Course Unit Descriptor

Study Programme: Biomedical engineering
Course Unit Title: Modeling and simulation of biophysical processes
Course Unit Code: BM118D
Name of Lecturer(s): Delić Vlado
Type and Level of Studies: Bachelor
Course Status (compulsory/elective): elective
Semester (winter/ summer): winter
Language of instruction: english
Mode of course unit delivery (face-to-face/distance learning): face-to-face
Number of ECTS Allocated: 5
Prerequisites: none
Course Aims:. Present to the students the modeling and simulation of biophysical processes as an attractive and highly multidisciplinary area of particular importance in biomedical engineering. Students should be familiar with the current models of key biophysical processes, principles of development of biophysical models and techniques of numerical implementation of the model for performing a number of in silico experiments in order to obtain the results of the impact of certain model parameters on the processes and occurrence of the diseases in the human body.
Learning Outcomes: Basic theoretical and applied knowledge necessary for work and communication in a multidisciplinary team of engineers, physicists, biologists and doctors. Capability to develop a new or improve the present biophysical models, as well as the implementation of the model using numerical models for performing in silico experiments. The ability of students to analyze the obtained simulation results and make conclusions about the impact of certain parameters on the processes and occurrence of the diseases in the human organism. Training for students to use commercially available software packages for numerical simulations.
Syllabus. Importance of modeling and simulation of biophysical processes (advantages and disadvantages). Model classification. Electrical model of cell membrane ion channels. GHK voltage equation. Simplified electrical model of cell membrane for a spherical cell. Electrical model of Na–K pump. Electrical resistance of myelinated and unmyelinated axon. Capacitance of axon. Electrical cable model of axon (model parameters per unit length, model voltage equation, analysis of signal propagation equation, spatial and time constants, velocity of signal propagation). Hodgkin–Huxley model (voltage–dependent conduction of Na and K ion channels, model parameters and Hodgkin–Huxley model equation, analysis of influence of model parameters on signal propagation along a neuron). Fitzhugh–Nagumo model (derivation from the Hodgkin-Huxley model, advantages and disadvantages). Modeling blood flow by analogy of cardiovascular system with electrical circuit (peripheral resistance, compliance and intertance, modeling of heart valves). Windkessel effect. 2–, 3– and 4–element Windkessel models (voltage equations of models, analytical solutions for systolic and diastolic phases, and analysis of influence of individual blood vessel parameters). Electrical model of cardiovascular system. Ventricular LVAD pump model. Basic modeling of respiratory system. Characteristics of tumor growth. Modeling tumor growth according to the exponential model. Structural model of tumor population growth. Logistic and Gompertz tumor growth model. Functional model based on cellular kinetics. Modeling tumor growth in the presence of a therapy (chemotherapy, immunotherapy and anti–angiogenic therapy). Modeling and simulation of radio–frequency and microwave ablation of cancer tissue (3D analysis of therapy effects). Introduction to pharmacokinetic modeling methods. Applications of PBPK model for the prediction of absorption, distribution, metabolism and excretion of antibiotics and cytostatics. PBPK model limitations.
Required Reading:

Weekly Contact Hours: 2	**Lectures: 3**	**Practical work: 0**
Teaching Methods: Lectures. Computer exercises. Consultations.		

Knowledge Assessment (maximum of 100 points):			
Pre-exam obligations	points	**Final exam**	points
Attendance			
Computer exercises			
Tests (4x)			