

SYLLABUS

1. Data about the program of study

1.1 Institution	The Technical University of Cluj-Napoca
1.2 Faculty	Faculty of Automation and Computer Science
1.3 Department	Computer Science
1.4 Field of study	Computer Science and Information Technology
1.5 Cycle of study	Master
1.6 Program of study/Qualification	Data Science / Master
1.7 Form of education	Full time
1.8 Subject code	14.20

2. Data about the subject

2.1 Subject name	Neuroscience				
2.2 Course responsible/lecturer	Prof. dr. eng. Dinşoreanu Mihaela - Mihaela.Dinsoreanu@cs.utcluj.ro				
2.3 Teachers in charge of seminars/ laboratory/project	Prof. dr. eng. Dinşoreanu Mihaela - Mihaela.Dinsoreanu@cs.utcluj.ro				
2.4 Year of study	II	2.5 Semester	1	2.6 Type of assessment (E – exam, C – colloquium, V – verification)	E
2.7 Subject category	DA – de aprofundare, DS – de sinteza, DC – complementară				DA
	DI – Impusă, Dop – opțională, Dfac – facultativă				DO

3. Estimated total time

3.1 Number of hours per week	3	of which:	Course	1	Seminars	1	Laboratory	1	Project	-
3.2 Number of hours per semester	42	of which:	Course	14	Seminars	14	Laboratory	14	Project	-
3.3 Individual study:										
(a) Manual, lecture material and notes, bibliography										15
(b) Supplementary study in the library, online and in the field										15
€ Preparation for seminars/laboratory works, homework, reports, portfolios, essays										15
(d) Tutoring										10
€ Exams and tests										3
(f) Other activities:										
3.4 Total hours of individual study (suma (3.3(a)...3.3(f)))				58						
3.5 Total hours per semester (3.2+3.4)				100						
3.6 Number of credit points				4						

4. Pre-requisites (where appropriate)

4.1 Curriculum	
4.2 Competence	Fundamental computer science concepts

5. Requirements (where appropriate)

5.1. For the course	Min 50% attendance required for the final exam
5.2. For the applications	Compulsory attendance required for the final exam

6. Specific competence

6.1 Professional competences	1. Working with advanced mathematical methods and models, engineering and computing specific techniques and technologies. 2. Contextual integration and exploitation of dedicated information systems. 3. Creative pooling of multidisciplinary knowledge in the field of computers and information technology for research, design, optimization, implementation and
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	testing of theories, algorithms and original methods specific to artificial intelligence and computer vision systems
6.2 Cross competences	1. Exercising the skill of continuous self-education and demonstrating critical, innovative and research abilities.

7. Discipline objective (as results from the *key competences gained*)

7.1 General objective	The first objective is to teach and clarify the basics of neuroscience: how neurons function, how they encode and transmit information, what are the main problems of neuroscience. The second objective is to show what are the signals that can be recorded from the brain and what are the analyses useful to probe those signals (in single cells, in population of multiple neurons, and between cortical areas). Third, the final objective is to draw a parallel between the biological computational principles, found in the brain, and the computation principles in the current artificial intelligence field.
7.2 Specific objectives	<ol style="list-style-type: none"> 1. Introduce the students to neuroscience. 2. Provide the biological fundamentals for the brain, the neuron and the synapses. 3. Explain the generation and transmission of action potential through mathematical neuronal models, based on the biophysics of neurons and synapses. 4. Clarify the basics biological learning mechanisms, such as long-term potentiation and depression. 5. Teach basic time-domain and spectral analyses for continuous signals, such as the auto- and cross-correlation, the Fourier transform and alternatives. 6. Describe the most used recording techniques, from invasive and non-invasive electrophysiology to calcium imaging, functional magnetic resonance and functional ultrasound imaging. 7. Present the challenges of spike sorting: to separate possibly overlapping action potentials. 8. Discuss the most prevalent problems and theories in neuroscience, such as the binding problem, consciousness, perception, behaviour etc... 9. Present the most common techniques used for continuous signals (i.e. local field potential and electroencephalogram) analysis. 10. Clarify the difference between continuous signals and the discrete, event-like, nature of action potentials and the most useful spike analysis methods. 11. Introduce the functional brain networks: what are those and how to build such networks from neuronal activity. 12. Machine learning has been used as a data analysis tool in neuroscience; explain how such techniques can be useful for neuroscience (data and behaviour analysis). 13. Reveal the similarities and differences between the computational principles found in biological brains and those underlying artificial intelligence.

8. Contents

8.1 Lectures	Hours	Teaching methods	Notes
Introduction to Neuroscience and the Brain	1	Oral presentations, ppt support, discussions.	
The brain, the neuron, and the synapse	1		
Mathematical neuron models	1		
Learning and plasticity	1		
Basics of signal processing	1		
Brain recording techniques	1		
Spike sorting	1		
Problems and theories in neuroscience	1		
Analysis of LFP and EEG data	1		
Spike analysis	1		

Functional brain networks	1		
Machine learning for neural data analysis	1		
Brain vs. artificial intelligence	1		
Final review	1		
Bibliography			
1. Buzsaki G. 2006. Rhythms of the Brain. Oxford University Press.			
2. Dayan P, Abbott LF. 2005. Theoretical Neuroscience: Computational And Mathematical Modeling of Neural Systems. 1st edition. ed. Cambridge, Mass.: MIT Press.			
3. Kandel ER, Schwartz JH, Jessell TM, Siegelbaum SA, Hudspeth AJ (Eds.). 2012. Principles of Neural Science, Fifth Edition. 5th edition. ed. New York: McGraw-Hill Education / Medical.			
4. Nunez PL, Srinivasan R. 2005. Electric Fields of the Brain: The Neurophysics of EEG, 2nd Edition. 2nd ed. Oxford University Press, USA.			
5. Proakis J, Manolakis D. 2006. Digital Signal Processing. 4th edition. ed. Upper Saddle River, NJ: Pearson.			
6. Purves D, Augustine GJ, Fitzpatrick D, Hall WC, LaMantia A-S, Mooney RD, Platt ML, White LE (Eds.). 2017. Neuroscience. 6th edition. ed. New York Oxford: Sinauer Associates is an imprint of Oxford University Press.			
7. Rieke F, Warland D, Steveninck RDRV, Bialek W. 1999. Spikes: Exploring the Neural Code. Reprint edition. ed. Cambridge, Massachusetts London, England: Bradford Books.			
8. Smith SW. 1997. The Scientist & Engineer’s Guide to Digital Signal Processing. First Edition. ed. San Diego, Calif: California Technical Pub.			
8.2 Applications – Seminars/Laboratory/Project	Hours	Teaching methods	Notes
1. Scientific writing and reading	2	Hands-on exercises, oral presentations, discussions	
2. Journal club	2		
3. Implementing your own neuron	2		
4. Connecting neurons	2		
5. Brain signal pre-processing	2		
6. Brain signal processing	2		
7. Spike sorting	2		
8. Journal club	2		
9. Spectral analyses	2		
10. Spike analysis	2		
11. EEG connectivity analyses	2		
12. Classifiers for brain data	2		
13. Journal club	2		
14. Final review and discussions	2		
Bibliography			
1. Buzsaki G. 2006. Rhythms of the Brain. Oxford University Press.			
2. Dayan P, Abbott LF. 2005. Theoretical Neuroscience: Computational And Mathematical Modeling of Neural Systems. 1st edition. ed. Cambridge, Mass.: MIT Press.			
3. Kandel ER, Schwartz JH, Jessell TM, Siegelbaum SA, Hudspeth AJ (Eds.). 2012. Principles of Neural Science, Fifth Edition. 5th edition. ed. New York: McGraw-Hill Education / Medical.			
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8. Smith SW. 1997. The Scientist & Engineer’s Guide to Digital Signal Processing. First Edition. ed. San Diego, Calif: California Technical Pub.			

**Se vor preciza, după caz: tematica seminariilor, lucrările de laborator, tematica și etapele proiectului.*

9. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

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10. Evaluation

Activity type	Assessment criteria	Assessment methods	Weight in the final grade
Course	Understanding of concepts and principles, Solving domain specific problems, Attendance and (inter)activity during class hours	Written Exam	50%
Seminar	-	-	-
Laboratory	Activity in class and solving assignments	Continuous evaluation, assignments	50%
Project	-	-	-
Minimum standard of performance: the student must score at least five at both the exam and laboratory activity			

Date of filling in: 01.09.2025	Responsible	Title First name Last name	Signature
	Course	Prof. dr. eng. Mihaela DÎNȘOREANU	
	Applications	Prof. dr. eng. Mihaela DÎNȘOREANU	

Date of approval in the department 17.09.2025	Head of department, Prof.dr.eng. Rodica Potolea
Date of approval in the Faculty Council 19.09.2025	Dean, Prof.dr.eng. Vlad Mureșan