Course Syllabus

PHOT 301 Quantum Photonics

2024 Fall

Instructor

Dr. Michaël Barbier

e-mail: michaelbarbier@iyte.edu.tr

Office: door on the right of Z5

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

Teaching Assistants

Yağız Oyun

e-mail: yagizoyun@iyte.edu.tr

Office: Z9B

Office hours: TBA

Course Schedule

Tuesday	13:30 – 15:15	F-building, D2
Friday	13:30 – 15:15	F-building, D2

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 the quantization of the electromagnetic field (photons). After having a good understanding of quantization of 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**, Pearson

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

Supplementary Materials:

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

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	Waves and Schrödinger's equation
Week 2	Time-dependent Schrödinger's equation
Week 3	Quantum mechanics formalism: Functions and operators
Week 4	Approximation methods
Week 5	Approximation methods (Cont'd)
Week 6	Periodic structures, Band structure, Bloch functions
Week 7	Midterm exam
Week 8	Methods for one-dimensional problems: Transmission, bound states
Week 9	Angular momentum and Hydrogen atom
Week 10	Spin
Week 11	Identical particles
Week 12	The density matrix
Week 13	Harmonic oscillators and photons
Week 14	Absorption, spontaneous emission, and stimulated emission
Week 15	Final exam
Week 16	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

Individual projects will be assigned during the term. These can be performed with help from others (fellow students, course instructors, etc.), but the solutions should have unique reports. Homework solutions/reports can be uploaded to Teams on the indicated due date until 23.59.

Late homework may be turned in, but 25 points will be deducted from the full score (100 points) for each day that it is late.

Quizzes

Non-graded quizzes can be given during specific lectures (TBA), these do not influence your grades and scores will only be given to the individual students for him/her to understand what type of questions he/she might expect on the exam.

Examinations and Grading

You will have one midterm exam and a final exam. The exams are closed book and exist out of open questions and problems which can be answered using pen and paper. If you miss one of the exams 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), you will receive a make-up exam at the end of the semester.

Your final grade is the weighted average of your projects, midterm and final exam grades, according to following weights (tentative):

- Projects: 40 %
- Midterm exam: 10 %
- Final exam: 50 %

Examination Dates (tentative)

TBA

Disabilities

Students with certified disabilities requiring special accommodation are urged to contact the instructor at the beginning of the semester 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 copying the reports of homework assignments (from a fellow student or internet), cheating on exams, use of unauthorized materials for exams, and changing solutions to returned assignments and exams.