

PHY 4440 Laser Principles and Applications

Course Description

This course provides an exposition of the basic principles as well as the applied aspects of laser. Topics covered include: electromagnetic theory, ray tracing in optical systems, propagation of laser beams, resonant cavities, laser oscillators and amplifiers, quantum treatment of two-level system, and laser applications. Students are advised to take PHY 3041 and 3202 or 3402, or their equivalents before taking this course. Prerequisite: permission of the instructor.

Course Content

	Topics	Highlights of Fundamental Concepts
1.	Fundamental of electromagnetic theory	Maxwell's equations, wave equation for free space, waves in dielectrics, spreading of an electromagnetic beam.
2.	Ray tracing in optical systems	Ray matrix, ray tracing in optical cavities, stability diagram.
3.	Gaussian beams	TEM waves, lowest order TEM_{00} mode, higher order modes, Gaussian beams in continuous media; the dielectric slab waveguide, modes in a step-index fiber, fiber-optic waveguide, dispersion in fibers.
4.	Resonant optical cavity	Gaussian beam in simple stable resonators, application of ABCD law of cavities, resonance, sharpness of resonance, photon life time, diffraction losses.
5.	Atomic radiation	Black body radiation theory, Einstein's A and B coefficients, rate equation approach, line shape, transition rate for monochromatic waves, amplification by an atomic system.
6.	Laser oscillation and amplification	Oscillation threshold, oscillation and amplification in a homogeneous broadened transition, oscillation in an inhomogeneous broadened system.
7.	Excitation mechanisms	3-level and 4-level systems, optical pumping, solid state and liquid state lasers, gaseous discharge lasers, excimer lasers, chemical lasers, free electron lasers, semiconductor lasers.
8.	Semi-classical theory of the laser	Time dependent Schrödinger equation, two state quantum system, density matrix and collisional relaxation, optical Bloch equation.
9.	Laser applications	Nonlinear laser spectroscopy, laser material processing, Lidar in remote sensing and current topics in laser applications.

Learning Outcomes

1.	Students will acquire the basic principle of lasers.
2.	Students will acquire the applications of lasers in different areas.
3.	Students should understand how to use the quantum and electromagnetics theories in explaining the basic of lasers. In addition, they should appreciate the correlation between these two theories.

Learning Activities

Lecture		Tutorial		Exercise Class and Assignment		Laboratory		Project / Report		Presentation		Case study		Web teaching		Other 1 (specify)		Other 2 (specify)	
(hr / week)		(hr / week)		(hr / week)		(hr / week)		(hr in total)		(hr in total)		(hr in total)		(hr / week)		(hr in total)		(hr in total)	
in class	out class	in class	out class	in class	out class	in class	out class	in class	out class	in class	out class	in class	out class	in class	out class	in class	out class	in class	out class
2.25	2	0.75	1	0.75	3														
M	M	M	M	M	M	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

M: Mandatory activity in the course O: Optional activity NA: Not applicable

Assessment Scheme

	Component	Description	Weight
1.	Homework	The homework will be graded by the TAs and the graded homework will be returned to you. If you have enquiries concerning the grading, please feel free to contact me or the TAs.	10%
2.	Quiz	The quiz will be graded by the TAs and the graded quiz will be returned to you. If you have enquiries concerning the grading, please feel free to contact me or the TAs.	25%
3.	Mid-term Examination	The schedule and venue of the mid-term examination will be announced later.	25%
4.	Final Examination	The final examination will be centrally arranged by the university.	40%

Learning Resources

	Resource	Web link or ref no. in library
1.	J T Verdeyen, "Laser Electronics", 2nd ed, Prentice-Hall, 1989	TA1675.V47 1989
2.	W Duley, "Laser Processing and Analysis of Materials", Plenum Press, 1983	TA1677.D84
3.	A Yariv, "Introduction to Optical Electronics", Holt, Rinehart and Winston, 1971	QC454 .D46 1996
4.	A Yariv, "Introduction to Optical Electronics", Holt, Rinehart and Winston, 1971	TK7871.3 .Y35
5.	P W Milonni and J H Eberly, "Lasers", Wiley, 1988	QC688.M55

Feedback for Evaluation

1.	Send email to the teacher, give him a call, or come to his office, especially for issues that require immediate action;
2.	express your views in the mid-term and term-end course evaluation;
3.	express your views (or ask a student representative to help you convey the messages) in the staff-student consultation meeting held every year;
4.	post a message on the forum of the course website.

Course Schedule

	Topics	Week No.	Activities / Readings / References
1.	Fundamental of electromagnetic theory	1	
2.	Ray tracing in optical systems	2	
3.	Gaussian beams	3-4	
4.	Resonant optical cavity	4-5	
5.	Atomic radiation	5-6	
6.	Laser oscillation and amplification	6-7	
7.	Excitation mechanisms	8-9	
8.	Semi-classical theory of the laser	9-10	
9.		10-13	

Teachers' or TAs' Contact Details

Teacher's Name	Contact	Additional Information
ONG Hock Chun, Daniel	Office : SC G10 Tel. no. : 2609 6324 Email : hcong@phy.cuhk.edu.hk	<ul style="list-style-type: none">•••
TA's Name	Contact	Additional Information
		<ul style="list-style-type: none">• To be arranged

Academic Honesty and Plagiarism

Attention is drawn to University policy and regulations on honesty in academic work, and to the disciplinary guidelines and procedures applicable to breaches of such policy and regulations. Details can be found at <http://www.cuhk.edu.hk/policy/academichonesty/>.

1.	After the course registration, you are required to submit "Declaration of Honesty in Academic Work" declaring that you are aware of these policies, regulations and procedures. The form can be found at http://www.phy.cuhk.edu.hk/ .
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Facilities for Posting Announcements and Materials

1.	The course website (http://www.phy.cuhk.edu.hk/course/2009-2010/1/phy4440) contains the following useful information and resources: (a) All course materials, including lecture notes, homework, quiz, solution and supplementaries. The password for download will be given to you in the first lecture. (b) A notice board for announcements of assignments, latest download, and important events (e.g. quiz, examination, etc). (c) A web forum for you to ask questions, discuss problems with teachers and classmates. You are also welcome to express your comments on the course in the forum.
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