II_komplex vizsga után -- tantárgy leírások

I_General subjects

Title of the subject: Annual report 3 -- 4	Credit value: 10 -- 40
Title of the subject in Hungarian: Éves beszámoló 3 -- 4	
Type of the class: lecture / seminar / laboratory / consultation / report number of classes: (*if the subject is (partially) taught in any language other than Hungarian, then the language*: ***English***)	
Form of evaluation (exam / practical mark / project work / other): Further (*specific*) forms to be applied in knowledge testing *(if any)*: ……..	
Required preliminary studies *(if any):*	

Description of the subject: the brief, still informative description of the knowledge to be attained
It is obligatory for PhD students to give an annual report on their research work before a scientific committee in the form of an English language lecture at the 'PhD Proceedings' conference of the doctoral school. The submission of a full-length conference paper of at least 4 pages in the given format approved by the supervisor is also necessary to complete this subject. See the education plan for more details.
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)
according to the specific requirements
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes
presentation skills, practice in scientific dispute, practice in summarizing scientific material, thesis extraction from scientific results

Subject owner (*name, position, scientific degree*): Prof. Dr. Gábor Szederkényi, DSc
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

ROSKA TAMÁS DOCTORAL SCHOOL OF SCIENCES AND TECHNOLOGY

Title of the subject: Independent research study 5 -- 8	Credit value: 10 -- 40
Title of the subject in Hungarian: Önálló témafeldolgozás 5 -- 8	
Type of the class: lecture / seminar / laboratory / consultation number of classes: 12 / semester (weekly consultation) + continuous independent work (*if the subject is (partially) taught in any language other than Hungarian, then the language*: ***English***)	
Form of evaluation (exam / practical mark / project work / other): Further (*specific*) forms to be applied in knowledge testing *(if any)*: ……..	
Required preliminary studies *(if any):*	
Description of the subject: the brief, still informative description of the knowledge to be attained	
The goal of this subject is the independent study of scientific topics needed to evaluate, compare, extend or contextualize the research methodologies and results of PhD students in agreement with the supervisor. For completing the subject, it is necessary to thoroughly study at least one relevant textbook or alternatively, at least 5 research articles. The completion of the subject is evaluated and justified by the supervisor based on the regular consultations and the submitted work report.	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
at least 1 textbook or 5 research articles in agreement with the supervisor	
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes	
independent studying, critical evaluation of scientific materials, summarizing scientific results	
Subject owner (*name, position, scientific degree*): Prof. Dr. Gábor Szederkényi, DSc	
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX	

ROSKA TAMÁS DOCTORAL SCHOOL OF SCIENCES AND TECHNOLOGY

Title of the subject: Participation at public PhD defense 5 -- 8	Credit value: 1 -- 8
Title of the subject in Hungarian: Részvétel nyilvános PhD védésen 5 -- 8	
Type of the class: lecture / seminar / laboratory / consultation / defense number of classes: (*if the subject is (partially) taught in any language other than Hungarian, then the language*: ***English***)	
Form of evaluation (exam / practical mark / project work / other): Further (*specific*) forms to be applied in knowledge testing *(if any)*: ……..	
Required preliminary studies *(if any):*	

Description of the subject: the brief, still informative description of the knowledge to be attained
This subject can be fulfilled by the documented participation at a PhD defense and a written summary of the event of 1000-2000 characters.
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)
n. a.
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes
summary of scientific results

Subject owner (*name, position, scientific degree*): Prof. Dr. Gábor Szederkényi, DSc
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

ROSKA TAMÁS DOCTORAL SCHOOL OF SCIENCES AND TECHNOLOGY

Title of the subject: Participation at home PhD defense 5 -- 8	Credit value: 1 -- 8
Title of the subject in Hungarian: Részvétel házi vitán 5 -- 8	
Type of the class: lecture / seminar / laboratory / consultation / defense number of classes: (*if the subject is (partially) taught in any language other than Hungarian, then the language*: ***English***)	
Form of evaluation (exam / practical mark / project work / other): Further (*specific*) forms to be applied in knowledge testing *(if any)*: ……..	
Required preliminary studies *(if any):*	

Description of the subject: the brief, still informative description of the knowledge to be attained
This subject can be fulfilled by the documented participation at a preliminary defense and a written summary of the event of 1000-2000 characters.
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)
n. a.
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes
summary of scientific results

Subject owner (*name, position, scientific degree*): Prof. Dr. Gábor Szederkényi, DSc
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

Title of the subject: Publication activity 5 -- 8	Credit value: 20/30/50
Title of the subject in Hungarian: Publikációs tevékenység 5 -- 8	
Type of the class: lecture / seminar / laboratory / consultation number of classes: continuous work (*if the subject is (partially) taught in any language other than Hungarian, then the language*: ***English****)*	
Form of evaluation (exam / practical mark / project work / other): accepted publication Further (*specific*) forms to be applied in knowledge testing *(if any)*: ……..	
Required preliminary studies *(if any):*	

Description of the subject: the brief, still informative description of the knowledge to be attained

The goal of this subject is to motivate the whole process of research work of PhD students from problem statement and research design through implementation, evaluation, documentation to peer reviewed publication. Credits are given to accepted publications in the following categories (see the education plan for details):

- journal paper with impact factor: max. 50 credits
- Scopus journal paper with Scimago Q1-Q4 rank but without impact factor: max. 30 credits
- peer reviewed full length conference paper: max. 20 credits
- peer reviewed conference abstract with oral or poster lecture at an international conference: 20 credits only for the presenter student

The credits can be approved by the head of the doctoral school or the heads of programmes if the journal/conference is relevant to the research fields of the doctoral school and the publication is properly registered to the official MTMT database.

List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)

according to the specific requirements

List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes

research design and implementation, research evaluation, publication skills, publication administration

Subject owner (*name, position, scientific degree*): Prof. Dr. Gábor Szederkényi, DSc

Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

Title of the subject: Submission of dissertation for preliminary defense	Credit value: 15
Title of the subject in Hungarian: Disszertáció benyújtása munkahelyi vitára	
Type of the class: lecture / seminar / laboratory / consultation / dissertation number of classes: (*if the subject is (partially) taught in any language other than Hungarian, then the language*: ***English****)*	
Form of evaluation (exam / practical mark / project work / other): Further (*specific*) forms to be applied in knowledge testing *(if any)*: ……..	
Required preliminary studies *(if any):*	

Description of the subject: the brief, still informative description of the knowledge to be attained
Students who successfully write and submit their dissertations fulfilling all formal requirements to the preliminary defense during the 8 active semesters of their studies can complete this subject.
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)
according to specific needs
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes
thesis writing, summary of scientific results

Subject owner (*name, position, scientific degree*): Prof. Dr. Gábor Szederkényi, DSc
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

II_Subjects of the PhD Supervisors

Title of the subject: Advanced Neural Networks	**Credit value: 6**
Title of the subject in Hungarian: Új módszerek neurális hálózatok tanításában	
Type of the class: lecture / seminar / laboratory / consultation **number of classes: 10 in the given semester,** **(*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)***	
Form of evaluation (exam / practical mark / project work / other): **Further (*specific*) forms to be applied in knowledge testing *(if any)*: .....**	
Required preliminary studies *(if any)*: Python programming, basics of neural network	
Description of the subject: the brief, still informative description of the knowledge to be attained	
The goal of this course is to highlight recent advancements in the theory of neural networks and their applications. **During the lectures and labs we will discuss, implement and analyze both the basic concepts and advanced research topics in key directions of neural networks. Discussed topics include:** **Recent architectures in segmentation problem** **Recent architectures in object detection** **Transformer networks** **Adversarial samples** **Generative adversarial networks and their training** **Wasserstein GANs** **Multitasking networks (gradient surgery)** **Domain adaptation and domain adversarial neural networks** **Visualization of neural network decisions and explainable AI** **Training with a low number of input samples: one-shot learning, data augmentation**	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep learning*. MIT press. **Wani, M. A., Bhat, F. A., Afzal, S., & Khan, A. I. (2020). *Advances in deep learning*. Springer.**	
List of those required professional competences, competence elements to the development of which the	

subject characteristically, materially contributes
Programming **Theoretical knowledge of differentiation and optimization** **Neural networks**
Subject owner (*name, position, scientific degree*): András Horváth, PhD / DSc / MHAS
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

Title of the subject: Advanced Sensory Robotics	**Credit value: 6**
Title of the subject in Hungarian: Advanced Sensory Robotics	
Type of the class: lecture / seminar / laboratory / consultation **number of classes: 24 in the given semester,** **(*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)***	
Form of evaluation (exam / practical mark / project work / other): **Further (*specific*) forms to be applied in knowledge testing *(if any)*: .....**	
Required preliminary studies *(if any)*:	
Description of the subject: the brief, still informative description of the knowledge to be attained	
The goal of this course is to highlight recent results in sensory robotics-oriented applications. Local and guest lecturers will present the basic concepts and advanced research topics in key directions of systems biology. Discussed topics include: Machine learning in robotics Reinforcement learning Memristor crossbar networks Medical signal processing Image processing Deep learning Deep neural networks Prosthetics Rapid prototyping methods Soft robotics Human-machine interfaces Augmented reality Sensors and actuators Swarm intelligence GPU based algorithms Exoskeletons in rehabilitation Simultaneous localization and mapping Depth cameras Distant measurement sensors	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
Jafari, Amir, and Nafiseh Ebrahimi, eds. *Soft Robotics in Rehabilitation*. Academic Press, 2021. **Plaat, Aske. "Deep Reinforcement Learning." *arXiv preprint arXiv:2201.02135* (2022).**	
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes	

Subject owner (*name, position, scientific degree*): Dr. György Gábor Cserey, habil. associate professor, PhD
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

Title of the subject: Advanced Systems Biology	**Credit value: 6**
Title of the subject in Hungarian: Advanced Systems Biology	
Type of the class: lecture / seminar / laboratory / consultation **number of classes: 24 in the given semester,** **(*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)***	
Form of evaluation (exam / practical mark / project work / other): **Further (*specific*) forms to be applied in knowledge testing *(if any)*: .....**	
Required preliminary studies *(if any)*:	
Description of the subject: the brief, still informative description of the knowledge to be attained	
The goal of this course is to highlight recent results in systems biology-oriented applications. Local and guest lecturers will present the basic concepts and advanced research topics in key directions of systems biology. Discussed topics include: Dynamical Systems Theory Cell cycle modelling DNA nanotechnology Interaction databases network visualization Signalling network, multiomics Proteomics Metabolic networks Metabolomes: Chromosome segregation Logic approaches Agent-based modeling Parameter Estimation Evolutionary genomics Origin of life Bacterial cell biology Autophagy MAP kinase signaling Computational neuroscience Computational immunology Mutational signatures Circadian clock High content microscopy Systems Ecology	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
Alon, U. (2019). An introduction to systems biology: design principles of biological circuits. CRC press. **Ingalls, B. P. (2013). Mathematical modeling in systems biology: an introduction. MIT press.**	

Klipp, E., Liebermeister, W., Wierling, C., & Kowald, A. (2016). Systems biology: a textbook. John Wiley & Sons. **Voit, E. (2017). A first course in systems biology. Garland Science.**
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes
Subject owner (*name, position, scientific degree*): Prof. Dr. Csikász-Nagy Attila, full professor, DSc
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

Title of the subject: Data processing in a neuropsychiatric approach	**Credit value: 6**
Title of the subject in Hungarian: Adatfeldolgozás neuropszichiátriai keretben	
Type of the class: lecture / seminar / laboratory / consultation **number of classes: 12 in the given semester,** **(*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)***	
Form of evaluation (exam / practical mark / project work / other): **Further (*specific*) forms to be applied in knowledge testing *(if any)*: .....**	
Required preliminary studies *(if any)*:	
Description of the subject: the brief, still informative description of the knowledge to be attained	
<Preferably a list of 10-15 topics representing the planned weekly schedule of the course> eye tracking and cognitive engagement; relationship between location and scanning during Rorschach process; the relationship between determinants and eye movement; content and inkblot scanning; different styles of visual scanning based on their personal preferences and psychological traits; different types of visual scanning based on psychiatric symptoms; effort, engagement, and eye movements; average fixations duration; average fixations number; average saccades amplitude	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
Ales, F., Giromini, L., & Zennaro, A. (2020). Complexity and cognitive engagement in the Rorschach task: An eye-tracking study. *Journal of personality assessment*, *102*(4), 538-550. **Dauphin, B., Greene, H. H., Juve, M., Boyle, M., & Day-Suba, E. (2024). Seeing eye-to-eye: Internal consistencies of eye-tracking variables during Rorschach administration. *Rorschachiana*, *45*(1), 4.** **Roy, A. K., Nasreen, S., Majumder, D., Mahadevappa, M., Guha, R., & Mukhopadhyay, J. (2019, July). Development of objective evidence in Rorschach ink blot test: an eye tracking study. In *2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)* (pp. 1391-1394). IEEE.** **Vitolo, E., Giromini, L., Viglione, D. J., Cauda, F., & Zennaro, A. (2021). Complexity and cognitive engagement in the Rorschach task: An fMRI study. *Journal of Personality Assessment*, *103*(5), 634-644.** **Schott, G. D. (2014). Revisiting the Rorschach ink-blots: from iconography and psychology to neuroscience. *Journal of Neurology, Neurosurgery & Psychiatry*, *85*(6), 699-706.**	
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes	
Subject owner (*name, position, scientific degree*): Dr Csigó Katalin, PhD	
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX	

Title of the subject: Domain Specific Languages in High Performance Computing	**Credit value: 6**
Title of the subject in Hungarian: Domén-Specifikus Nyelvek Nagyteljesítményű Számításokban	
Type of the class: lecture / seminar / laboratory / consultation **number of classes: 24 in the given semester,** **(*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)***	
Form of evaluation (exam / practical mark / project work / other): **Further (*specific*) forms to be applied in knowledge testing *(if any)*: .....**	
Required preliminary studies *(if any)*:	
Description of the subject: the brief, still informative description of the knowledge to be attained	
High Performance Computing applications: legacy C/C++/Fortran codes **High Performance Computing applications: new generation of Python libraries** **Parallel Programming models used on CPUs: MPI, OpenMP** **Parallel Programming models used on GPUs: OpenMP, OpenACC, SYCL, CUDA, etc** **Defining a domain specific abstraction: embedded in C/Python** **Mapping a DSL to different hardware: case study of OP2/OPS** **Automatic code generation: boilerplate code + user code** **Automatic code generation: traditional text-based scriping** **Automatic code generation: compiler techniques - case study of OP-CG** **Automatic code generation: using LLVM and MLIR**	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
Required: M.B. Giles, G.R. Mudalige, Z. Sharif, G. Markall, P.H.J Kelly. *Performance Analysis of the OP2 Framework on Many-core Architectures* . (2011). ACM SIGMETRICS Perform. Eval. Rev. 38 (4) ISSN 0163-5999 **Required: I.Z. Reguly, G.R. Mudalige, M.B. Giles, D. Curran and S. McIntosh-Smith, *The OPS Domain Specific Abstraction for Multi-Block Structured Grid Computations* . In proceedings of the 4th international workshop on Domain-Specific Languages and High-Level Frameworks for High Performance Computing (WOLFHPC '14).Held in conjunction with IEEE/ACM Supercomputing 2014(SC'14).** **Recommended: Hager, G., & Wellein, G. (2010). Introduction to high performance computing for scientists and engineers. CRC Press. ISBN 978-1439811924**	
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes	

Understanding of the structure of science and engineering codes, the way they are implemented in computer code **Ability to understand levels of abstraction provided by various DSLs and libraries** **Experience with coding up simple parallel algorithms running on parallel architectures** **Understanding of differences between different hardware and how this is reflected in software** **Ability to design automated steps from high-level abstraction to low level implementation**
Subject owner (*name, position, scientific degree*): Dr. István Zoltán Reguly Professor, PhD
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

Title of the subject: Electromagnetic retrodirective reflector engineering	Credit value: 6
Title of the subject in Hungarian: Elektromágneses retrodirektív felületek tervezése	
Type of the class: consultation number of classes: 12 in the given semester	
Form of evaluation (exam / practical mark / project work / other): project work Further (*specific*) forms to be applied in knowledge testing *(if any)*: -	
Required preliminary studies *(if any)*: -	
Description of the subject: the brief, still informative description of the knowledge to be attained	
- Introduction: reflection, refraction and scattering of electromagnetic waves - Van Atta array improvement with checkerboard array - Periodic structures, unit cell engineering and optimization - Checkerboard arrays from microwave to optical frequencies - Retrodirective surface design based on Phase Gradient Metasurfaces - Retrodirective surface design based on Transformation Optics - Comparison and electrical efficiency of different retrodirective solutions	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN):	
- Constantine A. Balanis, Antenna Theory: Analysis and Design, 3rd Edition, ISBN: 0-471-66782-X, p. 393-399 - David M. Pozar, Microwave engineering—4th ed., 2011 - Alharbi, M.; Alyahya, M.A.; Ramalingam, S.; Modi, A.Y.; Balanis, C.A.;Birtcher, C.R. Metasurfaces for Reconfiguration of Multi-Polarization Antennas and Van Atta Reflector Arrays. Electronics 2020, 9, 1262. https://doi.org/10.3390/electronics908126 - Fan Yang; Yahya Rahmat-Samii, "Electromagnetic Band Gap Structures in Antenna Engineering", ISBN: 9780521889919 - Arbabi, A., Arbabi, E., Horie, Y. et al. Planar metasurface retroreflector. Nature Photon 11, 415–420 (2017). https://doi.org/10.1038/nphoton.2017.96 - Ma, Y., Ong, C., Tyc, T. et al. An omnidirectional retroreflector based on the transmutation of dielectric singularities. Nature Mater 8, 639–642 (2009). https://doi.org/10.1038/nmat2489	
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes:	
- Electromagnetic theory	

- **Circuit theory**
- **Antenna design**
- **Numerical design tools in electromagnetic engineering (Ansys-HFSS, CST)**

Subject owner (*name, position, scientific degree*): Zsolt Szabó, Prof., DSc / MHAS

Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

Title of the subject: Experimental approaches in quantitative biology	**Credit value: 6**
Category of the subject: required / optional *(strike out as appropriate!)*	
Extent of the theoretical or practical nature of the subject, "*educational character*": 100 (credit%)	
Type of the class: lect. / sem. / pract. / cons. and number of classes: ? in the given semester, **(*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)*** **Further (*specific*) forms, characteristics of the transfer of the given knowledge *(if any)*: .....**	
Form of testing (exam / pract. mark / other): Student essays on selected topics will be marked **Further (*specific*) forms to be applied in knowledge testing*(if any)*: .....**	
Position of the subject in the curriculum (number of the semester): optional	
Required preliminary studies *(if any)*: *none*	
Description of the subject: the brief, still informative description of the knowledge to be attained	
The focus of the course will be on the experimental approaches that are used to approach biology in a quantitative manner: with the use of mathematical models, or just with the quantification of key experimental observables. Scientists giving lectures are all actively performing experiments as well as analyzing data. So, the specificity of the course is on the analysis of quantitative experimental data in biology. In particular, scientists from different european institutions will address single cell analyses, the use of microfluidics, long-term evolution experiments, the dynamics of COVID, mechanisms of cell motion, and others.	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, handbooks) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
Lecturers will provide notes for the students.	
List of those required professional competences, competence elements *(knowledge, skill*, etc., *Section 8 of the Educational and Output Requirements*) to the development of which the subject characteristically, materially contributes	
Attendants should have preliminary knowledge in both biology and mathematics. In particular, knowledge in molecular biology, cell biology, evolutionary biology, from the one side. And in statistics and dynamical systems (ordinary differential equations) on the other.	
Subject owner (*name, position, scien. degree*): Andrea Ciliberto PhD	
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX	

Title of the subject: Fetal monitoring with multimodal methods	**Credit value: 6**
Title of the subject in Hungarian: Fetal monitoring with multimodal methods	
Type of the class: lecture / seminar / laboratory / consultation number of classes: 24 in the given semester, **(*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)***	
Form of evaluation (exam / practical mark / project work / other): Further (*specific*) forms to be applied in knowledge testing *(if any)*:	
Required preliminary studies *(if any)*:	
Description of the subject: the brief, still informative description of the knowledge to be attained	
The main purpose of this course is to highlight the foundation of different fetal monitoring techniques as well as the deepening of the knowledge in the field of biomedical signal processing. Finally recent, innovative technologies are also introduced. **Discussed topics include:** **- Fetal development and the basis of fetal monitoring** **- Processing and evaluation of raw phonocardiographic signals** **- Processing and evaluation of raw electrocardiographic signals** **- Medical ultrasound in a nutshell** **- Medical and engineering fundamentals of the measurement of fetal breathing movements** **- Fetal cardiodiagnostical methods and their applicability** **- Data science point of view in the case of medical data I.** **- Data science point of view in the case of medical data II.** **- Practical considerations in the case of multimodal measurements** **- Short overview in recent advances of fetal monitoring**	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
D. Pani, C. Rabotti, M. G. Signorini, L. Burattini "Innovative Technologies and Signal Processing in Perinatal Medicine," Springer, 2021 **L. Sörnmo, P. Laguna "Bioelectrical Signal Processing in Cardiac and Neurological Applications," Elsevier, 2005** **Z. Tóth, Z. Papp "Szülészet-Nőgyőgyászati Ultrahang-Diagnosztika," White Golden Book Kft., 2006** **M. Berényi, F. Katona "Fejlődésneurológia, Medicina, 2012** **D. Gibb, S. Arulkumaran "A magzatmonitorozás gyakorlata," Oriold és Társai Kft., 2009**	

List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes
Subject owner (*name, position, scientific degree*): Dr. Koller Miklós, PhD, associate professor
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

Title of the subject: Human motor control and neurorehabilitation	**Credit value: 6**
Title of the subject in Hungarian: Human motor control and neurorehabilitation	
Type of the class: lecture / seminar / laboratory / consultation number of classes: 24 in the given semester, **(*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)***	
Form of evaluation (exam / practical mark / project work / other): **Further (*specific*) forms to be applied in knowledge testing *(if any)*: .....**	
Required preliminary studies *(if any)*:	
Description of the subject: the brief, still informative description of the knowledge to be attained	
The goal of this course is to highlight recent results in Human Movement Science and their applications in neurorehabilitation. Discussed topics include: **Biological control Biological learning** **Joint spaces, Muscle spaces, Space in the Brain, Dimension reduction Redundancy and Variability of human limb movements Sensorimotor transformation** **Planning experiments to measure human movement** **Performing experiments to measure human movement using motion analyzer systems. Simulation and modeling of human movement** **Artificial control of human movement Functional Electrical Stimulation (FES)** **Human-machine interface in neurorehabilitation.** **Communicate research results in a professional manner with clinicians and patients.**	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
Laczko J and Latash M.L.(2016) Progress in Motor Control – Theories and Translations, Publ. Springer Enoka R.M. (2008) Neuromechanics of Human Movement, Publ. Human Kinetics , Champaign. IL. Shadmehr R & Mussa-Ivaldi S. (2012) Biological Control and Learning, Publ. MIT Press, Cambridge MA.	
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes	
The course focuses on natural and artificial control of human motion. The students learn how to measure, process and analyze data recorded from human movements. How hidden parameters and features of the studied movements (e.g. limb movements) can be revealed by mathematical and computational approaches? The students get insight into state of the art applications in Human Machine interfacse and neurorehabilitaion.	
Subject owner (*name, position, scientific degree*): József Laczkó PhD, Dr. Habil.	

Lecturer(s), instructor(s) involved in the teaching of the subject, if any (*name, position, scien. degree*): Botzheim Lilla PhD, Mravcsik Mariann PhD.
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

Title of the subject: Infinite Dimensional Dynamical Systems	Credit value: 6
Title of the subject in Hungarian: Végtelen dimenziós dinamikai rendszerek	
Type of the class: consultation number of classes: 12 in the given semester, (*if the subject is (partially) taught in any language other than Hungarian, then the language*:***English***)*	
Form of evaluation: exam / practical mark / project work / other): Further (*specific*) forms to be applied in [1] knowledge testing *(if any)*: ……..	
Required preliminary studies*(if any)*: a moderate background in functional analysis	
Description of the subject: the brief, still informative description of the knowledge to be attained	
Topics to be covered include: • linear dynamical systems, Cauchy's functional equation • uniformly continuous, strongly continuous semigroups • generators of semigroups and their resolvents • Hille-Yosida generation theorems • special semigroups: analytic, differentiable, etc. • perturbations of contractive and analytic semigroups • Trotter-Kato approximation theorems	
List of the most important 2–5 pieces of*required*and*recommended*literature (lecture notes, textbooksfundamental articles) with bibliographical details (author, title, edition information (or specific pages),ISBN)	
Required literature: lecture notesRecommended literature: • KJ. Engel, R. Nagel, One-Parameter Semigroups for Linear Evolution Equations, Springer, 2000. • KJ. Engel, R. Nagel, A Short Course on Operator Semigroups, Springer, 2006.	
List of those required professional competences, competence elements to the development of which thesubject characteristically, materially contributes	
Subject owner (*name, position, scientific degree*): Mihály Kovács, professor, DSc	
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX	

Title of the subject: **Introduction to Stochastic Partial Differential Equations**	Credit value: 6
Title of the subject in Hungarian: Bevezetés a sztochasztikus parciális differenciálegyenletek elméletébe	
Type of the class: lecture number of classes: 12 in the given semester, (*if the subject is (partially) taught in any language other than Hungarian, then the language*: ***English***)	
Form of evaluation: project work Further (*specific*) forms to be applied in knowledge testing *(if any)*: ……..	
Required preliminary studies *(if any)*: a moderate background in functional analysis (mainly Hilbert spaces), some measure theory, and basic finite dimensional stochastic analysis	
Description of the subject: the brief, still informative description of the knowledge to be attained	
Topic to be covered include: • Gaussian measures and Gaussian random variables in Hilbert spaces • infinite dimensional Wiener processes in Hilbert spaces • martingales in Banach spaces • measurability of operator valued random variables • stochastic integration with respect to infinite dimensional Wiener processes • the semigroup approach for stochastic evolution equations with additive noise • the stochastic heat equation, the stochastic wave equation	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
Required literature: lecture notes Recommended literature: • G. Da Prato and J. Zabczyk, Stochastic Equations in Infinite Dimensions, Cambridge University Press, 1992. • C. Prévôt and M. Röckner, A Concise Course on Stochastic Partial Differential Equations, Springer, 2007.	
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes	

Subject owner (*name, position, scientific degree*): Mihály Kovács, professor, DSc
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

Title of the subject: Mechanisms of cell division	**Credit value: 6**
Title of the subject in Hungarian: A sejtosztódás mechanizmusai	
Type of the class: lecture / seminar / laboratory / consultation **number of classes: 6… in the given semester,** **(*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)***	
Form of evaluation (exam / practical mark / project work / other): Q & A session after presentation **Further (*specific*) forms to be applied in knowledge testing *(if any)*: journal club presentations (6)**	
Required preliminary studies *(if any)*: basics of cell biology	
Description of the subject: the brief, still informative description of the knowledge to be attained	
<Preferably a list of 10-15 topics representing the planned weekly schedule of the course> **1. Cell cycle, the clock model and Xenopus** **2. Cell cycle, the domino model and budding yeast** **3. Single cell vs population studies** **4. Thresholds and transitions in biological systems** **5. Synthetic Biology and microfluidics** **6. Mitosis and chromosome dynamics** **7. Checkpoints as surveillance mechanisms of cell cycle transitions** **8. The DNA damage checkpoint** **9. The mitotic checkpoint** **10. Mechanisms of adaptation and checkpoint override** **11. Consequences of adaptation and the threshold model** **12. Aneuploidy and its paradox in cancer**	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
- Cells Escape an Operational Mitotic Checkpoint through a Stochastic Process. **Bonaiuti P, Chiroli E, Gross F, Corno A, Vernieri C, Štefl M, Cosentino Lagomarsino M, Knop M, Ciliberto A.Curr Biol. 2018 Jan 8;28(1):28-37.e7** **- Implications of alternative routes to APC/C inhibition by the mitotic checkpoint complex.**	

Gross F, Bonaiuti P, Hauf S, Ciliberto A.PLoS Comput Biol. 2018 Sep 10;14(9):e1006449. doi: 10.1371/journal.pcbi.1006449.

- A synthetic oscillatory network of transcriptional regulators.

Elowitz MB, Leibler S.Nature. 2000 Jan 20;403(6767):335-8. doi: 10.1038/35002125.

- Dominoes and clocks: the union of two views of the cell cycle.

Murray AW, Kirschner MW.Science. 1989 Nov 3;246(4930):614-21. doi: 10.1126/science.2683077.

- Feedback control of mitosis in budding yeast.

Li R, Murray AW.Cell. 1991 Aug 9;66(3):519-31. doi: 10.1016/0092-8674(81)90015-5.

List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes

Understanding the process of cell division and especially the possible mistakes occurring during such process that may fuel cancer. The students will learn how to connect historical key discoveries in the field of cell cycle control to current studies in the emergence of resistance to cancer treatment. The course will also show how mathematical models of molecular regulatory networks helped to understand such processes.

Subject owner (*name, position, scientific degree*): Andrea Ciliberto, Researcher, PhD

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Title of the subject: Molecular Biology of Yeast	Credit value: 6
Title of the subject in Hungarian: Élesztők molekuláris biológiája	
Type of the class (lecture / seminar / laboratory / consultation): consultation number of classes: 12 in the given semester, (*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)*	
Form of evaluation (exam / practical mark / project work / other): exam Further (*specific*) forms to be applied in knowledge testing *(if any)*:	
Required preliminary studies *(if any)*:	
Description of the subject: the brief, still informative description of the knowledge to be attained	
1. Cell-Cycle Analysis in Diverse Eukaryotes 2. Life Cycles of Budding and Fission Yeasts 3. Genetic Analysis of Cell-Cycle Control in Yeast 4. Cyclins Required for Activation of Replication Origins in Yeast 5. Cyclins that Promote Mitotic Entry in Yeast 6. Control of Late Mitosis in Budding Yeast 7. The Positioning and Timing of Cytokinesis in Yeast 8. Cytokinesis 9. The Actin–Myosin Ring 10. Assembly and Contraction of the Actin–Myosin Ring 11. Membrane and Cell Wall Deposition at the Division Site 12. The Positioning and Timing of Cytokinesis in Yeast 13. Activation of Gene Expression at Start in Budding Yeast 14. Activation of S–Cdks in Budding Yeast 15. Extracellular Control of Start in Yeast: Mating Factor Signaling 16. Coordination of Cell Growth and Division in Yeast	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
David O. Morgan: Cell Cycle: Principles of Control. 2006. New Science Press: London. 297 p. ISBN: (Paperback) 9780878935086.	

List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes
Subject owner (*name, position, scientific degree*): Dr. Csikász-Nagy Attila, full professor, DSc
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

Title of the subject: Open Set Recognition Methodologies	Credit value: 6
Title of the subject in Hungarian: Open Set Recognition Methodologies	
Type of the class: lecture / seminar / laboratory / consultation number of classes: 24 in the given semester, (*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)*	
Form of evaluation (exam / practical mark / project work / other): Further (*specific*) forms to be applied in knowledge testing *(if any)*: project work	
Required preliminary studies *(if any)*: Machine Learning	
Description of the subject: the brief, still informative description of the knowledge to be attained	

The objective of the course is to review the fundamentals of i) the open set recognition problem and its mathematical formulation, ii) basic approaches for open set recognition, iii) recent solutions.
 	
Discussed topics are
 	
• Closed-set vs open-set problems (classification and recognition)
• Mathematical formulation, open-set risk
• Anomaly and novelty detection
• Out-of-distribution detection
• Open-set recognition approaches
  ○ SVM based solutions
  ○ Extreme Value Theory
  ○ Extreme Value Machine
  ○ Deep Set Networks (OpenMax)
  ○ Generative Approaches
• Datasets for evaluation
• Evaluation metrics and protocols	

List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
• M. Salehi, H. Mirzaei, D. Hendrycks, Y. Li, M. Rohban, and M. Sabokrou: A Unified Survey on Anomaly, Novelty, Open-Set, and Out-of-Distribution Detection: Solutions and Future Challenges, https://doi.org/10.48550/arXiv.2110.14051 • Walter J. Scheirer and Anderson Rocha and Archana Sapkota and Terrance E. Boult: Towards Open Set Recognition, IEEE Transactions on Pattern Analysis and Machine Learning, 2013, 35 (7)	

- **Ethan Rudd, Lalit P. Jain, Walter J. Scheirer, Terrance Boult, The Extreme Value Machine, IEEE Transactions on Pattern Analysis and Machine Intelligence (T-PAMI), 2018, 40 (3)**
- **Ethan Rudd, Lalit P. Jain, Walter J. Scheirer, Terrance Boult, Towards Open Set Deep Networks, Ethan Rudd, Lalit P. Jain, Walter J. Scheirer, Terrance Boult,**

List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes

Subject owner (*name, position, scientific degree*): Dr. TORNAI Kálmán, PhD

Lecturer(s), instructor(s) involved in the teaching of the subject, if any (*name, position, scien. degree*):

Dr. ZSEDROVITS Tamás, PhD

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Title of the subject: Physics of Computation	**Credit value: 6**
Title of the subject in Hungarian: A számítások végzésének fizikája	
Type of the class: lecture / seminar / laboratory / consultation **number of classes: … in the given semester,** **(*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)***	
Form of evaluation (exam / practical mark / project work / other): **Further (*specific*) forms to be applied in [1] knowledge testing *(if any)*: ……**	
Required preliminary studies *(if any)*: ……none……	
Description of the subject: the brief, still informative description of the knowledge to be attained	
An overview of various computing paradigms and the physics that enables them: analog computers, mechanical, chemical computing, digital computing machines, quantum computers. Understanding the physical limits of computation. **Analog computing** **Neural models of computation** **Mechanical computers,** **Digital computers and binary switches** **Magnetolectronics** **Optical computing** **Quantum computers** **Speed, footprint and von Neumann bottleneck in computing** **Power dissipation in computing**	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
M. Wolf: The Physics of Computing Morgan Kaufmann; 1st edition (November 16, 2016) ISBN-10 : 0128093811 **Hey, Anthony. Feynman and computation. CRC Press, 2018.** **Marković, Danijela, Alice Mizrahi, Damien Querlioz, and Julie Grollier. "Physics for neuromorphic computing." Nature Reviews Physics 2, no. 9 (2020): 499-510.** **Bennett, Charles H. "The thermodynamics of computation—a review." International Journal of Theoretical**	

[1] e.g. hand-in assignments, such as case studies, elaboration of specific topics, compositions, essays, business and organizational plans, etc.

Physics 21, no. 12 (1982): 905-940.
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes
Subject owner (*name, position, scientific degree*): György Csaba full professor PhD
Lecturer(s), instructor(s) involved in the teaching of the subject, if any (*name, position, scien. degree*): **Adam Papp PhD**
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

Title of the subject: Predictive Control of Nonlinear Stochastic Systems	**Credit value: 6**
Title of the subject in Hungarian: Nemlineáris sztochastikus rendszerek prediktív irányítása	
Type of the class: lecture / seminar / laboratory / consultation **number of classes: 10x 90min in the given semester,** **(*if the subject is (partially) taught in any language other than Hungarian, then the language: English)***	
Form of evaluation (exam / practical mark / project work / other): **Further (*specific*) forms to be applied in knowledge testing *(if any)*: .....**	
Required preliminary studies *(if any): Computer Controlled Systems (BSc)*	
Description of the subject: the brief, still informative description of the knowledge to be attained	
The goal of this course is to highlight important results in nonlinear systems' and control theory and robotics. The subject of this course will be discussed in weekly consultations on the following topics: **I. Model Predictive Controller (MPC) techniques [1], [2]** **- Basic MPC techniques employing linear prediction models** **- Receeding horizon control, offline control, and preliminary control feasibility test** **- Nonlinear MPC (NMPC) and convex approximations** **- Stochastic (N) MPC and convex approximations** **- Unknown-input reconstruction, parameter estimation, and state observation in an MPC framework** **II. Gaussian process (GP) regression models [3], [4]** **- Multivariate function approximation from measurements using Gps** **- Hyperparameter tuning using log-likelihood optimization** **- Sparse GP approximations: FITC, VFE, distance-based dictionaries** **- Dynamic model calibration using GPs** **- Prediction models augmented with Gps** **- Stochastic GP model-based predictions using different model approximations (e.g., Taylor approximation or analytic moment calculations)** **- MPC approaches employing nonlinear prediction models augmented with GP regressors (GP-MPC)** **- GP-MPC implementation techniques and approximations:** **III. Useful numerical methods, available software tools, and their usage** **- Advanced Matlab/Simulink tools and techniques relevant in the field**	

- Algorithmic differentiation tools (e.g., CasADi) and gradient-based nonlinear optimization solvers (e.g., IPOPT, FORCES PRO)

- GPML Toolbox for GP manipulation

List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)

[1] Pablo S. González Cisneros and Herbert Werner. Nonlinear model predictive control for models in quasi-linear parameter varying form. International Journal of Robust and Nonlinear Control, 30 (10):3945–3959, 2020.

[2] Ali Mesbah. Stochastic model predictive control: An overview and perspectives for future research. IEEE Control Systems Magazine, 36 (6):30–44, December 2016.

[3] Carl Edward Rasmussen and Christopher K. I. Williams. Gaussian processes for machine learning. Adaptive computation and machine learning. MIT Press, 2006.

[4] Marc Peter Deisenroth. Efficient reinforcement learning using Gaussian processes – Revised version. PhD thesis, Faculty of Informatics Institute for Anthropomatics Intelligent Sensor-Actuator-Systems Laboratory (ISAS), 2017.

List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes

Analysis of complex nonlinear systems, understanding and manipulating the behavior of such physical biological, social, etc., process systems.

Subject owner (*name, position, scientific degree*): Dr. Péter Polcz, PhD

Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

Title of the subject: Recent Advances in Drug Delivery Research	**Credit value: 6**
Title of the subject in Hungarian: A gyógyszer beviteli kutatások legújabb eredményei	
Type of the class: lecture / seminar / laboratory / consultation **number of classes: 6 in the given semester,** **(*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)***	
Form of evaluation (exam / practical mark / project work / other): Q & A session after presentation **Further (*specific*) forms to be applied in knowledge testing *(if any)*: journal club presentations (6)**	
Required preliminary studies *(if any)*: Drug research and development BSc subject (NOT compulsory)	
Description of the subject: the brief, still informative description of the knowledge to be attained	
1. **Anatomical and molecular properties of the *blood-brain barrier*** 2. **Anatomical/cellular properties of *nasal* drug delivery route** 3. **Anatomical features of *dermal* drug delivery route** 4. **Methodological opportunities for testing *dermal* drug delivery (in vitro, ex vivo, in vivo)** 5. **Microfluidic diffusion chambers** 6. **Drug formulation techniques to enhance *dermal* drug absorption** 7. **Physical methods to enhance *dermal* drug delivery** 8. **Tricks for overcoming the *blood-brain barrier*** 9. **Studying species differences in the skin** 10. **Opportunities to reduce the number of experimental animals in drug delivery studies** 11. **Testing *dermal* barrier permeability in healthy and diseased conditions.** 12. **Testing *blood-brain barrier* permeability in healthy and diseased conditions.**	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
Kocsis D, Klang V, Schweiger EM, Varga-Medveczky Z, Mihály A, Pongor C, Révész Z, Somogyi Z, Erdő F. Characterization and ex vivo evaluation of excised skin samples as substitutes for human dermal barrier in pharmaceutical and dermatological studies. Skin Res Technol. 2022 Jun 21. doi: 10.1111/srt.13165 **Kocsis D, Horváth S, Kemény Á, Varga-Medveczky Z, Pongor C, Molnár R, Mihály A, Farkas D, Naszlady BM, Fülöp A, Horváth A, Rózsa B, Pintér E, Gyulai R, Erdő F. Drug Delivery through the Psoriatic Epidermal Barrier-A "Skin-On-A-Chip" Permeability Study and Ex Vivo Optical Imaging.** **Int J Mol Sci. 2022 Apr 11;23(8):4237. doi: 10.3390/ijms23084237**	

Ponmozhi J, Dhinakaran S, Varga-Medveczky Z, Fónagy K, Bors LA, Iván K, Erdő F. Development of Skin-On-A-Chip Platforms for Different Utilizations: Factors to Be Considered. Micromachines (Basel). 2021 Mar 10;12(3):294. doi: 10.3390/mi12030294.

Lukács B, Bajza Á, Kocsis D, Csorba A, Antal I, Iván K, Laki AJ, Erdő F. Skin-on-a-Chip Device for Ex Vivo Monitoring of Transdermal Delivery of Drugs-Design, Fabrication, and Testing.

Pharmaceutics. 2019 Sep 2;11(9):445. doi: 10.3390/pharmaceutics11090445.

Luca Anna Bors and Franciska Erdő Overcoming the Blood–Brain Barrier. Challenges and Tricks for CNS Drug Delivery, Sci. Pharm. 2019, 87(1), 6; https://doi.org/10.3390/scipharm87010006

List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes

Analyzing and synthetizing ability to make short, informative presentations on recent scientific results on the field of drug delivery across the physiological barriers.

Getting theoretical background knowledge on the field of physiological barriers and making and evaluating the drug delivery experiments.

Subject owner (*name, position, scientific degree*): Franciska Vidáné Erdő, full professor, PhD

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Title of the subject: Reinforcement learning in robotics	**Credit value: 6**
Title of the subject in Hungarian: Reinforcement learning in robotics	
Type of the class: lecture / seminar / laboratory / consultation number of classes: 24 in the given semester, ***(if the subject is (partially) taught in any language other than Hungarian, then the language: English)***	
Form of evaluation (exam / practical mark / project work / other): **Further (*specific*) forms to be applied in knowledge testing *(if any)*: .....**	
Required preliminary studies *(if any)*:	
Description of the subject: the brief, still informative description of the knowledge to be attained	
The goal of this course is to highlight the foundations of reinforcement learning (RL) and its general applicability to robotic problems. In addition to reviewing RL-fundamentals, the course includes a brief review of classical approaches to basic robotics computational problems (direct and inverse kinematical problem, etc), in order to help the deeper understanding of how modern RL-approaches work. **Discussed topics include:** **- General concepts of deep neural networks** **- Modern architectures, training strategies and fine details of practical realizations** **- General formalism of the RL-problem** **- The main RL-apporaches: value-based and policy-based** **- Latest results on modern value-based and policy-based approaches, hybrid methods I.** **- Latest results on modern value-based and policy-based approaches, hybrid methods II.** **- Environmental simulators in a nutshell (pyBullet, MuJoCo, etc)** **- Baseline algorithms in existing simulated environments** **- Recap on theoretical aspects of robotic manipulators** **- Constructional aspects of a new simulated environment, interfacing with a modern RL-algorithm** **- Training strategies of the realized environment-agent combination, debug opportunities** **- Sim-to-real considerations and the necessary extensions to the created combinaton**	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	

I. Goodfellow, Y. Bengio, A. Courville, "Deep learning," MIT Press, www.deeplearningbook.org , 2016

R. S. Sutton, A. G. Barto, "Reinforcement Learning: An Introduction," 2nd edition, MIT Press, incompleteideas.net/book/the-book-2nd.html , 2020

Cs. Szepesvári, "Algorithms for Reinforcement Learning," Morgan&Claypool Publishers, https://sites.ualberta.ca/~szepesva/rlbook.html , 2009

J. Achiam, "Spinning Up Documentation," https://spinningup.openai.com , 2020

L. Sciavicco, B. Siciliano: "Modelling and Control of Robot Manipulators," 2nd edition, Springer, 1999 Lectures of UC Berkeley "Deep Reinforcement Learning" by Sergey Levine, https://rail.eecs.berkeley.edu/deeprlcourse/ 2021

List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes

Subject owner (*name, position, scientific degree*): Dr. Koller Miklós, PhD, associate professor

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Title of the subject: Simulation of biological experiments	**Credit value: 6**
Title of the subject in Hungarian: Biológiai kísérletek szimulációi	
Type of the class: lecture / seminar / laboratory / consultation number of classes: 6 in the given semester, **(*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)***	
Form of evaluation (exam / practical mark / project work / other): none; Further (*specific*) forms to be applied in knowledge testing *(if any)*: none	
Required preliminary studies *(if any)*: *none*	
Description of the subject: the brief, still informative description of the knowledge to be attained	
Mathematical modelling techniques to simulate experiments in biological systems. Modelling and experimental techniques and how one cam move between them will be highlighted. Key topics include: **Oscillators: cell cycle, circadian clock, repressillator** **Biological switches: differentiation, apoptosis** **Adaptation: chemotaxis** **Whole cell modelling**	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
Klipp, E., Liebermeister, W., Wierling, C., & Kowald, A. (2016). Systems biology: a textbook. John Wiley & Sons. **Ingalls, B. P. (2013). Mathematical modeling in systems biology: an introduction. MIT press.** **Elowitz, M. B., & Leibler, S. (2000). A synthetic oscillatory network of transcriptional regulators. Nature, 403(6767), 335-338.** **Tyson, J. J., Chen, K. C., & Novak, B. (2003). Sniffers, buzzers, toggles and blinkers: dynamics of regulatory and signaling pathways in the cell. Current opinion in cell biology, 15(2), 221-231.** **Karr, J. R., Sanghvi, J. C., Macklin, D. N., Gutschow, M. V., Jacobs, J. M., Bolival Jr, B., ... & Covert, M. W. (2012). A whole-cell computational model predicts phenotype from genotype. Cell, 150(2), 389-401.**	
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes	
The PhD students will learn to interpret experimental results and design mathematical models to simulate them. They will also understand how to design experiment, which can lead to results contributing to model development.	
Subject owner (*name, position, scientific degree*): Attila Csikász-Nagy, full professor, DSc	
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX	

Title of the subject: Spatial data analysis	Credit value: 6
Title of the subject in Hungarian: Téradatok elemzése	
Type of the class: lecture / seminar / laboratory / consultation number of classes: 52 in the given semester, (*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)*	
Form of evaluation (exam / practical mark / project work / other): Further (*specific*) forms to be applied in knowledge testing *(if any)*: -	
Required preliminary studies *(if any)*: -	
Description of the subject:	

The primary goal of the subject is to obtain basic theoretical and practical knowledge of sensors and algorithmic tools used in spatial information systems focusing on applications of remote sensing and medical imaging. The course provides an overview of the operating principles of the various 3D sensing technologies and their areas of use, the data structures describing the provided measurements, with a special emphasis on the automated data processing methods and algorithms, which nowadays play a prominent role due to the heterogeneity of the available data, and the large and continuously expanding size of current spatial databases.

Main topics:

1. Concept of spatial information sciences, main types and applications of spatial information systems

2. Operation principles of geospatial and medical 3D data collection sensor technologies and tools

3. Geometric reference systems, spatial geometric transformations, projective geometry

4. Formation and representation of various data types: 2D images (optical visible/infrared, radar, X-ray images), 2.5D distance maps, real 3D Lidar point clouds and 3D voxel models (e.g. CT, MR)

5. Geospatial and medical databases: data acquisition and data storing models

6. Data quality standards and quality assurance. Hardware and software tools in spatial information system, database management issues.

7. Automatic processing and interpretation of spatial data sets: segmentation of data from different sources, separation of different classes, recognition and reconstruction of spatial objects

8. Hierarchical description of complex spatial scenes, stochastic optimization techniques (Markov fields, Markov point processes)

9. Automatic 3D model generation from raw measured data, processing of 3D point clouds (e.g. LIDAR) and voxel models (e.g. computed tomography).

10. Time sequence analysis, registration, and change detection for multitemporal data

11. Basic concepts of augmented and mixed reality systems

List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)
Csaba Benedek: "Multi-level Bayesian Models for Environment Perception," Springer International Publishing, 202 pages, ISBN 978-3-030-83654-2, 2022 **Pinliang Dong, Qi Chen, "LiDAR Remote Sensing and Applications", CRC Press, 220 pages, ISBN 978-1-138-74724-1, 2017** **Dougherty Geoff, "Medical Image Processing", Springer, 396 pages, ISBN: 978-1-441-99769-2, 2011**
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes
Algorithm development, computer programming, machine learning applications
Subject owner (*name, position, scientific degree*): Csaba Benedek, full professor, DSc
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

Title of the subject: Structural biology	**Credit value: 6**
Title of the subject in Hungarian: *Szerkezeti biológia*	
Type of the class: lecture / seminar / laboratory / consultation **number of classes: 12 in the given semester,** **(*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)***	
Form of evaluation (exam / practical mark / project work / other): a 3-5 page proposal on the complex structural investigation of a chosen biomacromolecule: rationale, methods, possible difficulties etc. **Further (*specific*) forms to be applied in knowledge testing *(if any)*: .....**	
Required preliminary studies *(if any)*:	
Description of the subject: the brief, still informative description of the knowledge to be attained	
The goal of the course is to provide introduction to the structural analysis of biological macromolecules by highlighting the fundamentals and the most recent developments. Topics include: **Fundamentals of protein structure** **Fundamentals of the 3D structure of nucleic acids** **Low-resolution structure analysis methods: circular dichroism, FT-IR, UV-VIS, SAXS** **Sample preparation for structural studies** **Macromolecular X-ray crystallography** **Macromolecular NMR spectroscopy** **Solid-state NMR for the investigation of biomolecules** **Cryo-electron microscopy** **Fluorescence-based methods to probe the structure and dynamics of proteins and complexes** **Single-molecule methods** **Fundamentals of molecular modeling** **Basics of molecular dynamics calculations** **Hybrid methods combining calculations with experimental data** **Interpretation of protein structures to understand biological function**	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
P Moore: Visualizing the invisible. Oxford University Press, 2012, ISBN: SBN13 9780199767090	

I Bertini, KS McGreevy, G Parigi: NMR of biomolecules. Wiley-Blackwell, 2012, ISBN:9783527328505. **DC Rapaport: The art of molecular dynamics simulation. Cambridge University Press, 2004, ISBN: 978-0521825689** **ID Campbell: Biophyiscal techniques. Oxford University Press, 2012. ISBN 9780199642144**
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes
Understand and interpret biomacromolecular structures, design experiments to probe functionally important structural features of proteins
Subject owner (*name, position, scientific degree*): Zoltán Gáspári, PhD / DSc / MHAS
Lecturer(s), instructor(s) involved in the teaching of the subject, if any (*name, position, scien. degree*): **Tamás Hegedűs, DSc**
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

Title of the subject: Technology of microscale neural interfaces	**Credit value: 6**
Title of the subject in Hungarian: Mikroméretű implantátumok technológiája	
Type of the class: lecture / seminar / laboratory / consultation **number of classes: 8 in the given semester,** **(*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)***	
Form of evaluation (exam / practical mark / project work / other): oral exam **Further (*specific*) forms to be applied in knowledge testing *(if any)*: .....**	
Required preliminary studies *(if any)*:	
Description of the subject: the brief, still informative description of the knowledge to be attained • **Micro- and nanotechnologies to create brain-machine interfaces** • **Overview of state-of-the-art materials of microimplants** • **Integrated electronics for brain electrodes** • **Soft,flexible materials used in implantable devices** • **Integrated optoelectronic features and optical stimulation using neural interfaces** • **Strategies to mitigate cellular damage on tissue-device interfaces** • **Longevity and biocompatibility of neural implants** • **Multimodal brain imaging methods relying on multifunctional brain electrodes**	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN) **Wellman, S. M., Eles, J. R., Ludwig, K. A., Seymour, J. P., Michelson, N. J., McFadden, W. E., ... & Kozai, T. D. (2018). A materials roadmap to functional neural interface design. *Advanced functional materials*, *28*(12), 1701269.** **Ruther, P., & Paul, O. (2015). New approaches for CMOS-based devices for large-scale neural recording. *Current opinion in neurobiology*, *32*, 31-37.** **Zhang, D., Chen, Q., Shi, C., Chen, M., Ma, K., Wan, J., & Liu, R. (2021). Dealing with the foreign-body response to implanted biomaterials: strategies and applications of new materials. *Advanced Functional Materials*, *31*(6), 2007226.** **Goncalves, S. B., Ribeiro, J. F., Silva, A. F., Costa, R. M., & Correia, J. H. (2017). Design and manufacturing challenges of optogenetic neural interfaces: a review. *Journal of neural engineering*, *14*(4), 041001.** **Shin, H., Lee, H. J., Chae, U., Kim, H., Kim, J., Choi, N., ... & Cho, I. J. (2015). Neural probes with multi-drug**	

delivery capability. *Lab on a Chip*, *15*(18), 3730-3737.
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes
material science, microtechnology, biomedical MEMS, implantables, bionic interfaces
Subject owner (*name, position, scientific degree*): Kristóf Iván PhD / DSc / MHAS
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX

Title of the subject: Translational Oncology	**Credit value: 6**
Title of the subject in Hungarian: Transzlációs onkológia	
Type of the class: lecture / seminar / laboratory / consultation **number of classes: 24 in the given semester,** **(*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)***	
Form of evaluation (exam / practical mark / project work / other): **Further (*specific*) forms to be applied in knowledge testing *(if any)*:--**	
Required preliminary studies *(if any)*:--	
Description of the subject: the brief, still informative description of the knowledge to be attained	
The goal of this course is to demonstrate examples and highlight recent results of translational oncology. Basic concepts and advanced research topics in key directions of translational clinical research will be discussed, including: oncogenesis (oncogenes and tumor suppressor genes) **angiogenesis** **metastasis formation** **clinical samples (origin and aim)** **primary cell cultures and cell lines** **tumor heterogeneity** **2D cellular models (proliferation, migration)** **3D cell-models (spheroids, matrices and invasion)** **animal models (PDX, tumor progression and colonization models)**	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
Beverly A. Teicher (ed): Tumor Models in Cancer Research (2011) **ESMO Handbook of Translational Research (2015)** **Geoffrey M. Cooper: The Cell: A Molecular Approach (2019)**	
List of those required professional competences, competence elements to the development of which the subject characteristically, materially contributes	
Subject owner (*name, position, scientific degree*): Garay Tamás, PhD	
Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX	

Title of the subject: Wireless Sensor Networks	**Credit value: 6**
Title of the subject in Hungarian: Vezeték nélküli érzékelő hálózatok	
Type of the class: lecture / seminar / laboratory / consultation **number of classes: 24 in the given semester,** **(*if the subject is (partially) taught in any language other than Hungarian, then the language*: *English)***	
Form of evaluation (exam / practical mark / project work / other): exam **Further (*specific*) forms to be applied in knowledge testing *(if any)*: -**	
Required preliminary studies *(if any)*: Information and Coding Theory	
Description of the subject: the brief, still informative description of the knowledge to be attained	
The followings are the main topics: – **Anatomy of a Sensor Node** – **Protocol Stack of WSNs** – **Radio Communications and fading models** – **Link Management** – **Multi-Hop Routing, Energy Aware Routing Techniques in WSN** – **Data Aggregation and Clustering** – **Time Synchronization** – **Localization Techniques** – **Designing and Deploying WSN Applications** – **Simulators and Emulators for WSNs** – **WSN applications (predictive maintenance, Industry 4.0….etc.)**	
List of the most important 2–5 pieces of *required* and *recommended* literature (lecture notes, textbooks fundamental articles) with bibliographical details (author, title, edition information (or specific pages), ISBN)	
- **Anna Forster: Introduction to Wireless Sensor Networks, Wiley-IEEE Press, 2016. ISBN: 978-1118993514** - **Fahmy, Hossam Mahmoud Ahmad: Concepts, applications, experimentation and analysis of wireless sensor networks. Springer Nature, 2020. ISBN: 9783030580148** - **Zagrouba, Rachid, and Amine Kardi. "Comparative study of energy efficient routing techniques in wireless sensor networks." Information 12.1 (2021): 42.**	
List of those required professional competences, competence elements to the development of which the	

subject characteristically, materially contributes

a. Knowledge

- **He/she is familiar with the communication protocol development for wireless sensor networks**
- **In the Infocommunication Technologies, he/she has deeper theoretical and practical knowledge in protocol development and implementation.**

b. Skills

- **He/she is able to use traditional algorithms in communication protocol development.**
- **He/she uses the infodommunicaton technology tools and standards at a skill level.**

c. Attitude

- **He/she is able to perform the development tasks on a professionally high level**

Subject owner (*name, position, scientific degree*): András Oláh, PhD, associate professor

Expected learning outcomes -- click here: https://itk.ppke.hu/storage/tinymce/uploads/Doktori-Iskola/Kepzesi-terv/II_kompetenciamatrix-doktori-komplex-vizsga-utan.pdf?u=1g0siX