City University of Hong Kong
Course Syllabus

offered by Department of Physics
with effect from Semester A 2022/23

Part I Course Overview

Course Title:

Fundamentals of Laser Optics

Course Code:

PHY8254

Course Duration:

One Semester

Credit Units:

3

Level:

R8

Medium of Instruction:

English

Medium of Assessment:

English

Prerequisites:
(Course Code and Title)

Advanced level course in electromagnetism – PHY3205 or equivalent

Precursors:
(Course Code and Title)

Nil

Equivalent Courses:
(Course Code and Title)

Nil

Exclusive Courses:
(Course Code and Title)

PHY6254 Fundamentals of Laser Optics

Part II Course Details

1. **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.

2. Course Intended Learning Outcomes (CILOs)

No.	CILOs	Weighting* (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
1.	Calculate light characteristics based on EM wave and photons; control them by various effects; interpret atomic and molecular spectra.			✓	
2.	Evaluate lasers according to several criteria; adopt suitable measures for protection of human health; survey various laser applications.			✓	
3.	Compute important characteristics of laser systems.			✓	
4.	Innovatively modify some laser properties; apply gas lasers.			✓	
5.	Identify state-of-the-art developments in the relevant area and to form opinions on specific issues, and participate in discovery and innovation.		✓	✓	
		100%			

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 self-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.

3. Teaching and Learning Activities (TLAs)

TLA	Brief Description	CILO No.					Hours/week (if applicable)
		1	2	3	4	5	
1	Explain key concepts, provide examples and solutions of common problems in laser optics	✔	✔	✔	✔		3hr/wk
2	Hands-on demonstration of principle taught in classes		✔		✔		0.5hr/wk

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

4. Assessment Tasks/Activities (ATs)

Assessment Tasks/Activities	CILO No.					Weighting*	Remarks
	1	2	3	4	5		
Continuous Assessment: 50%							
Assignment	✔	✔	✔	✔		20%	
Project presentation & term paper		✔				15%	
Midterm exam					✔	15%	
Examination (duration: 2 hrs)	✔	✔	✔	✔	✔	50%	
						100%	

5. Assessment Rubrics

Applicable to students admitted in Semester A 2022/23 and thereafter

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-, C+, C)	Failure (F)
1. Assignment	Capable to show a good understanding of the taught materials from solving the given problems.	High	Significant	Basic	Not given enough efforts or unable to grasp the basic concept.
2. Term paper and presentation	Ability to carry out a literature search and understand	High	Significant	Basic	Not given enough efforts or unable to grasp the basic concept.
3. Midterm	Ability to solve common laser optics problems.	High	Significant	Basic	Not given enough efforts or unable to grasp the basic concept.
4. Exam	Ability to grasp the concept of the taught materials and to solve common laser optics problems.	High	Significant	Basic	Not given enough efforts or unable to grasp the basic concept.

Applicable to students admitted before Semester A 2022/23

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Assignment	Capable to show a good understanding of the taught materials from solving the given problems.	High	Significant	Moderate	Basic	Not given enough efforts or unable to grasp the basic concept.
2. Term paper and presentation	Ability to carry out a literature search and understand	High	Significant	Moderate	Basic	Not given enough efforts or unable to grasp the basic concept.
3. Midterm	Ability to solve common laser optics problems.	High	Significant	Moderate	Basic	Not given enough efforts or unable to grasp the basic concept.

4. Exam	Ability to grasp the concept of the taught materials and to solve common laser optics problems.	High	Significant	Moderate	Basic	Not given enough efforts or unable to grasp the basic concept.

Part III Other Information

1. 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.

2. Reading List

2.1 Compulsory Readings

1.	
2.	
3.	
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2.2 Additional Readings

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).