Course Syllabus

PHOT 411 Numerical Methods for Photonics

2025 Spring

Instructor

Dr. Michaël Barbier

e-mail: michaelbarbier@iyte.edu.tr

Office: door on the right of Z5

Office hours: Friday 11:00 – 13:00 (or via appointment)

Teaching Assistants

Yağız Oyun

e-mail: yagizoyun@iyte.edu.tr

Office: Z9B

Office hours: TBA

Course Schedule

Tuesday	15:30 – 17:15	F-building – TBD
Friday	15:30 – 17:15	F-building – TBD

Course Fundamentals

Course Description

This course introduces numerical methods within the context of optoelectronics and photonics components. After providing an overview of basic numerical methods within a general context, the focus will be shifted towards methods against the background of electromagnetics and photonics: spectral and modal methods, finite difference time-domain (FDTD), and finite element methods (FEM). The theory will be complemented with applied numerical implementations during the practice sessions. The project/homework will provide further opportunities to establish a more practical understanding of the topic.

Course Objectives (Learning Outcomes)

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

1. Model modern photonic components.
2. Implement numerical methods to solve specific problems.
3. Convert systems of partial differential equations into numerical algorithms.
4. Write basic programs for specific problems from scratch.

5. Understand the common numerical methods, the underlying mathematics, and algorithmic issues for photonics problems.

Prerequisites

There are no official prerequisites for this course, and no previous experience with programming is assumed. However, basic knowledge of calculus and algebra is required. Further, having passed the PHOT 313 Electromagnetic Waves for Photonics course (or similar) would be beneficial.

Textbooks

Course Textbook:

A.V. Lavrinenko *et al.*, **Numerical methods in photonics**, CRC Press (2014)

Supplementary Materials:

Johan Larsson's lecture notes on basic numerical methods.

Steven C. Chapra, Raymond P. Canale: **Numerical Methods for Engineers**, McGraw-Hill Education (2015)

Raymond C. Rumpf's online course: Empossible web page, Youtube playlist of the course (general numerical methods).

Marek S. Wartak, **Computational Photonics: An Introduction with MATLAB**, Cambridge University Press (2013)

S. Obayya, **Computational Photonics**, Wiley (2010)

Course website and announcements

You will find all announcements relevant to the course (homework, grades, etc.) on MS-Teams. 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. During the practice sessions numerical algorithms will be implemented using MATLAB, and the project will focus on practical implementations as well.

Course schedule (tentative)

Week 1	Introduction to Numerical Problems

Week 2	Basic numerical methods: function discretization, root-finding, interpolation, and numerical differentiation and integration
Week 3	Solving ordinary differential equations: Euler, Verlet, leap-frog methods, Runge-Kutta
Week 4	LU decomposition, Eigenvalue equations, Singular value decomposition (SVD), Matrix norms, Condition number
Week 5	Partial differencial equations: Finite-difference methods
Week 6	Iterative methods, (over-)relaxation methods, stability & regularization
Week 7	Midterm exam
Week 8	Finite-difference time domain method
Week 9	Finite-difference time domain method (Cont'd)
Week 10	Finite-difference time domain method (Cont'd)
Week 11	Nonlinear systems
Week 12	Modal methods
Week 13	Finite element method
Week 14	Finite element method (Cont'd)
Week 15	Final exams
Week 16	Final exams

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

One individual project will be assigned during the term. This project can be performed with help from others (fellow students, course instructors, etc.), but the solution should be individually written and afterwards presented as a 5-minute slide-show presentation. 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.

Examinations and Grading

You will have one midterm exam and a final project. The exams will be closed book and exist out of open questions and problems that will be solved on the computer (using MATLAB).
Your final grade is the weighted average of your project, midterm and final exam grades, according to following weights (tentative):

- Project and project presentation: 40 %
- Midterm exam: 30 %
- Final exam: 30 %

Examination Dates (tentative)

Midterm exam: Friday, April 4, at 15:30, duration: 2 hours
Project: Task description will be sent out on April 4, the project presentation is on May 2
Final exam: TBA, duration: 3 hours

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.