-, C+, C) Basic

Failure
(F) Not given enough efforts or unable to grasp the basic concept.

Part III Other Information

Keyword Syllabus
- Review the EM theory of light, specifications of light, Maxwell equations, reflection and transmission, polarization, interference and diffraction, magneto-optic and electro-optic effects.
- Light sources and spectra, luminescence, blackbody radiation, hydrogen spectra and the Bohr model, spectra of emission, absorption and scattering.
- Spectra of atoms, molecules and solids, quantum numbers.
- Laser operation modes. Laser characteristics. Applications. Safety.
- Stimulated emission and population inversion. Threshold condition.
- Oscillation and resonance cavity. Q-factor and gain. Cavity lifetime.
- Multiple interference and Fabry-Perot interferometer. The Airy function. Chromatic resolving power. Fabry-Perot laser and threshold gain. Stable cavity.
- Beam modes Longitudinal and transverse. Gaussian bean and beam characteristics. Focus spot size and depth.
- Diode lasers and its applications. Heterojunction design for confinement of injected carriers and light.
- Three-level and four-level lasers. Ruby laser and Nd:YAG laser, their applications, transparent power.
- Fiber lasers principle and applications.
- Principles of mode-locking and Q-switching lasers.

Reading List

Compulsory Readings

	Title
1	Nil

Additional Readings

	Title
1	Kenneth A Jones, “Introduction to Optical Electronics”, (John Wiley 1987).
2	J Wilson and J Hawkes, “Optoelectronics”, (Prentice Hall 1998).
3	J T Verdeyen, “Laser Electronics” (Prentice Hall 1995).