# Вычислительные методы в физике

**Lecturers:**
Константин Ладутенко

**Language:**
Русский

**Credit points:**
6 з.е.

**Monitoring type:**
Exam

**Educational Program:**
Нанофотоника
1, 3 семестры
Гибридные материалы
1, 3 семестры
Квантовые материалы
1, 3 семестры
Компьютерное моделирование квантовых и нанофотонных систем
1, 3 семестры

| Lectures (a.h)* | Practice (a.h) | Labs (a.h) |
|---|---|---|
| 32 | 32 | |
| *1 academic hour = 45 minutes | | |

Computer simulations have become a vital part of modern physics saving time and resources and giving researchers a competitive edge. Since there are so many numerical methods and approaches to computations in physics, we select a few fundamental approaches. We pay special attention to common associated difficulties and pitfalls and cover them by self-test sections for each task in the assignment. Once you complete the assignment you will have enough experience to implement other methods not covered in the course, such as RCWA, DDA, MoM, FIT, FVM, PIC. You will also have more insight when running a simulation using some available software. In research, it is vitally important to understand the underlying machinery of the numerical methods utilized. This course will help you to avoid wrong simulation results and time wasted struggling with unnecessary difficulties that would not have arisen if a more appropriate numerical method had been selected. For example, one typical error is to use a time-domain method to investigate a model with a high Q-factor, whereas in general, it is preferable to start with a frequency domain or eigenmode solver. After completing the course, you will have the experience to select the best tools to accelerate your research.

## Course content

## Plan of a course

## Структура курса

**1. Solving PDE with finite differences:**

1.1 Iterative solver

1.2 Inverse matrix method

1.3 Heat transfer equation

1.4 Wave equation

**2. FDTD:**

2.1 Vanish electric field in vacuum

2.2 Simple ABC

2.3 Mur ABC

2.4 CPML

2.5 Fresnel equation

2.6 Dielectric slab

**3. FDFD:**

3.1 PEC-PMC cavity

3.2 Multilayer band gap (BG) diagram

**4. FEM:**

4.1 Quadratic elements

4.2 (optional) Scattering on infinite cylinder

## Recommended resources

1)“Finite Difference Computing with PDEs” by Hans Petter Langtangen and Svein Linge
https://link.springer.com/book/10.1007%2F978-3-319-55456-3

2)Understanding the Finite-Difference Time-Domain Method, John B. Schneider, www.eecs.wsu.edu/~schneidj/ufdtd, 2010. (it is also available at GitHub https:// github.com/john-b-schneider/uFDTD )

3)Numerical electromagnetics : the FDTD method / Umran S. Inan, Robert A. Marshall. 2011

4)A. Taflove and S. C. Hagness, Computational Electrodynamics: The Finite-Difference Time-Domain Method, 3rd ed. Norwood, MA: Artech House, 2005.

5)Presentation Course FDFD.pdf at https://github.com/kostyfisik/fdfd-1d