UCLouvain

lgbio2072

2025

Mathematical models in neuroscience

The version you're consulting is not final. This course description may change. The final version will be published on 1st June.

5.00 credits	30.0 h + 30.0 h	Q1

Teacher(s)	Crevecoeur Frédéric ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Prerequisites	Prerequisites are the fundamentals in mathematics and physics from bachelor level in engineering, including: basic electrical circuits, mechanical systems, system theory (sampling, time-frequency domains, and transfer functions), state-space representations, ordinary differential equations, probability theory and fundamentals of linear algebra. Basic knowledge of biology will be covered in the course.
Main themes	The course will provide an introductory overview of how mathematical models are used to characterize the nervous system, and how these models capture the relationship between neural activity and functions such as decision-making, perception, and learning. The topics are organized from the microscopic scale of a single cells' activity to macroscopic models of movement control. The intended program will cover the following topics: - Motivation: the brain as an information processing system. Perspective from evolution, behaviour, and computational models. - Models of neurons' activity: leak integrate-and-fire, from continuous current input to spike trains of action potentials - From spike trains to rate/time encoding of information, receptive fields, homogenous Poisson model of firing rates, tuning functions. - Population activity, competing populations, drift-diffusion model and link with decision-making. - From population codes to perception: maximum likelihood/Bayesian estimation, cue-combination, multisensory integration. - Motor control: closed loop control of reaching movements, internal models, motor responses to mechanical or visual perturbations, feedback control models, neural basis of feedback control, motor learning. - (Optional) Graph-theoretic approach of brain architecture: topology, classification, and link with cognitive functions.
Learning outcomes	**At the end of this learning unit, the student is able to :** 1 — At the end of this course, students will be able to: c. Disciplinary Learning Outcomes 1. Understand how mathematical models are useful to study how neural activity supports behaviour. Critique and discuss models and their limitations, identify challenges in neuroscience. 2. Evaluate whether a model is suitable to account for experimental data. 3. Manipulate equations and simulations of the activity in neural circuits to produce behaviour in silico. 4. Understand the literature on the neural basis of motor and cognitive functions. 5. Draft up an experimental protocol intending to validate or falsify a pre-existing model. d. Transversal Learning Outcomes 1. Read and present a scientific article 2. Communication skills : prepare figures and illustration, describe results, set up presentation slides and present results to the audience
Faculty or entity in charge	GBIO

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Biomedical Engineering	GBIO2M	5		
Master [120] in Computer Science and Engineering	INFO2M	5		
Master [120] in Computer Science	SINF2M	5		
Master [120] in Mathematical Engineering	MAP2M	5		