



ЦЕНТЪР ЗА ОБУЧЕНИЕ – БАН

1000 София
ул. „Сердика“ № 4
<http://edu.bas.bg>

email: tdc-phd@cu.bas.bg
тел.: 02 987 31 67
02 979 52 60

Basic Information:

Course Title: MATHEMATICAL FOUNDATIONS OF NEUROBIOLOGY

Lecturer: Prof. Dr. Petia Koprinkova-Hristova

Phone: 02 979 6622, 0887330498

Email: petia.koprinkova@iict.bas.bg, pkoprinkova@yahoo.com

Total Teaching Hours: 30

Annotation (up to 150 words)

The course is an introduction to the methods of mathematical modeling of brain processes at the level of nerve cells and their interactions. Its goal is to familiarize mathematicians and engineers with the basic concepts in neurobiology necessary for work in this interdisciplinary field, as well as neuroscientists with the possibilities for simulation studies of various brain structures. The topics covered in the course include an introduction to the theoretical foundations of models of brain functions at the nerve cell level, as well as the NEST Simulator library and its application for simulation of neural structures using Python.

Course content (brief description by topics or modules)

1. Introduction to brain biology
2. Modeling nerve cells - Hodgkin-Huxley equations
3. Dendrites and their modeling - cable equation
4. Ion channels in the cell membrane and their modeling
5. Synapses as communication channels and their models
6. Adaptation of synapses - types of plasticity
7. Spike timing and firing rate models
8. NEST simulator - capabilities and applications
9. Neuronal structures and their dynamics

Teaching and assessment methods

Lectures and exercises when gathering a group of at least 5 course participants.

Consultations with the teacher when conducting the course individually.

The acquired skills for creating spike timing neural models with NEST Simulator based on literature data for a selected brain structure are assessed.

Competencies acquired as a result of training (3–5 points)

1. Knowledge of the structure of the human brain and the principles of its operation in processing information at the nerve cell level.
2. Knowledge of brain-inspired spike timing neural models.
3. Skills for simulating spike timing neural models of the brain with the NEST Simulator library using Python language.

Literature:



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1. Izhikevich E.M. (2007) Dynamical Systems in Neuroscience: The Geometry of Excitability and Bursting; <https://www.izhikevich.org/publications/dsn.pdf>
 2. Bard Ermentrout and David Terman, Foundations of Mathematical Neuroscience; https://neuropsychics.ucsd.edu/courses/physics_171/Ermentrout_Therman.pdf

Additional information (optional) (e.g., special requirements, laboratory equipment, prior knowledge)

It is desirable that course participants have basic programming skills, preferably in the Python language.