COURSE OUTLINE

## (1) GENERAL

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|---|---|---|---|
| SCHOOL | MEDICINE | | |
| ACADEMIC UNIT | MSC NEUROSCIENCES | | |
| LEVEL OF STUDIES | 7(2nd cycle – POSTGRADUATE) | | |
| COURSE CODE | NEURO 208 | SEMESTER | 2nd |
| COURSE TITLE | Principles of Computational Modeling in Neural Circuits | | |

| INDEPENDENT TEACHING ACTIVITIES<br>*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* | WEEKLY TEACHING HOURS | CREDITS |
|---|---|---|
| | 5 | 6 |
| | | |
| | | |
| *Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).* | | |

| | |
|---|---|
| COURSE TYPE<br>*general background, special background, specialised general knowledge, skills development* | special background |
| PREREQUISITE COURSES: | |
| LANGUAGE OF INSTRUCTION and EXAMINATIONS: | English |
| IS THE COURSE OFFERED TO ERASMUS STUDENTS | YES |
| COURSE WEBSITE (URL) | |

## (2) LEARNING OUTCOMES

**Learning outcomes**

*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.*

*Consult Appendix A*

- *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*

On completion the students will have gained:

1. Overview of the various subfields of Computational Neuroscience discipline
2. First insights and comprehension of the brain function complexity ranging across all subfields.
3. Knowledge about the interplay between mathematical (theoretical) and computational models and the level of abstraction (synapse, neuronal model, neural network, etc.)
4. Access to various levels of modelling in Computational Neuroscience.

| General Competences |
| --- |
| *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?*<br><br>*Search for, analysis and synthesis of data and information, with the use of the necessary technology*<br>*Adapting to new situations*<br>*Decision-making*<br>*Working independently*<br>*Team work*<br>*Working in an international environment*<br>*Working in an interdisciplinary environment*<br>*Production of new research ideas*<br>*Project planning and management*<br>*Respect for difference and multiculturalism*<br>*Respect for the natural environment*<br>*Showing social, professional and ethical responsibility and sensitivity to gender issues*<br>*Criticism and self-criticism*<br>*Production of free, creative and inductive thinking*<br>*……*<br>*Others…*<br>*…….* |
| Search for, analysis and synthesis of data and information, with the use of the necessary technology.<br>Working in an interdisciplinary environment.<br>Production of new research ideas.<br>Team work.<br>Project planning and management. |

(3) SYLLABUS

1. Introduction to methods in neural circuit modeling (Practical tutorial 1 and 2)
   - Ordinary differential equations (ODEs)
   - Numerical methods to solve ODEs (e.g., Euler, Runge-Kutta)
   - Dynamical systems: phase-plane analysis, steady-state, fixed-points
2. Spiking neuronal models (Practical tutorial 3)
   - FitzHugh-Nagumo model
   - (Leaky) Integrate-and-fire (I&F), Quadratic I&F, Adaptive Exponential I&F models
   - Izhikevich model
3. Connections among neuronal models
   - Modelling of synapses (Excitatory/Inhibitory)
   - Rate-based models
4. Hodgkin-Huxley (HH) formalism and Biophysical models (Practical tutorial 4)
   - HH equations
   - Ion channel equations (e.g., $Na^+$, $Ca^{2+}$, $K^+$)
   - Cable theory
   - Multi-compartmental models
5. Synaptic plasticity (LTP, LTD) (Practical tutorial 5)
   - Hebbian based rules
   - BCM model (rate-based models)
   - Spike-Time Dependent Plasticity (STDP) rule

## (4) TEACHING and LEARNING METHODS - EVALUATION

| | |
|---|---|
| DELIVERY<br>*Face-to-face, Distance learning, etc.* | Face-to-face (distance learning only in case of unforeseen circumstances, e.g., covid positive case) |
| USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY<br>*Use of ICT in teaching, laboratory education, communication with students* | Use of ICT in teaching (slides, video presentation), Communication with students via email and on a specific communication platform (e.g., discord, slack). |

**TEACHING METHODS**

*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.*

*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*

| *Activity* | *Semester workload* |
|---|---|
| Lectures | 15 |
| Practical tutorials | 10 |
| Self-preparation/study | 75 |
| Final project | 50 |
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| Course total | ***150*** |

**STUDENT PERFORMANCE EVALUATION**

*Description of the evaluation procedure*

*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*

*Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*

The evaluation is in English via an oral examination.

Students are evaluated on their final project (written assignment/report and presentation), as well as on their participation during the lectures and the practical tutorials.

The evaluation criteria are explicitly mentioned in the Course Guide and are communicated to the students at the beginning of the Course.

## (5) ATTACHED BIBLIOGRAPHY


*- Suggested bibliography:*

*• 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.*

*- Related academic journals:*

*Neuron, eLife, Journal of Computational Neuroscience, Journal of Neural Engineering, PLoS computational biology, PNAS*