



Univerza v Mariboru



Univerza v Mariboru

Fakulteta za naravoslovje in
matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet:	Modeliranje in simulacije v medicini in biologiji
Course title:	Modeling and Simulations in Medicine and Biology

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Fizika 2. st.		2	3
Physics 2 nd degree		2	3

Vrsta predmeta / Course type izbirni/ optional

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Teren. vaje Field work	Samost. delo Individ. work	ECTS
15	15	0	15	0	105	5

Nosilec predmeta / Lecturer: Aleš Fajmut, Marjan Slak Rupnik

Jeziki / Languages: **Predavanja / Lectures:** slovenski/Slovenian in/and angleški/English
Vaje / Tutorial: slovenski/Slovenian in/and angleški/English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: **Prerequisites:**
Ni zahtev. No prerequisites

Vsebina: **Content (Syllabus outline):**

Vsebina predavanj:

- SRCE IN CIRKULACIJA KRVI (matematično modeliranje cirkulacije krvi brez zunanje kontrole, kontrolni mehanizmi, avto regulacija, dinamika arterialnega pulza, računalniška simulacija pulzirajočega krvnega pretoka)
- IZMENJAVA PLINOV V PLJUČIH IN V KRVI (modeliranje transporta kisika v pljučih, modeliranje transporta ogljikovega dioksida, vezava kisika na hemoglobin)
- KONTROLA CELIČNEGA VOLUMNA IN ELEKTRIČNE LASTNOSTI CELIČNE MEMBRANE (modeliranje kontrole celičnega volumna, prehod ionov preko membrane, simulacija širjenja akcijskega potenciala po živčni celici)
- MEHANIKA MIŠIČ (relacija med silo in hitrostjo,

Lectures outline:

- HEART AND BLOOD CIRCULATION (mathematical modeling of uncontrolled circulation, control mechanisms, autoregulation, dynamics of the arterial pulse, computer simulation of pulsatile blood flow):
- GAS EXCHANGE IN LUNGS AND BLOOD (modeling of oxygen transport in lungs, modeling of carbon dioxide transport, binding of oxygen to hemoglobin)
- CONTROL OF CELL VOLUME AND ELECTRICAL PROPERTIES OF CELL MEMBRANES (modeling of cell volume control, the movement of ions across membrane, computer simulation of the nerve action potential)
- MUSCLE MECHANICS (the force-velocity

dinamika prečnih mostičkov, računalniška simulacija pripetja in odpetja prečnih mostičkov)

- BIOLOŠKI RITMI (razne oscilacije v bioloških sistemih)
- REKONSTRUKCIJA SLIK V MEDICINI (z uporabo konvolucijskega integrala in Fourierjeve transformacije)

Vsebina seminarja:

Študent izbere eno izmed tem, ki jih razpiše predavatelj. Projektna naloga ima obliko krajšega znanstvenega prispevka. Študent po izdelavi in predavateljevem pregledu naloge pripravi predstavitev pred kolegi.

Vsebina laboratorijskih vaj:

- modeliranje izbranih bioloških procesov tudi s stališča medicine
- računalniška simulacija in vizualizacija rezultatov z računalniškimi orodji

relationship, crossbridge dynamics, computer simulation of crossbridge attachment and detachment)

- BIOLOGICAL RHYTHMS (various oscillations in biological systems)
- IMAGE RECONSTRUCTION IN MEDICINE (with use of convolution integrals and Fourier transforms)

Seminar outline:

Student chooses one of the themes offered by the lecturer. Project has a form of short scientific contribution. After the review of the final version student presents his project for the colleagues.

Laboratory work outline:

- modeling of selected biological processes also from the medical point of view
- computer simulation and visualization of results with computer tools

Temeljni literatura in viri / Readings:

1. Hoppensteadt F. C., Peskin C. S. Modeling and Simulation in Medicine and the Life Sciences, Springer-Verlag, New York 2004.
2. Keener J., Sneyd J. Mathematical Physiology, Springer-Verlag, New York 1998
3. Goldbeter A. Biochemical Oscillations and Cellular Rhythms, Cambridge University Press, Cambridge 1996
4. Hobbie R. K. Intermediate Physics for Medicine and Biology, John Wiley & Sons, New York 1988

Cilji in kompetence:

Predmet je usmerjen v obravnavo bioloških procesov v človeškem telesu s stališča modeliranja in simulacij, katerega poglobljen cilj je poglobljen študij izbranih fizioloških procesov in njihova aplikacija medicini z metodami matematičnega modeliranja in računalniških simulacij.

Objectives and competences:

The subject is focused on the biological processes in the human body from the point of view of modeling and simulation. The major aim is to study selected physiological processes and its application in medicine with methods of mathematical modeling and computer simulations.

Predvideni študijski rezultati:

Znanje in razumevanje:

Študent pridobi:

- poznavanje in razumevanje fizioloških procesov na ravni matematičnega modela;
- znanje izbranih fizioloških procesov v smislu poznavanja aktualne problematike, ki omogoča nadaljnje raziskave.

Prenosljive/ključne spretnosti in drugi atributi:

Študent pridobi zmožnosti formuliranja matematičnega modela izbranega problema in računalniške simulacije in vizualizacije rezultatov.

Intended learning outcomes:

Knowledge and Understanding:

Student gets:

- knowledge and understanding of physiological processes on the level of mathematical model;
- knowledge of the processes studied in details. This enables her/him further research in this field.

Transferable/Key Skills and other attributes:

Student gets abilities of mathematical modeling of selected problem and its computer simulation and visualization.

Metode poučevanja in učenja:

- Predavanja
- Seminar
- Laboratorijske vaje

Learning and teaching methods:

- Lectures
- Seminar
- Laboratory work

Načini ocenjevanja:Delež (v %) /
Weight (in %)**Assessment:**

• Ustno	40	• Oral
• Opravljeno delo v laboratoriju in domače naloge	30	• Practical work in laboratory and Homework
• Seminarska naloga	30	• Project

Reference nosilca / Lecturer's references:**Aleš Fajmut:**

MBIKOU, Prisca, FAJMUT, Aleš, BRUMEN, Milan, ROUX, Etienne. Theoretical and experimental investigation of calcium-contraction coupling in airway smooth muscle. *Cell Biochem. Biophys.*, 2006, vol. 46, no. 3, str. 233-251. [COBISS.SI-ID 15168776]

FAJMUT, Aleš, BRUMEN, Milan. MLC-kinase/phosphatase control of Ca²⁺ signal transduction in airway smooth muscles. *J. theor. biol.*, 2008, vol. 252, no. 3, str. 474-481. [COBISS.SI-ID 15856392]

MBIKOU, Prisca, FAJMUT, Aleš, BRUMEN, Milan, ROUX, Etienne. Contribution of Rho kinase to the early phase of the calcium-contraction coupling in airway smooth muscle. *Exp. physiol.*, 2011, vol. 96, issue 2, str. 240-258. [COBISS.SI-ID 18009864]

DOBOVIŠEK, Andrej, FAJMUT, Aleš, BRUMEN, Milan. Role of expression of prostaglandin synthases 1 and 2 and leukotriene C 4 synthase in aspirin-intolerant asthma: a theoretical study. *J. Pharmacokin. Pharmacodyn.*, 2011, vol. 38, no. 2, str. 261-278. [COBISS.SI-ID 18203144]

DOBOVIŠEK, Andrej, FAJMUT, Aleš, BRUMEN, Milan. Strategy for NSAID administration to aspirin-intolerant asthmatics in combination with PGE₂ analogue: a theoretical approach. *Med. biol. eng. comput.*, 2012, vol. 50, no. 1, str. 33-42. [COBISS.SI-ID 18845192]

Marjan Slak Rupnik:

SKELIN, Maša, RUPNIK, Marjan, VOLK, Marko. Breeding of laboratory mice for biomedical research. *Agricultura*. [Print ed.], 2010, issue 12, str. 33-40. [COBISS.SI-ID [3062572](#)]

HUANG, Ya-Chi, RUPNIK, Marjan, GAISANO, Herbert Y. Unperturbed islet [alpha]-cell function examined in mouse pancreas tissue slices. *J Physiol*, Published online before print November 15, 2010, doi: [10.1113/jphysiol.2010.200345](#). [COBISS.SI-ID [512107576](#)]

SKELIN, Maša, RUPNIK, Marjan. cAMP increases the sensitivity of exocytosis to Ca²⁺ primarily through protein kinase A in mouse pancreatic beta cells. *Cell Calcium*, 2011, vol. 49, issue 2, str. 89-99, doi: [10.1016/j.ceca.2010.12.005](#). [COBISS.SI-ID [66514689](#)]

NYQVIST, Daniel, SPEIER, Stephan, RODRIGUEZ-DIAZ, Rayner, MOLANO, R. Damaris, LIPOVŠEK DELAKORDA, Saška, RUPNIK, Marjan, DICKER, Andrea, ILEGEMS, Erwin, ZAHR-AKRAWI, Elsie, MOLINA, Judith, LOPEZ-CABEZA, Maite,

VILLATE, Susana, ABDULREDA, Midhat, RICORDI, Camillo, CAICEDO, Alejandro, PILEGGI, Antonello, BERGGREN, Per-Olof. Donor islet endothelial cells in pancreatic islet revascularization. *Diabetes (N. Y. N. Y.)*, 2011, vol. 60, no. 10, str. 2571-2577, ilustr., doi: [10.2337/db10-1711](https://doi.org/10.2337/db10-1711). [COBISS.SI-ID [18639624](#)]

MANDIC, SA, SKELIN, Maša, JOHANSSON, JU, RUPNIK, Marjan, BERGGREN, Per-Olof, BARK, C. Munc18-1 and Munc18-2 proteins modulate β -cell Ca^{2+} sensitivity and kinetics of insulin exocytosis differently. *J Biol Chem*, 2011, vol. 286, no. 32, str. 28026-28040, doi: [10.1074/jbc.M111.235366](https://doi.org/10.1074/jbc.M111.235366). [COBISS.SI-ID [512148536](#)]