Course Syllabus

PHOT 301 Quantum Photonics

2024-2025 Summer

Instructor

Dr. Michaël Barbier

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Office: door on the right of Z5

Office hours: 9:00 – 17:00 (via appointment)

Course Schedule

Thursday	09:45 – 16:15	F-building, D5
Friday	13:30 – 16:15	F-building, D5

Course Fundamentals

Course Description

This course introduces the fundamental concepts of quantum mechanics within the context of photonics. We will start by introducing Schrödinger's equation and the basic quantum mechanics formalism. Thereafter we will apply it to standard problems and learn how to calculate eigenvalues and eigenfunctions. Specifically, we will look at problems such as the hydrogen atom, harmonic oscillator, 1D barriers and quantum wells, and two-level systems in an electromagnetic field. After having a good understanding of interaction with light, the concepts of stimulated emission, spontaneous emission, and optical absorption will be introduced.

Course Objectives (Learning Outcomes)

At the end of the course, you should be able to:

1. Solve Schrödinger's equation for simple one-dimensional systems and interpret the results.
2. Understand the fundamental postulates of quantum mechanics.
3. Describe the formalism, commutator relations, and conservation laws.
4. Calculate eigenvalues and eigenfunctions for a given system.
5. Understand how to solve time-dependent quantum mechanical problems
6. Understand the different approaches to approximate solutions: perturbation theory, finite basis method, tight binding method, the variational method, etc.
7. Identifying the mechanisms behind absorption, emission and photo detection

Prerequisites

MATH 141 and MATH 142 are prerequisites for this course. Having passed the PHOT 222 course (or a similar course) is not required but highly recommended.

Textbooks

Course Textbook:

D.J. Griffiths, **Introduction to Quantum Mechanics**, 3rd edition, Pearson

Supplementary Materials:

D.A.B. Miller, **Quantum Mechanics for Scientists and Engineers**, Cambridge

C.C. Gerry and P.L. Knight, **Introductory Quantum Optics**, Cambridge

Course materials available on the **personal webpage** of D.A.B Miller

QuVis: Web site with quantum mechanics visualizations and simulations for educational purposes

QuTip: Computational library for quantum mechanical simulations in Python

Applet(s) by Paul Falstad for 1D quantum systems (many other science related educational applets can be found on www.falstad.com/)

Course website and announcements

You will find all announcements relevant to the course (homework, grades, etc.) on MS-Teams. Some course materials will also be made available via Michaël Barbier's webpage. Syllabus and course schedule may be subject to change during the semester.

Class structure

The course material will be presented on the whiteboard and on the screen. All lecture notes and class materials can be reached from Teams.

Course schedule (tentative)

Week 1	Introduction & Required Mathematical Methods. Waves and Schrödinger's equation, Probability, Uncertainty and Time evolution, Infinite square well.
Week 2	The harmonic oscillator, Creation and annihilation operators. Free particle, 1D Bound states & Scattering/Transmission, Finite well

Week 3	Quantum mechanics formalism: Functions and operators, uncertainty. Approximation methods.
Week 4	Angular momentum and the Hydrogen atom, Spin Magnetic fields, The Pauli equation, Minimal Coupling, Aharonov Bohm Perturbation: Fine Structure of Hydrogen, The Zeeman Effect
Week 5	Identical particles, Periodic table, Molecular bonds, Periodic structures, Band structure, Bloch functions Time-dependent perturbation: Absorption, spontaneous emission, and stimulated emission
Week 6	Final exam

Course Policies

Attendance and class behavior

Students who attend the lecture are expected to actively participate (in listening, taking notes, understanding, problem solving sessions, etc.).

Homework assignments

Non-graded homework will be assigned every week. These can be performed with help from others (fellow students, course instructors, etc.) and will not influence the grade. The purpose of the homework is for individual students to understand what type of questions he/she might expect on the quiz/exam.

Quizzes

Every week one quiz will be given during specific lectures listed below.

Examinations and Grading

The final exam is closed-book and exists out of open questions and problems which can be answered using pen and paper. Your grade is based on the scores of the quizzes and the final exam. If you miss one of the quizzes without a valid excuse, a zero will be averaged into your grade. If you have a valid excuse (i.e., an official certified medical report), the weight of the other quizzes will be increased to compensate for that.

Your final grade is the weighted average of your quizzes and final exam grades, according to the following weights:

- Total of 4 quizzes: 30 %
- Final exam: 70 %

Examination Dates (tentative)

Quiz 1: Friday 25.07.2025

Quiz 2: Friday 01.08.2025

Quiz 3: Friday 08.08.2025

Quiz 4: Friday 15.08.2025

Final exam (all topics): Friday 22.08.2025

Disabilities

Students with certified disabilities requiring special accommodation are urged to contact the instructor at the beginning of the course so that suitable arrangements may be made.

Academic Integrity

Students who violate University rules on academic dishonesty are subject to disciplinary penalties, including the possibility of failure in the course and/or suspension from the University. Forms of academic dishonesty include cheating on exams or quizzes, use of unauthorized materials for exams, and changing solutions to returned exams.