THEORETICAL BIOPHYSICS

Basic Information

This is a course, which contributes to MSc award in Biology

Course period	From October 1st till February 1st, 1 semester (16 weeks)
Study credits	3 ECTS credits
Duration	108 hours
Language of instruction	English
Academic requirements	– BSc degree in Biology, Physics, Biophysics, Chemistry, Biochemistry, Environmental Sciences or equivalent (transcript of records), – Good command of English (certificate or other official document)

Course Description

The course is a part of International Master Program "Biological Engineering" offered by Siberian Federal University. Any advanced engineering discipline is based on a set of technologies that allow the creation of new application systems. This means that the creators have to predict or calculate operating parameters of the created system, which is impossible without the developed theoretical concepts and tools.

The course consists of three parts (modules). In the first module some widely used mathematical instrumentation is considered. Specificity of biophysical approach to modeling biological systems is discussed. This module plays the role of some kind of a basis for the course. The second module is devoted to the consideration of well known mathematical models which played essential role in understanding living systems or/and in organizing scientific research. The third module acquaints students with new mathematical instrumentation or with new applications of known techniques.

Special Features of the Course

In the context of theoretical biophysics the course introduces students to the basic mathematical tools, the results of these tools application to the solution of some biological problems, and it also provides insight into developed mathematical approaches for modeling biological systems.

Course Aims

The primary aim of the course is to provide students with general mathematical modeling skills, to introduce examples of effective mathematical modeling, and to show prospects of further development of theoretical and mathematical models.

Course Objectives

The course objectives are:

- to help students master the skills of using basic mathematical tools for modeling biological systems ;
- to provide students with understanding of the target formulation specificity and creation mode of the well-known mathematical models that provides their scientific significance;
- to give the students an idea about the possibilities of promising mathematical tools.

Learning Outcomes of the Course

After completing the course students should be able to:

- build first approximation mathematical models on the base of tradition mathematical tool;

- assess the prospects of applying a mathematical tool for modeling biological systems of different levels of the hierarchy and objectives of investigation.

Course (module) Structure

Learning Activities	Hours
Lectures	16
Practice sessions / Seminars,	16
Self-study Assignments	76
Final Exam (including preparation)	-
Total study hours	**108**

Course Outline

Week	Lectures	Practical work / Assignments	Hours
	Module 1 « Basic mathematical instrumentation »		
	• Lecture “Qualitative theory of ordinary	• Seminar “Simplifying principles for biological systems	

1-3	differential equations" • Lecture "Stationary, non-stationary and relaxation enzyme kinetics" • Lecture "Hierarchy of information processing systems, Gödel's theorem"	modeling" • Seminar "Graph and diagrammatic techniques in quasistationary kinetics" • Seminar "Propositional algebra, finite state machines, Turing machine"	16
4-9	Module 2 «Essence, origin and searching for life» • Lecture "Turing's model and conceptual models of morphogenesis" • Lecture "Eigen's hypercycles and models of natural self-organization" • Lecture Self-organized criticality and Bak-Sneppen's model of evolution" • Lecture "Kauffman's NK-automata and living on the edge of chaos and order" • Lecture "Lefebr's model of making decision subject"		8
10-12	Module 3 «Machine-like structure of biological systems» • Lecture "Fractals in Biology" • Lecture "Group theory in biology" • Lecture "p-adic numbers in biology" • Lecture "Theory of categories in biology"	• Seminar "Perspective mathematical tools"	8

Course Instructors and Tutors, Contact Information

Prof. Sergey *BARTSEV*
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Assessment

The overall course percentage grade will be computed from the final test results (25%) and the combined grades of 3 modules assignments (75%).

The each module scores are the sum of the following assignments:

- Module 1 (27% from 75%):
  - lecture attendance (each 1.5%, 9% total),
  - written answers to 3 question sets (each 3%, 18% total).
- Module 2 (24% from 75%):
  - lecture attendance (each 1.8%, 9% total),
  - written answers to the 3 question sets (each 3%, 15% total).
- Module 3 (24% from 75%):
  - lecture attendance (each 1.8%, 9% total),
  - written answers to 3 question sets (each 3%, 15% total).

The overall course percentage grade will be converted into a letter grade as follows:

A = 91-100%

B = 81-90%

C = 71-80%

D = 61-70%

E = less than 61%.

Attendance Policy

Since almost every class contains material, which is not presented in literature in compact form, attendance of all of them is highly desirable.

Web page of the course

The webpage of the course «*Theoretical Biophysics*» is available through E-learning SibFU web site: www.e.sfu-kras.ru. You must be logged in to access this course. Course Guide and all accompanying materials are also available at the course web-page.

Core reading

Essential portion of topics of the course contain mathematical models in the form of differential equations. For productive starting the course it is very recommended to update knowledge on Qualitative analysis of differential equations. The book «Qualitative analysis of differential equations» by Panfilov A. can be helpful it.

The knowledge of basic concepts of chemical and biochemical kinetics is obligatory for successful assimilation of the course content. The ability to transform kinetic schemes into differential equations and back is a basic practical skill, which is expected to be mastered by students. Therefore, the reading of selected chapters from «Enzyme kinetics» by H.Bisswanger (pp.51-58) and «Theoretical molecular biophysics» by P. Scherer and S.F. Fischer (pp. *75-85*) is very desirable.

Facilities, Equipment and Software

The program is designed with a strong emphasis on theoretical knowledge. Lectures and seminars take place in rooms equipped with interactive tablets and direct projection boards.