PHY4254: FUNDAMENTALS OF LASER OPTICS

Effective Term
Semester A 2022/23

Part I Course Overview

Course Title
Fundamentals of Laser Optics

Subject Code
PHY - Physics
Course Number
4254

Academic Unit
Physics (PHY)

College/School
College of Science (SI)

Course Duration
One Semester

Credit Units
3

Level
B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
AP3205/PHY3205 Electromagnetism

Precursors
AP3204/PHY3204 Waves and Optics

Equivalent Courses
AP4254 Fundamentals of Laser Optics

Exclusive Courses
Nil

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 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	Modify some laser properties; apply gas lasers.		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.

Teaching and Learning Activities (TLAs)

	TLAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures/Student Centred Activities/ Miniprojects	Explain key concepts, provide examples and solutions of common problems in laser optics	1, 2, 3, 4	3 hours/week
2	Class Demonstration	Hands-on demonstration of principle taught in classes	2, 4	0.5 hour/week

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Assignments	1, 2, 3, 4	15	
2	Test	1, 2, 3, 4	15	

Continuous Assessment (%)

30

Examination (%)

70

Examination Duration (Hours)
2

Additional Information for ATs
For a student to pass the course, at least 30% of the maximum mark for the examination must be obtained

Assessment Rubrics (AR)

Assessment Task
1. Assignments

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
2. Test

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
3. Examination

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.

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.
- He-Ne laser, engineering problems. CO2 laser and various designs. Applica-tions.

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).