

COURSE OUTLINE

(1) GENERAL

SCHOOL			
ACADEMIC UNIT	Interdisciplinary Graduate Programme in the BRAIN and MIND sciences		
LEVEL OF STUDIES	7		
COURSE CODE	B&M-238	SEMESTER	Spring
COURSE TITLE	Principles of Neural Circuit Modeling		
INDEPENDENT TEACHING ACTIVITIES <i>if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits</i>		WEEKLY TEACHING HOURS	CREDITS
lectures		5	6
<i>Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).</i>			
COURSE TYPE <i>general background, special background, specialised general knowledge, skills development</i>	Special background		
PREREQUISITE COURSES:	B&M-105 Introduction to Molecular & Cellular Neuroscience B&M -103 Introduction to Computational Neuroscience		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	English		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES		
COURSE WEBSITE (URL)			

(2) LEARNING OUTCOMES

<p>Learning outcomes</p> <p><i>The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.</i></p> <p>Consult Appendix A</p> <ul style="list-style-type: none"> • Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area • Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B • Guidelines for writing Learning Outcomes 		
<p><i>During the course, students will acquire the following skills:</i></p> <ul style="list-style-type: none"> • Overview of the various fields of Computational Neuroscience. • Understanding the complexity of brain function across all subfields. • Knowledge of the interactions between mathematical methods/models and the level being modeled (from synapses to single neurons to neural networks). • Access to the different levels of modeling in Computational Neurosciences. 		
<p>General Competences</p> <p><i>Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?</i></p> <table style="width: 100%; border: none;"> <tr> <td style="vertical-align: top;"> <ul style="list-style-type: none"> Search for, analysis and synthesis of data and information, with the use of the necessary technology Adapting to new situations Decision-making Working independently Team work Working in an international environment Working in an interdisciplinary environment </td> <td style="vertical-align: top;"> <ul style="list-style-type: none"> Project planning and management Respect for difference and multiculturalism Respect for the natural environment Showing social, professional and ethical responsibility and sensitivity to gender issues Criticism and self-criticism Production of free, creative and inductive thinking </td> </tr> </table>	<ul style="list-style-type: none"> Search for, analysis and synthesis of data and information, with the use of the necessary technology Adapting to new situations Decision-making Working independently Team work Working in an international environment Working in an interdisciplinary environment 	<ul style="list-style-type: none"> Project planning and management Respect for difference and multiculturalism Respect for the natural environment Showing social, professional and ethical responsibility and sensitivity to gender issues Criticism and self-criticism Production of free, creative and inductive thinking
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- Search for, analysis and synthesis of data and information, with the use of the necessary technology.
- Working independently.
- Teamwork.
- Working in an interdisciplinary environment.
- Project planning and management
- Production of new research ideas.
- Criticism and self-criticism.
- Production of free, creative and inductive thinking.
- Applying knowledge in practice.

(3) SYLLABUS

1. Introduction to Neural Circuit Modeling Methods (Lecture 1 and Tutorials 1 & 2)
 - Ordinary Differential Equations (ODEs)
 - Computational Methods for Solving ODEs (e.g., Euler, Runge-Kutta)
 - Dynamical Systems: Analysis with Phase-Plane Diagrams, Steady-State, Fixed Points
2. Spiking Models with Dynamical Systems (Lecture 2 and Tutorial 3)
 - FitzHugh-Nagumo Model
 - (Leaky) Integrate-and-Fire (I&F) Models, Quadratic I&F, and Adaptive Exponential I&F
 - Izhikevich Model
3. Connections Between Neuronal Cells (Lecture 3)
 - Modeling Synapses (Excitatory/Inhibitory)
 - Non-Spiking Models (Rate-Based)
4. Hodgkin-Huxley (HH) Formalism and Biophysical Models (Lecture 4 and Tutorial 4)
 - HH Equations
 - Equations of Ionic Channels
 - Cable Theory and Compartmental models
5. Synaptic Plasticity (LTP, LTD) (Lecture 5 and Tutorial 5)
 - Hebb's Rule(s)
 - BCM Rule (Rate-Based Models)
 - STDP (Spike-Time Dependent Plasticity) Rule

(4) TEACHING and LEARNING METHODS - EVALUATION

<p>DELIVERY <i>Face-to-face, Distance learning, etc.</i></p>	Face-to-face	
<p>USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY <i>Use of ICT in teaching, laboratory education, communication with students</i></p>	<p>Integration of ICT in teaching Communication with students via e-mail and/or open office hours Use of publisher databases/electronic repositories of scientific articles</p>	
<p>TEACHING METHODS <i>The manner and methods of teaching are described in detail. Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.</i></p> <p><i>The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS</i></p>	Activity	Semester workload
	Lectures	15
	Tutorials	15
	Study and analysis of bibliography	75
	Project	50
<p>STUDENT PERFORMANCE EVALUATION <i>Description of the evaluation procedure</i></p> <p><i>Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other</i></p> <p><i>Specifically-defined evaluation criteria are given, and if and where they are accessible to students.</i></p>	<p>Evaluation Language: English Assessment Methods: The quality of the presentations and coding scripts and participation in the discussions of the lectures and tutorials.</p> <p>Evaluation criteria are outlined in the study guide and communicated to students at the beginning of the course.</p>	

(5) ATTACHED BIBLIOGRAPHY

<p>Suggested textbooks:</p> <ul style="list-style-type: none"> • Abbott LF, Dyan P. (2001) Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems. The MIT Press. • Sterratt D, Graham B, Gillies A, Willshaw D. (2012) Principles of Computational Modelling in Neuroscience. Cambridge University Press. • Izhikevich EM. (2006) Dynamical Systems in Neuroscience: The Geometry of Excitability and Bursting. The MIT Press. <p>Relevant scientific journals: <i>Neuron, eLife, Journal of Computational Neuroscience, Journal of Neural Engineering, PLoS computational biology, PNAS</i></p>
