ABDULLAH GÜL UNIVERSITY
BIOENGINEERING PROGRAM
COURSE PLAN

Course unit title	Code	Semester	T+P Hours	Credits	ECTS
Neurodynamics	BENG540	SPRING	3 + 0	3	10

Prerequisite	None

Type of course	Selective
Langiage	English
Course coordinator	Assoc. Prof. Dr. Sergey Borisenok
Lecturer	Assoc. Prof. Dr. Sergey Borisenok
Course TA	-
Objectives of the course	Detailed coverage of mathematical methods in neurodynamic; experience of analysis of neurodynamics at the different levels of cortical hierarchy; experience of modeling of neurons and neuron populations; introduction to quantitative EEG analysis.
Learning outcomes	To provide an opportunity for students to: 1. learn the basic principles of hierarchic modeling of human brain; 2. learn the modeling of single neuron providing the realistic analysis of its spiking and bursting; 3. learn the modeling of neural clusters and their topological features; 4. learn the basic methods of quantitative analysis of electroencephalography and brain imaging; 5. learn the usage of basic computer tools for the brain dynamics modeling; 6. 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 neurodynamics; Continuous (‘condensed matter’) models in neurodynamics; Methods of quantitative electroencephalography (EEG) and functional magnetic resonance imaging (fMRI); Neurodynamical models of for some diseases; Control methods in neurodynamics.

WEEKLY DETAILED COURSE CONTENT

Week	Subject	Self-preparation
1	Human brain. Neurons: Methods and hierarchic approach of neurodynamics.	Corresponding parts in the textbooks, scientific articles.
2	Mathematical neurons vs biological neurons.	Corresponding parts in the textbooks, scientific articles.
3	Phenomenological models in neurodynamics. 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.	Corresponding parts in the textbooks, scientific articles.
4	Bursting of neuron: Classification of bursting. Discrete-time approach to bursting. Continuous-time model for bursting	Corresponding parts in the textbooks, scientific articles.
5	‘Quantum’ models in neurodynamics and concepts of ‘quantum neuron’.	Corresponding parts in the textbooks, scientific articles.
6	Structural characterization of brain networks. Types of brain connectivity. Clustering. Random graph models. Statistical network models for brain.	Corresponding parts in the textbooks, scientific articles.
7	Hierarchic models in neurodynamics: K-model family. Interacting neural populations with different topology. Excitatory and inhibitory links.	Corresponding parts in the textbooks, scientific articles.
8	Umezawa class of models and ‘corticons’. Long-range	Corresponding parts in

	collective modes in the brain. 'Quantization' of the collective modes.	the textbooks, scientific articles.
9	MIDTERM	
10	Electroencephalography (EEG) and functional magnetic resonance imaging (fMRI): Introduction to the methods of quantitative EEG (qEEG).	Corresponding parts in the textbooks, scientific articles.
11	Searching for a time hierarchy in neurodynamics: Codes in brain.	Corresponding parts in the textbooks, scientific articles.
12	Searching for a macroscopic spatial hierarchy in neurodynamics: Geometric approaches and topology.	Corresponding parts in the textbooks, scientific articles.
13	Models of BD for some diseases: Epilepsy, autism.	Corresponding parts in the textbooks, scientific articles.
14	Control methods in neurodynamics.	Corresponding parts in the textbooks, scientific articles.
15	Perspectives of neurodynamics.	Corresponding parts in the textbooks, scientific articles.
16	FINAL EXAM	

SOURCES	
Textbooks	**(a)** P. P. Mitra, H. Bokil, (2008), Observed Brain Dynamics, Oxford University Press. **(b)** P. beim Graben, Ch. Zhou, M. Thiel, J. Kurths (Eds.), (2008), Lectures in Supercomputational Neuroscience. Dynamics in Complex Brain Networks, Berlin-Heidelberg, Springer-Verlag. **(c)** D. A. Steyn-Ross, M. Steyn-Ross (Eds), (2010) Modeling Phase Transitions in the Brain, N. Y., Springer.
Other materials	Scientific articles on neurodynamics

SHARING MATERIALS	
Documents	-
Home works	8 home works
Exams	Midterm, final

SYSTEM OF EVALUATION		
SEMESTER WORK	**Quantity**	**Weight, %**
Midterm	1	30
Quiz	1	10
Home works	1	30
Final	8	30
TOTAL		100
Contribution of Term (year) Learning Activites to Success Grade		70
Contribution of Final Exam to Success Grade		30
TOTAL		100

Category	
Basic Sciences and mathematics	x
Engineering Sciences	
Social Sciences	

RELATIONSHIP BETWEEN COURSE LEARNING OUTCOMES AND PROGRAM QUALIFICATIONS

No	Program Competencies	Contribution Level				
		1	2	3	4	5
1	Understanding of Life Sciences, Mathematics and Engineering at the post-graduate level, and being able to implement of this knowledge into bioengineering problems					x
2	Having the ability of developing a new scientific method or a technological product or process, and, designing experiments, implementing, collecting data and evaluating regarding these issues					x
3	Choosing technical equipment used in the applications related to bioengineering, having sufficient knowledge in adopting and using new technological equipment				x	
4	Having the ability of reaching the information, using resources, contributing to the literature by transferring the process and results of scientific studies as written or verbally in the national and international environments					x
5	Having the ability of working as an individual or a team, in the teams composed of discipline or different disciplines, gaining awareness of leadership and taking responsibility					x
6	Having advanced level of foreign language knowledge to manage efficient verbal, written and visual communication in the major field					x
7	Having the understanding of ethics in science and the responsibility in profession with the awareness of lifelong learning, being beneficial to society and sensitiveness to global issues					x
8	Being aware of the social impacts of the solutions and applications of the challenges regarding bioengineering				x	

*1’den 5’e kadar artarak gitmektedir.

ECTS / WORK LOAD TABLE			
Activities	Quantuty	Duration (hour)	Total Work Load (hour)
Lectures (Including exam weeks: 16x total hour duration)	16	3	48
Out-Class Activities (Self-learning, enhancement)	16	5	80
Reading			
Searching in Internet, working in library	16	5	80
Material design, application			
Preparation of reports			
Preparation for presentations			
Presentations			
Home works	8	8	64
Midterms	1	14	14
Semester Final Exams	1	16	16
Total Work Load			302
Total Work Load / 30			302/30
ECTS Credits			10