ABDULLAH GÜL UNIVERSITY GRADUATE SCHOOL OF ENGINEERING & SCIENCE MATERIALS SCIENCE AND MECHANICAL ENGINEERING PROGRAM COURSE DESCRIPTION AND SYLLABUS					
Course Title	**Code**	**Semester**	**T+L Hours**	**Credit**	**ECTS**
BRAIN DYNAMICS	ECE 642	SPRING	3 + 0	3	7,5

Prerequisite Courses	None

Type	Selective
Language	English
Coordinator	Assoc. Prof. Dr. Sergey Borisenok
Instructor	Assoc. Prof. Dr. Sergey Borisenok
Adjunt	None
Aim	Detailed coverage of mathematical methods of brain dynamic; experience of analysis of brain dynamics at the different levels of cortical hierarchy; experience of modeling of neurons and neuron populations; introduction to quantitative EEG analysis.
Learning Outcomes	• Learn the basic principles of hierarchic modeling of human brain; • Learn the modeling of single neuron providing the realistic analysis of its spiking and bursting; • Learn the modeling of neural clusters and their topological features; • Learn the basic methods of quantitative analysis of electroencephalography and brain imaging; • Learn the usage of basic computer tools for the brain dynamics modeling; • Learn the basic concepts of nonlinear dynamics mathematical modeling for human brain.
Course Content	• Phenomenological models, spiking and bursting of neurons; • Concepts of 'quantum neuron'; • Network models for human brain; • Hierarchic models in BD; • Continuous ('condensed matter') models in BD; • Methods of quantitative electroencephalography (EEG) and functional magnetic resonance imaging (fMRI); • Models of BD for some diseases; • Control methods in BD.

WEEKLY TOPICS AND PRELIMINARY STUDY		
Week	**Topic**	**Preliminary Study**
1	Human brain. Neurons: Methods of Brain Dinamics (BD). Hierarchic approach to the models of BD.	The relevant articles from the literature
2	Mathematical neurons vs biological neurons.	The relevant articles from the literature
3	Phenomenological models in BD. Spiking of neuron: Spike-generation of neurons and after-spike neuron reaction. Hodgkin-Huxley equations. 2D ODE spiking models for the membrane potential. Input stimulation.	The relevant articles from the literature
4	Bursting of neuron: Classification of bursting. Discrete-time approach to bursting. Continuous-time model for bursting.	The relevant articles from the literature
5	'Quantum' models in BD and concepts of 'quantum neuron'.	The relevant articles from the literature
6	Network models in BD: Structural characterization of brain networks. Types of brain connectivity. Clustering. Random graph models. Statistical network models for brain. 'Brain temperature'.	The relevant articles from the literature
7	Hierarchic models in BD: K-model family. Interacting neural populations with different topology. Excitatory and inhibitory links. Chaotic BD. Attractors in the brain.	The relevant articles from the literature
8	Midterm Exam	
9	Continuous ('condensed matter') models in BD: Umezawa class of models and 'corticons'. Long-range collective modes in the brain. 'Quantization' of the collective modes.	The relevant articles from the literature
10	Electroencephalography (EEG) and functional magnetic resonance imaging (fMRI): Introduction to the methods of quantitative EEG (qEEG).	The relevant articles from the literature

11	Searching for a time hierarchy in brain: Codes in brain.	The relevant articles from the literature
12	Searching for a macroscopic spatial hierarchy in brain: Geometric approaches. Topology.	The relevant articles from the literature
13	Models of BD for some diseases: Epilepsy, autism.	The relevant articles from the literature
14	Control methods in BD.	The relevant articles from the literature
15	Brain dynamics perspectives and global issues	The relevant articles from the literature
16	Final Exam	

SOURCES	
Lecture Notes	Lecture slides
Other Sources	**TEXTBOOK:** • P. P. Mitra, H. Bokil, (2008), Observed Brain Dynamics, Oxford University Press. [very good and very clear introduction to BD] • P. beim Graben, Ch. Zhou, M. Thiel, J. Kurths (Eds.), (2008), Lectures in Supercomputational Neuroscience. Dynamics in Complex Brain Networks, Berlin-Heidelberg, Springer-Verlag. • D. A. Steyn-Ross, M. Steyn-Ross (Eds), (2010) Modeling Phase Transitions in the Brain, N. Y., Springer. **RECOMMENDED BOOKS:** • W. J. Freeman, (2000), Neurodynamics; An Exploration of Mesoscopic Brain Dynamics, London, Springer-Verlag. • M. Marinaro, S. Scarpetta, Y. Yamaguchi (Eds.), (2008), Dynamic Brain – from Neural Spikes to Behaviors, Berlin-Heidelberg, Springer-Verlag. • C. von der Malsburg, W. A. Phillips, W. Singer (Eds.), (2010), Dynamic Coordination in the Brain: From Neurons to Mind, The MIT Press.

COURSE MATERIALS SHARING	
Documents	Lecture notes and slides
Homeworks	Students will be given 6 homeworks
Exams	1 Midterm and 1 Final Exam

EVALUATION SYSTEM		
SEMESTER STUDY	**NUMBER**	**CONTRIBUTION**
Midterm	1	30
Homework	6	30
Quizzes	2	10
SUB-TOTAL		70
Contribution of Semester Study		70
Contribution of Final Exam	1	30
TOTAL		100

Course Category	
Sciences and Mathematics	70%
Engineering	30%
Social Sciences	0%

RELATIONSHIPS BETWEEN LEARNING OUTCOMES AND PROGRAM QUALIFICATIONS						
No	Program Qualifications	Contribution Level				
		1	2	3	4	5
1	The skills of using mathematics, science and engineering information in advanced research,					**X**
2	The skills of analyzing, designing and/or implementing an original system that will be able to solve an engineering problem,					**X**

3	The skills of using the required software, hardware and modern measurement equipments in their field of research,			**x**		
4	The skills of planning independent research and implementing in detail,				**x**	
5	The skills of following literature, listening to and making technical presentation, writing a paper in academic level,				**x**	
6	The skills of innovative and interrogative thinking and finding original solutions.					**x**

*Increasing from 1 to 5.

ECTS / WORK LOAD TABLE			
Activities	Number	Duration (Hours)	Total Work Load
Course Length (includes exam weeks: 16x total course hours)	16	3	48
Out-of-class Study Time (Pre-study, practice)	16	5	90
Internet search, library work, literature search	16	4	64
Presentation	8	4	32
Homework	6	5	30
Midterm	1	20	20
Final Exam	1	20	20
Total Work Load			304
Total Work Load / 30			304/30
Course ECTS Credit			7,5