



## **COMPUTER SCIENCE BSC**

**2021**

**Mode:** Full-time training

**Program Coordinator:** Dr. Márton Ispány ([ispany.marton@inf.unideb.hu](mailto:ispany.marton@inf.unideb.hu))

**Mentor:** Dr. Péter Jeszenszky ([jeszenszky.peter@inf.unideb.hu](mailto:jeszenszky.peter@inf.unideb.hu))

### **Qualification requirements**

General requirements of the diploma are regulated by The Rules and Regulations of The University of Debrecen.

### **Work and Fire Safety and Physical Education**

The courses of „Work and Fire Safety” and „Physical Education” are worth 1 - 1 credit, which must be completed in excess of the number of credits required for the diploma as specified in the training and outcome requirements of the degree.

### **Diploma credit requirements**

Matematics and Computer Science:	60 credits
Informatics:	90 credits
Compulsory topics:	54 credits
Differentiated knowledge topics:	36 credits
Professional Training:	12 credits
Thesis work:	20 credits
Free choise subjects:	10 credits
<b>Total:</b>	<b>180 credits</b>
Work and Fire Safety:	1 credit
Physical Education (2 semesters):	2 credits

### Mathematics and Computer Science – needed 60 credits

Code	Subject name	Cre- dit	Type and number			Asses- ment	Prerequisites	Period	Semes- ter
			lec.	practice					
				sem.	lab				
INBPA0101-21 INBPA0101E INBPA0101G	Logic in computer science	6	2	2		E S		1	1
INBPA0102-17 INBPA0102E INBPA0102G	Discrete mathematics	6	2	2		PM		1	1
INBPA0103-17 INBPA0103E INBPA0103L	Computer aided mathematics and visualization	6	2		2	PM		1	1
INBPA0206-17 INBPA0206E INBPA0206G	Data structures and algorithms	6	2	2		E S	INBPA0101-21 INBPA0102-17	2	2
INBPA0207-21 INBPA0207E INBPA0207G	Calculus	6	2	2		PM		2	2
INBPA0313-17 INBPA0313E INBPA0313L	Applied statistics	6	2		2	E S	INBPA0207-21	1	3
INBPA0314-21 INBPA0314E INBPA0314G	Introduction to computer science	6	2	2		E S	INBPA0102-17	1	3
INBPA0417-21 INBPA0417G INBPA0417L	Applied mathematics	6		2	2	PM	INBPA0102-17	2	4
INBPA0418-21 INBPA0418E INBPA0418L	Foundations of artificial intelligence	6	2		2	E S	INBPA0101-21 INBPA0211-21	2	4
INBPA0419-17 INBPA0419E INBPA0419L	Foundations of computer security	6	2		2	E S	INBPA0211-21	2	4

### Informatics (Compulsory topics) – needed 54 credits

Code	Subject name	Cre- dit	Type and number			Asses- ment	Prerequisites	Period	Semes- ter
			lec.	practice					
				sem.	lab				
INBPA0104-21 NBPA0104L	Introduction to programming	3			2	PM		1	1
INBPA0105-21 INBPA0105E INBPA0105L	Operating systems	6	2		2	E S		1	1
INBPA0208-17 INBPA0208E	Database systems	3	2			E	INBPA0101-21	2	2
INBPA0209-17 INBPA0209L	Database systems lab	3			2	PM	INBPA0101-21	2	2
INBPA0210-17 INBPA0210E INBPA0210L	Network architectures and protocols	6	2		2	E S	INBPA0104-21 INBPA0105-21	2	2

Code	Subject name	Cre- dit	Type and number			Asses- ment	Prerequisites	Period	Semes- ter
			lec.	practice					
				sem.	lab				
INBPA0211-21 INBPA0211E INBPA0211L	High-level programming languages 1	6	2		2	E S	INBPA0104-21	2	2
INBPA0315-21 INBPA0315G INBPA0315L	High-level programming languages 2	6		2	2	PM	INBPA0211-21	1	3
INBPA0316-17 INBPA0316E INBPA0316L	Web technologies	6	2		2	E S	INBPA0104-21	1	3
INBPA0420-21 INBPA0420E INBPA0420L	Software engineering and technologies	6	2		2	PM	INBPA0315-21	2	4
INBPA0521-17 INBPA0521L	Software development methodologies	3			2	PM	INBPA0211-21	1	5
INBPA0522-21 INBPA0522G INBPA0522L	Web application development	6		2	2	PM	INBPA0315-21 INBPA0316-17	1	5

#### Thesis work – needed 20 credits

Code	Subject name	Cre- dit	Type and number			Asses- ment	Prerequisites	Period	Semes- ter
			lec.	gyakorlat					
				tant.	labor				
INBPA0523-21 INBPA0523X	Thesis 1	5				PM		1	5
INBPA0623-21 INBPA0623X	Thesis 2	15				PM		2	6

#### Informatics (Differentiated knowledge topics) – needed 36 credits

Code	Subject name	Cre- dit	Type and number			Asses- ment	Prerequisites	Period	Semes- ter
			lec.	practice					
				sem.	lab				
INBPA9924-17 INBPA9924L	3D printing and modeling	3			2	PM	INBPA0103-17	2	2
INBPA9925-17 INBPA9925L	Cloud computing	3			2	PM	INBPA0105-21	2	2
INBPA9926-17 INBPA9926L	Basics of GIS	3			2	PM	INBPA0103-17	2	2
INBPA9927-17 INBPA9927L	Bioinformatics	3			2	PM	INBPA0206-17	1	3
INBPA9928-21 INBPA9928E	E-Sport	3	2			E	INBPA0211-21	1	3
INBPA9929-17 INBPA9929E INBPA9929L	Operation of infocommunication systems	6	2		2	PM	INBPA0210-17	1	3
INBPA9930-17 INBPA9930L	Image processing in practice	3			2	PM	INBPA0211-21	1	3

Code	Subject name	Cre- dit	Type and number			Asses- ment	Prerequisites	Period	Semes- ter
			lec.	practice					
				sem.	lab				
INBPA9931-17 INBPA9931L	High-level programming languages 3	3			2	PM	INBPA0211-21	1	3
INBPA9942-17 INBPA9942L	Scripting Languages	3			2	PM	INBPA0211-21	1	3
INBPA9932-17 INBPA9932L	Introduction to 3D game development	3			2	PM	INBPA0103-17 INBPA0315-21	2	4
INBPA9933-17 INBPA9933L	Compilers	3			2	PM	INBPA0211-21 INBPA0314-21	2	4
INBPA9934-17 INBPA9934L	Machine learning in practice	3			2	PM	INBPA0211-21 INBPA0313-17	2	4
INBPA9935-17 INBPA9935L	Advanced database knowledge	3			2	PM	INBPA0209-17	2	4
INBPA9936-17 INBPA9936L	NoSQL databases	3			2	PM	INBPA0209-17 INBPA0315-21	2	4
INBPA9943-17 INBPA9936E	Fundamentals of Information and Coding Theory	3	2			E	INBPA0313-17	2	4
INBPA9937-17 INBPA9937L	Mobile application development	3			2	PM	INBPA0420-21	1	5
INBPA9938-17 INBPA9938L	Computer Statistics	3			2	PM	INBPA0313-17	1	5
INBPA9939-17 INBPA9939L	Software testing	3			2	PM	INBPA0420-21	1	5
INBPA9940-17 INBPA9940L	Advanced data security	3			2	PM	INBPA0419-17 INBPA0522-21	2	6
INBPA9941-17 INBPA9941L	Advanced web technologies	3			2	PM	INBPA0522-21	2	6
INBPA9951-17 INBPA9951E	Blockchain technology	3	2			E		1	
INBPA9955-17 INBPA9955L	Introduction to reinforcement learning	3			2	PM		1	
INBPA9997-21 INBPA9997G	Professional Training	12				PM	INBPA0315-21 INBPA0208-17 INBPA0209-17	1	6

### Free choice – needed 10 credits

Code	Subject name	Cre- dit	Type and number			Asses- ment	Prerequisites	Period	Semester
			lec.	practice					
				sem.	lab				

Exam types: E exam  
S signature  
PM practical mark

# COMPUTER SCIENCE BSC

## Description of Subjects

### *Mathematics and Computer Science*

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#### LOGIC IN COMPUTER SCIENCE

INBPA0101-21

<b>Semester:</b>	1
<b>Type:</b>	Lecture / Seminar
<b>Number of Classes:</b>	2+2+0
<b>Credit:</b>	6
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Exam
<b>Prerequisites:</b>	None
<b>Responsible:</b>	Dr. György Vaszil

#### **Topics:**

Exploring the logical structure of statements. Formalization in propositional logic. The language of propositional logic, the inductive definition of formulas, basic elements of syntax. Unary and binary logical operations, truth tables. Concepts of semantics: interpretation, truth valuation in interpretations, satisfiability and validity, equivalent formulas. Consequences in propositional logic. The language of first-order logic: terms and formulas, syntax. Formalization in first-order logic. Free and bound occurrences of variables, renaming bound variables, congruent formulas. Concepts of semantics in first order logics: interpretation, variable assignment, valuation of terms and formulas. Satisfiability, validity, contradiction, equivalence in first-order logics. Conjunctive and disjunctive normal forms, prenex form. First-order consequences. Checking the correctness of reasoning. A simple logical calculus: derivations, soundness, completeness.

#### **Compulsory/Recommended Readings:**

- Mordechai Ben-Ari: Mathematical Logic for Computer Science, 3rd ed., Springer, 2012. ISBN 978-1-4471-4128-0.
- Michael Huth, Mark Ryan: Logic in Computer Science, Cambridge University Press, 2002. ISBN 0-521-54310-X.

## DISCRETE MATHEMATICS

INBPA0102-17

<b>Semester:</b>	1
<b>Type:</b>	Lecture / Seminar
<b>Number of Classes:</b>	2+2+0
<b>Credit:</b>	6
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	None
<b>Responsible:</b>	Dr. Bernadett Aradi

### Topics:

Sets, relations, functions. Numbers, mathematical induction, recursions. Complex numbers, their algebraic and trigonometric forms, operations, roots of unity. Polynomials, fundamental theorem of algebra, division of polynomials, Horner's method. Basic notions of number theory: divisibility, prime numbers, congruences. Elements of combinatorics: permutations, ordered selections, combinations.

Binomial theorem and its applications. Cardinality of sets. Systems of linear equations. Gaussian elimination. The  $n$ -dimensional Euclidean space. Vector spaces (linear dependence, basis).

Matrices (operations, determinant, rank). Inverse of a matrix. Linear transformations.

Eigenvalue, eigenvector. Introduction to graph theory.

### Compulsory/Recommended Readings:

- Steven J. Leon: Linear Algebra with Applications. Pearson, 2010.
- Seymour Lipschutz, Marc Lipson: Schaum outline of Theory and problems of discrete mathematics.

## COMPUTER AIDED MATHEMATICS AND VISUALIZATION

INBPA0103-17

<b>Semester:</b>	1
<b>Type:</b>	Lecture / Laboratory
<b>Number of Classes:</b>	2+0+2
<b>Credit:</b>	6
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	None
<b>Responsible:</b>	Dr. Roland Imre Kunkli

### Topics:

Functions, relations, basic function types. Drawing function graphs with computer software, visualizing different function properties. Bivariate functions and the possibilities of the visualization of their graphs. Basic vector operations, multiplication of vectors. Introducing derivatives and integrals through interactive and illustrative visual examples. Implicit equations and parametric equation systems of curves and surfaces. Short review of other well-known techniques for visualizing surfaces. Equations and equation systems of lines and planes. Relationships among spatial objects, distance and angle measurement. Finite mathematical and geometrical problems, and their computer based solutions. Matrices (multiplication of matrices, inverse, determinant). Linear equation systems through a geometrical approach. Linear transformations, orthogonal and symmetric matrices. Interesting problems solved by using homogeneous coordinates.

### Compulsory/Recommended Readings:

- Farin, Gerald and Hansford, Dianne: Practical Linear Algebra: A Geometry Toolbox (3rd Edition), A K Peters/CRC Press, 2013., ISBN: 978-1466579569
  - Thomas, George B., Weir, Maurice D., Hass, Joel R.: Thomas' Calculus (13th Edition), Pearson, 2014., ISBN: 978-0321878960
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## DATA STRUCTURES AND ALGORITHMS

**INBPA0206-17**

<b>Semester:</b>	2
<b>Type:</b>	Lecture / Seminar
<b>Number of Classes:</b>	2+2+0
<b>Credit:</b>	6
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Exam
<b>Prerequisites:</b>	INBPA0101-21 (Logic in computer science) and INBPA0102-17 (Discrete mathematics)
<b>Responsible:</b>	Dr. Géza Horváth

### Topics:

The course covers commonly used data structures, the algorithms necessary to manipulate them, and introduces the basic concepts of algorithmic complexity. Topics include elementary data structures, searching, sorting; hash tables, trees, graphs; time complexity, parallel algorithms basics.

### Compulsory/Recommended Readings:

- Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein: Introduction to Algorithms. Third Edition. The MIT Press, Cambridge, Massachusetts London, England, 2009
  - Donald E. Knuth: The Art of Computer Programming, volume 1. Third edition, Addison-Wesley, 1997
  - Donald E. Knuth: The Art of Computer Programming, volume 3. Second edition, Addison-Wesley, 1998
  - Seymour Lipschutz: Data Structures, McGraw-Hill, 2014
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# CALCULUS

INBPA0207-21

<b>Semester:</b>	2
<b>Type:</b>	Lecture / Seminar
<b>Number of Classes:</b>	2+2+0
<b>Credit:</b>	6
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	None
<b>Responsible:</b>	Dr. Mihály Bessenyei

## Topics:

Sequences and their properties. Continuity of real functions. Differentiation of functions, extrema, Taylor's expansion. Riemann integral of real functions. Applications of differential and integral calculus.

## Compulsory/Recommended Readings:

- Serge Lang, A first course in calculus, Undergraduate Texts in Mathematics, Springer-Verlag, 2012.
  - Serge Lang, Undergraduate analysis, Undergraduate Texts in Mathematics, Springer-Verlag, New York, 1997.
  - Thomas' Calculus, Addison Wesley (11th edition, 2005), ISBN: 0-321-24335-8
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## APPLIED STATISTICS

### INBPA0313-17

<b>Semester:</b>	3
<b>Type:</b>	Lecture / Laboratory
<b>Number of Classes:</b>	2+0+2
<b>Credit:</b>	6
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Exam
<b>Prerequisites:</b>	INBPA0207-21 (Calculus)
<b>Responsible:</b>	Dr. István Fazekas

#### Topics:

Statistical observations. Numerical and graphical characteristics of the sample. Fitting functions to observations (regression analysis). Randomness of observations. Event, relative frequency, probability.

Conditional probability, independence of events. Theorem of total probability, the Bayes theorem.

Discrete random variables. Binomial, hypergeometric, and Poisson distributions. Expectation and variance of discrete random variables. Applications. The general notion of random variables. Cumulative distribution function, probability density function. Expectation and variance. Uniform, exponential, normal distributions and their applications. Joint distributions. Correlation coefficient. Multivariate normal distribution. Laws of large numbers and the central limit theorem. Their visualizations and applications. Statistical estimators: unbiased and consistent estimators. Confidence intervals. Testing statistical hypotheses. The u- and the t-tests. Nonparametric tests. Regression analysis. Analysis of variance: one-way classification. Classifications: linear separation and clustering.

#### Compulsory/Recommended Readings:

- D.C. Montgomery, G. C. Runger: Applied Statistics and Probability for Engineers. Wiley, 2003.
- Dirk P. Kroese: A Short Introduction to Probability. University of Queensland.

## INTRODUCTION TO COMPUTER SCIENCE

INBPA0314-21

<b>Semester:</b>	3
<b>Type:</b>	Lecture / Seminar
<b>Number of Classes:</b>	2+2+0
<b>Credit:</b>	6
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Exam
<b>Prerequisites:</b>	INBPA0102-17 (Discrete mathematics)
<b>Responsible:</b>	Dr. György Vaszil

### Topics:

Basics of formal languages and automata theory. Operations on words and languages, generative grammars, generated languages. Chomsky hierarchy and language classes. Regular grammars, regular expressions, closure properties. Nondeterministic and deterministic finite automata. Push-down automata, Chomsky normal form, the Cocke-Younger-Kasami algorithm. Deterministic context-free languages, LL(k) and LR(k) parsers. Deterministic Turing machines, algorithm models, decidable and undecidable problems, time/space complexity. Nondeterministic Turing machines, the complexity classes P and NP.

### Compulsory/Recommended Readings:

- Géza Horváth, Benedek Nagy, Formal Languages and Automata Theory, Typotex, 2014.
  - John Martin: Introduction to Languages, and the Theory of Computation, 4th edition, McGraw-Hill, New York, NY, 2011.
  - Michael Sipser: Introduction to the Theory of Computation, Thomson, 2006.
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## APPLIED MATHEMATICS

### INBPA0417-21

<b>Semester:</b>	4
<b>Type:</b>	Seminar / Laboratory
<b>Number of Classes:</b>	0+2+2
<b>Credit:</b>	6
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0102-17 (Discrete mathematics)
<b>Responsible:</b>	Dr. Ágnes Baran

#### Topics:

Floating point arithmetic, errors. Perturbed linear systems, condition numbers of matrices. Numerical solution of system of linear equations. Least square approximations. Interpolation (Lagrange, Hermite, spline). Numerical integration. Eigenvalue problems, sparse matrices. Numerical solution of nonlinear equations and system of nonlinear equations. Minimization of functions. Solving Linear Programming problems (graphical solution, simplex method, Two-Phase simplex method). Duality and sensitivity analysis. Transportation and assignment problems. Solving optimization problems.

#### Compulsory/Recommended Readings:

- Gisbert Stoyan, Agnes Baran, Elementary Numerical Mathematics for Programmers and Engineers, Birkhäuser, 2016, ISBN 978-3-319-44659-2
  - W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery, Numerical Recipes, Cambridge UP, 2007 ISBN 978-0-521-88407-5
  - Wayne L. Winston Operations Research: Applications and Algorithms, ISBN-13: 978-0534380588, ISBN-10: 0534380581
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## FOUNDATIONS OF ARTIFICIAL INTELLIGENCE

### INBPA0418-21

<b>Semester:</b>	4
<b>Type:</b>	Lecture / Laboratory
<b>Number of Classes:</b>	2+0+2
<b>Credit:</b>	6
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Exam
<b>Prerequisites:</b>	INBPA0101-21 (Logic in computer science) and INBPA0211-21 (High-level programming languages 1)
<b>Responsible:</b>	Dr. Balázs Harangi

#### Topics:

Problem representations, state-space representation, state-space graph, examples. Uninformed systematic search in state-space graphs. Heuristic search strategies. Constraint satisfaction problems. Two-player games, representation of the game, game tree. Winning strategy. Min-max procedure, the alpha-beta pruning procedure. Knowledge representation: categories, objects, actions, situations, events, reasoning. Probabilistic reasoning (Bayesian networks). Tools of machine learning: learning from examples, statistical learning, perceptrons, neural networks, deep learning

#### Compulsory/Recommended Readings:

- Peter Norvig, Stuart J. Russell: Artificial Intelligence: A Modern Approach, 3rd edition, Pearson Education Limited, 2013. ISBN 129-202-420-8.
  - Pedro Domingos: The Master Algorithm, Basic Books; 1 edition, 2015
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## FOUNDATIONS OF COMPUTER SECURITY

**INBPA0419-17**

<b>Semester:</b>	4
<b>Type:</b>	Lecture / Laboratory
<b>Number of Classes:</b>	2+0+2
<b>Credit:</b>	6
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Exam
<b>Prerequisites:</b>	INBPA0211-21 (High-level programming languages 1)
<b>Responsible:</b>	Dr. Andrea Pintér-Husztí

### **Topics:**

Computer security concepts. The CIA triad. Physical and infrastructure security. Malicious software, DOS, firewalls. Encryption schemes, Caesar-, Vigenère-, substitution ciphers, OTP, DES, 3DES, AES, RSA. Digital signatures, PKI, Identification, authentication, authorization. The SSL/TLS protocol.

### **Compulsory/Recommended Readings:**

- William Stallings: Computer Security, Principles and Practice, 3. edition, 2015. ISBN-13: 978-0133773927
  - Douglas R. Stinson: Cryptography Theory and Practice, 3. edition, Chapman & Hall/CRC, 2006, ISBN-13 978-1-58488-508-5
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### **INTRODUCTION TO PROGRAMMING**

**INBPA0104-21**

<b>Semester:</b>	1
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	None
<b>Responsible:</b>	Dr. Péter Jeszenszky

#### **Topics:**

The goal of the subject is to demonstrate what is programming and how computer programs are made. Presenting the basic concepts and constructs of programming it aims at building basic level programming skills. Building and developing problem-solving and algorithmic skills necessary for programming is also a key objective of the subject. The following main topics are covered using a high-level programming language that supports procedural programming (e.g., C, C++, Python, Java, C#):

- Types, literals
- Operators, expressions
- Variables, assignment
- Statements
- Control structures
- Basic data structures of the programming language of the course (e.g., arrays, lists)
- Functions
- Basic I/O
- Other basic features of the programming language of the course (e.g., pointers)
- Writing simple programs
- Steps of creating executable programs
- Errors and bugs, debugging
- Basic level use of developer tools (e.g., an integrated development environment)

#### **Compulsory/Recommended Readings:**

- Robert C. Seacord. Effective C: An Introduction to Professional C Programming. No Starch Press, 2020.
- Bjarne Stroustrup. Programming: Principles and Practice Using C++. 2nd ed. Addison-Wesley Professional, 2014.

- John V. Guttag. Introduction to Computation and Programming Using Python. 3rd ed. MIT Press, 2021.
  - Eric Matthes. Python Crash Course: A Hands-On, Project-Based Introduction to Programming. 2nd ed. No Starch Press, 2019.
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## OPERATING SYSTEMS

INBPA0105-21

<b>Semester:</b>	1
<b>Type:</b>	Lecture / Laboratory
<b>Number of Classes:</b>	2+0+2
<b>Credit:</b>	6
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Exam
<b>Prerequisites:</b>	None
<b>Responsible:</b>	Dr. László Szathmáry

### Topics:

Concepts, tasks, and components of an operating system. Classification of the operating systems. Historical overview. Hardware, architectures. The Unix and the Linux operating systems. Boot sequence of Linux. Files and file systems. Special files under Unix. Redirection. Unix file systems. The i-node table. Extended File System. Filesystem Hierarchy Standard, a.k.a. the Unix directory structure. Process management. Signals. Priority, priority handling. Scheduling. File systems on Microsoft platforms (FAT, FAT32). The NTFS file system. Mobile operating systems.

### Compulsory/Recommended Readings:

- Abraham Silberschatz, Greg Gagne, Peter B. Galvin: Operating system concepts, John Wiley and Sons, 2011.
  - Andrew S. Tanenbaum, Albert S. Woodhull: Operating Systems Design and Implementation (3rd Edition), 2013.
  - Eric S. Raymond: The Art of UNIX Programming, 2003.
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## DATABASE SYSTEMS

INBPA0208-17

<b>Semester:</b>	2
<b>Type:</b>	Lecture
<b>Number of Classes:</b>	2+0+0
<b>Credit:</b>	3
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Exam
<b>Prerequisites:</b>	INBPA0101-21 (Logic in computer science)
<b>Responsible:</b>	Dr. Márton Ispány

### Topics:

Basic concepts: database, database system, database management system. Features, languages, interfaces, users of the DBMSs. Data modelling, abstraction. Entity, attribute, relationship. Features of the attributes and relationships. The relational model: relation schema, relation, integrity constraints.

The abstract query languages of the relational model. Functional dependency and its features. Basics of relational database design: normalization, normal forms (1NF, 2NF, 3NF). Higher normal forms (BCNF, 4NF, 5NF). Multivalued and join dependency. The entity-relationship model. Mapping the entity-relationship model into relational data model. The enhanced entity-relationship model. Mapping the enhanced entity-relationship model into relational data model. Object-relational databases, Transaction, privileges and concurrency control, Data warehouses, NoSQL databases, Basics of Big Data, visualization, Basics of database administration and tuning.

### Compulsory/Recommended Readings:

- Ramez Elmasri, Shamkant B. Navathe: Fundamentals of Database Systems (7th Edition), Pearson, 2015.
  - Nenad Jukic, Susan Vrbsky, Svetlozar Nestorov: Database Systems: Introduction to Databases and Data Warehouses, Prospect Press, 2016.
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## DATABASE SYSTEMS LAB

### INBPA0209-17

<b>Semester:</b>	2
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0101-21 (Logic in computer science)
<b>Responsible:</b>	Dr. Márton Ispány

#### Topics:

With using the selected relational database management system using and getting acquainted with the followings: SELECT statement and its parts (ORDER BY, WHERE, GROUP BY, grouping functions, HAVING, JOINS, subqueries, set operations). SQL functions. Data dictionary views. SQL DDL statements handling tables (CREATE, ALTER, DROP, TRUNCATE). SQL DML statements (INSERT, DELETE, UPDATE, MERGE). SQL DCL statements (COMMIT, ROLLBACK, SAVEPOINT, GRANT, REVOKE). Using other database objects.

#### Compulsory/Recommended Readings:

- Ramez Elmasri, Shamkant B. Navathe: Fundamentals of Database Systems (7th Edition), Pearson, 2015.
  - Viescas, Hernandez: SQL Queries for Mere Mortals, Addison-Wesley Professional, 2014.
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## NETWORK ARCHITECTURES AND PROTOCOLS

### INBPA0210-17

<b>Semester:</b>	2
<b>Type:</b>	Lecture / Laboratory
<b>Number of Classes:</b>	2+0+2
<b>Credit:</b>	6
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Exam
<b>Prerequisites:</b>	INBPA0104-21 (Introduction to programming) and INBPA0105-21 (Operating systems)
<b>Responsible:</b>	Dr. Szabolcs Szilágyi

#### Topics:

Basic notions, history of the data networks, classification of the networks. Layered architecture, network reference models (OSI, TCP/IP, hybrid), intermediate network nodes. Elements and characteristics of the physical layer. Signal coding and modulation technics. Data network topologies. Elements and characteristics of the data link layer. Mechanisms of the MAC sublayer. Static and dynamic channel access: FDM, TDM, ALOHA, slotted ALOHA, CDMA. LAN communication technologies: Ethernet (IEEE 802.3), token ring (IEEE 802.5). WAN communication technologies: SLIP, PPP, ISDN, ATM, DSL. IP network protocol: structure of the datagram, addressing system (classes, VLSM, CIDR), datagram switching. Dual addressing mechanisms: ARP, RARP, BOOTP, DHCP. IP address translation mechanisms: NAT, PAT. IPv6 addressing. Static and dynamic routing: DV, RIPv1, RIPv2, IGRP, EIGRP, Link-state routing, Dijkstra algorithm, IS-IS, OSPF, Inter-Area OSPF, DR, ABR functions. Transport layer protocols: segment structures of the UDP and TCP. TCP link management. Application layer protocols: DNS, FTP, TELNET, HTTP, SMTP, NTP, SNMP, RMON.

#### Compulsory/Recommended Readings:

- A. S. Tanenbaum, D. J. Wetherall: Computer Networks, 5th edition, Pearson, 2011.
  - James F Kurose; Keith W Ross: Computer networking: a top-down approach, Pearson, 2017.
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## HIGH-LEVEL PROGRAMMING LANGUAGES 1

### INBPA0211-21

<b>Semester:</b>	2
<b>Type:</b>	Lecture / Laboratory
<b>Number of Classes:</b>	2+0+2
<b>Credit:</b>	6
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Exam
<b>Prerequisites:</b>	INBPA0104-21 (Introduction to programming)
<b>Responsible:</b>	Dr. László Szathmáry

#### Topics:

The main goal of this course is to introduce basic programming concepts and tools with the use of a programming language that supports imperative programming. By the end of the semester, the students will be able to plan and implement simple programs, to read complex source codes and to proceed into an advanced course of programming.

The course covers the following basic programming tools. Compiler and interpreter. Variables, constants. Local and global variables. Scopes, lifetime. Control statements. Types, operators, operands. I/O tools. Functions, evaluation and pass-by techniques. Recursion, function call. Using the memory. Error handling; syntax and semantic errors. Command line arguments. Using libraries. Some thoughts will be given about basic computer science topics like Neumann-architecture, number systems, programming paradigms and history of programming languages.

The secondary aim of this course is to give an introduction into the tools and foundations of object oriented programming. The topics covered are: classes, objects, instantiation, constructors. Data and function members, inheritance, class hierarchies.

#### Compulsory/Recommended Readings:

- Brian W. Kernighan, Dennis M. Ritchie: The C Programming Language (2nd ed.). Englewood Cliffs, NJ: Prentice Hall, 1988
- Bjarne Stroustrup: The C++ Programming Language (4<sup>th</sup> edition), Addison-Wesley, 2013
- Kathy Sierra, Bert Bates: Head First Java (2<sup>nd</sup> ed.), O'Reilly, 2009
- Allen B. Downey: Think Python (How to Think Like a Computer Scientist), O'Reilly, 2012

## HIGH-LEVEL PROGRAMMING LANGUAGES 2

**INBPA0315-21**

<b>Semester:</b>	3
<b>Type:</b>	Seminar / Laboratory
<b>Number of Classes:</b>	0+2+2
<b>Credit:</b>	6
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0211-21 (High-level programming languages 1)
<b>Responsible:</b>	Dr. László Szathmáry

### **Topics:**

The main goal of this course is to give detailed insight into the tools of object oriented programming with the use of an object oriented programming language. By the end of the semester, the students will be able to write simple programs following the object oriented paradigm. The following topics will be covered: Data members and function members. Data hiding. Static methods and members. Inheritance, class hierarchies. Function overloading, polymorphism, overriding. Abstract classes, abstract methods. Packages, namespaces. Interfaces. Type conversions. Built-in types and reference types. Exceptions, exception handling.

The secondary aim of this course is to provide insights into the basics of functional programming tools (lambda expressions, e.g. streams), parallel programming and the programming of graphical user interfaces.

### **Compulsory/Recommended Readings:**

- Bjarne Stroustrup: The C++ Programming Language (4<sup>th</sup> ed.), Addison-Wesley, 2013
  - Herbert Schildt. Java: A Beginner's Guide (8<sup>th</sup> ed.), McGraw-Hill Education, 2018
  - Y. Daniel Liang: Introduction to Java Programming and Data Structures (11<sup>th</sup> ed.), Pearson, 2017
  - RB Whitaker: The C# Player's Guide (3rd ed.), Starbound, 2016
  - Allen B. Downey: Think Python (How to Think Like a Computer Scientist), O'Reilly, 2012
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## WEB TECHNOLOGIES

### INBPA0316-17

<b>Semester:</b>	3
<b>Type:</b>	Lecture / Laboratory
<b>Number of Classes:</b>	2+0+2
<b>Credit:</b>	6
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Exam
<b>Prerequisites:</b>	INBPA0104-21 (Introduction to programming)
<b>Responsible:</b>	Dr. Péter Jeszenszky

#### Topics:

The class introduces the basic concepts, architecture, standards, data formats (XML, JSON) and the operation (URI, HTTP) of the web. The HTML markup language, style-sheet languages (e.g., CSS, Less, Sass, Stylus), JavaScript, JQuery and the basics of responsive web design are also presented.

#### Compulsory/Recommended Readings:

- Ethan Brown. Learning JavaScript: JavaScript Essentials for Modern Application Development. O'Reilly Media, 2016.
  - Adam Freeman. The Definitive Guide to HTML5. Apress, 2011.
  - Peter Gasston. The Book of CSS3: A Developer's Guide to the Future of Web Design. 2nd ed. No Starch Press, 2014.
  - Ilya Grigorik. High Performance Browser Networking: What every web developer should know about networking and web performance. O'Reilly Media, 2013.
  - Peter Gasston. The Modern Web: Multi-Device Web Development with HTML5, CSS3, and JavaScript. No Starch Press, 2013.
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## SOFTWARE ENGINEERING AND TECHNOLOGIES

### INBPA0420-21

<b>Semester:</b>	4
<b>Type:</b>	Lecture / Laboratory
<b>Number of Classes:</b>	2+0+2
<b>Credit:</b>	6
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0315-21 (High-level programming languages 2)
<b>Responsible:</b>	Dr. Péter Jeszenszky

#### Topics:

The main goal of the course is to communicate knowledge required for designing and creating quality software, and also to introduce students with developer tools used widely in industrial software projects. The course covers the following major topics:

- Foundations of object oriented design, UML
- Patterns in software development, architectural patterns, design patterns
- Principles of object-oriented programming
- Clean code, code refactoring
- Software testing, test-driven development
- Software quality, software measurement, software metrics
- Software licenses, free and open source software

The following topics are discussed with the use of industry standard developer tools:

- Advanced version control, e.g., working with branches, workflows for team work (Git)
- Build automation and project management (e.g., Maven, Gradle)
- Issue tracking (e.g., GitHub Issues, Jira, Trello)
- Continuous integration, continuous deployment, continuous delivery (e.g., GitHub Actions, Jenkins)

#### Compulsory/Recommended Readings:

- Ian Sommerville. *Software Engineering*. 10th ed. Pearson Education, 2015.  
<http://iansommerville.com/software-engineering-book/>
- David Thomas, Andrew Hunt. *The Pragmatic Programmer, 20th Anniversary Edition*. 2nd ed. Addison-Wesley Professional, 2019.  
<https://pragprog.com/titles/tpp20/the-pragmatic-programmer-20th-anniversary-edition/>
- Martin Fowler. *Refactoring: Improving the Design of Existing Code*. 2nd ed. Addison-Wesley Professional, 2018.  
<https://martinfowler.com/books/refactoring.html>
- Robert C. Martin. *Clean Code: A Handbook of Agile Software Craftsmanship*. Prentice Hall, 2008



- Scott Chacon, Ben Straub. *Pro Git*. 2nd edition. Apress, 2014. <https://git-scm.com/book/en/v2>
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## SOFTWARE DEVELOPMENT METHODOLOGIES

### INBPA0521-17

<b>Semester:</b>	5
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0211-21 (High-level programming languages 1)
<b>Responsible:</b>	Dr. Attila Adamkó

#### Topics:

The aim of the subject is to introduce the software development process, software engineering methods (traditional, agile) and the tools and processes of software engineering.

#### Compulsory/Recommended Readings:

- Ian Sommerville: Software Engineering, Pearson Education, 10th edition, 2015
  - Kenneth S. Rubin: Essential Scrum: A Practical Guide to the Most Popular Agile Process (Addison-Wesley Signature Series (Cohn)),
  - Klaus Pohl, Chris Rupp: Requirements Engineering Fundamentals, Rocky Nook Inc.2015
  - Lisa Crispin, Janet Gregory: Agile Testing: A Practical Guide for Testers and Agile Teams, Addison-Wesley Professional, 2009
  - Andrew Stellman, Jennifer Greene: Learning Agile: Understanding Scrum, XP, Lean, and Kanban, 2014.
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## WEB APPLICATION DEVELOPMENT

### INBPA0522-21

<b>Semester:</b>	5
<b>Type:</b>	Lecture / Laboratory
<b>Number of Classes:</b>	0+2+2
<b>Credit:</b>	6
<b>Status:</b>	Obligatory
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0315-21 (High-level programming languages 2) and INBPA0316-17 (Web technologies)
<b>Responsible:</b>	Dr. Zoltán Godó

#### Topics:

In the class the students are introduced to the tools and processes of the development of web applications through the presentation and practice of technologies widely applied in the industry.

#### Compulsory/Recommended Readings:

- Jason Hunter, William Crawford: Java Servlet Programming, O'Reilly Media, 2011
  - Joel Murach & Michael Urban: Murach's Java Servlets and JSP, Mike Murach & Associates, 2014
  - Craig Walls: Spring in Action, Manning, 2014
  - Bill Burke: RESTful Java with JAX-RS 2.0, O'Reilly Media, 2009
  - Spring Framework Reference Documentation, 2016
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## ***Differentiated Knowledges***

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### **3D PRINTING AND MODELING**

**INBPA9924-17**

<b>Semester:</b>	2
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0103-17 (Computer aided mathematics and visualization)
<b>Responsible:</b>	Dr. Ildikó Papp

#### **Topics:**

The goal of this subject is to acquaint the students with the basic concepts of 3D printing and modeling, applicability of additive manufacturing in the industrial environment, through illustrative examples and practices. Related topics: Introduction from CAD to CAM, Fundamentals of 3D printing, FDM and other technologies, Preparing models to 3D printing, Fundamentals of 3D modeling, Advanced modeling techniques: parametric modeling, script-based and mesh based design, 3D scanning in model building, Applications of 3D printing (industry, healthcare, research etc.).

#### **Compulsory/Recommended Readings:**

- M. Amundsen, E. Arden, D. Lentz, P. Lyttle, L. Taalman: MakerBot in The Classroom, An Introduction to 3D Printing and Design, MakerBot Publishing, Brooklyn, NY, 2015. ISBN:9781495161759.
  - Matt Lombard: SolidWorks 2010 Bible, Wiley Publishing Inc., 2010. Indianapolis
  - ISBN: 978-047055481.
  - Al Williams: OpenSCAD for 3D Printing, CreateSpace Independent Publishing Platform, 2014, ISBN: 1500582476.
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## CLOUD COMPUTING

**INBPA9925-17**

<b>Semester:</b>	2
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0105-21 (Operating systems)
<b>Responsible:</b>	Dr. Tamás Bérczes

### **Topics:**

The goal of the subject is to provide an introduction to cloud computing (C2) topics, especially the software development in the cloud computing methods. Students will learn about cloud computing (C2) system and foundations. Get acquainted with the functioning of the Clouds, programming methods, as well as the management of common problems in the development.

### **Compulsory/Recommended Readings:**

- Rajkumar Buyya: Cloud Computing Principles and Paradigms, Wiley, 2011.
  - Roger Jennings: Cloud Computing with the Windows Azure Platform, Wrox, 2009.
  - Jurg van Vliet, Flavia Paganelli: Programming Amazon EC2, O'Reilly Media, 2011.
  - James Beswick: Google Apps Express: The Fast Way To Start Working in the Cloud, CreateSpace, 2011.
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## **BASICS OF GIS**

### **INBPA9926-17**

<b>Semester:</b>	2
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0103-17 (Computer aided mathematics and visualization)
<b>Responsible:</b>	Dr. Marianna Zichar, Bodroginé

#### **Topics:**

Representing, editing, handling, and analyzing vector and raster data using a geographic information system (styling, scale dependent visibility, automated update, classification, etc.). Projections, measuring, planning and performing network analysis. Publishing geospatial data on the web, special data formats. Applications of 3D models in GIS. Case studies.

#### **Compulsory/Recommended Readings:**

- Longley, Paul A. and Goodchild, M. F.: Geographic Information Science and Systems, Wiley, 2015, 978-1118676950
  - Fu, P. and Sun J.: Web GIS, Principles and applications, ESRI Press, 2011. 978-1589482456
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## BIOINFORMATICS

### INBPA9927-17

<b>Semester:</b>	3
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0206-17 (Data structures and algorithms)
<b>Responsible:</b>	Dr. Zoltán Attila Godó

#### Topics:

Learning opportunities for the application of information technology in the field of life sciences. Issues, problems and their solutions to biological information processing. Developing special IT approach, due to the nature of biological field of study.

#### Compulsory/Recommended Readings:

- Hassanien, Aboul Ella, Taher Azar, Ahmad (Eds.): Brain-Computer Interfaces, Current Trends and Applications. Springer, 2015.
  - N.C. Jones, A. Pavel, A. Pevzner: An Introduction to Bioinformatics Algorithms, MIT Press, 2004.
  - P. Baldi, S. Brunak, S. Brunak: Bioinformatics: The Machine Learning Approach, S.E. (Adaptive Computation and Machine Learning), MIT Press, 1998.
  - S. Letovsky: Bioinformatics: Databases and Systems, Springer-Verlag, 1999.
  - Stephen Hawking, Leonard Mlodinow: The Grand Design, Hardcover, 2010.
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## E-SPORT

### INBPA9928-21

<b>Semester:</b>	3
<b>Type:</b>	Lecture
<b>Number of Classes:</b>	2+0+0
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Exam
<b>Prerequisites:</b>	INBPA0211-21 (High-level programming languages 1)
<b>Responsible:</b>	Renátó Besenczi

#### Topics:

The goal of subject is to familiarize students with the world of e-sports. The topics are the followings. History of electronic games and the video game culture, 1337 cipher case study. Gaming industry, business models. Electronic game genres. MMOG, RPG, FPS, RTS and MOBA. Social/casual, mobile and competitive gaming. Linux gaming. Open source games. E-sports. Tiers of competitive gaming. Live event case studies (organized play with classmates). E-sports shoutcasting. E-sports spectating. Game broadcasting, streaming case study (OBS streaming to Twitch). E-sports communities. Organizing e-sports tournaments, organizing case study. Games and AI, AI and games case studies. E-sport analytics.

#### Compulsory/Recommended Readings:

- T. L. Taylor (2012) Raising the Stakes: E-Sports and the Professionalization of Computer Gaming. The MIT Press.
  - Juho Kuorikoski (2015) Finnish Video Games: A History and Catalog. McFarland.
  - Dal Yong Jin (2010) Korea's Online Gaming Empire. The MIT Press.
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## OPERATION OF INFOCOMMUNICATION SYSTEMS

### INBPA9929-17

<b>Semester:</b>	3
<b>Type:</b>	Lecture / Laboratory
<b>Number of Classes:</b>	2+0+2
<b>Credit:</b>	6
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0210-17 (Network architectures and protocols)
<b>Responsible:</b>	Dr. Szabolcs Szilágyi

#### Topics:

Explore the corporate networks. Network devices. Configure the network operating system. Physical layer. Twisted-pair communication standards, termination and testing tasks. Data Link layer. Ethernet. Network layer. IP configuration. IP subnetting. Transport layer. UDP. T•CP. Application layer. Introduction to switched networks. Basic switching concepts and configuration. VLANs. Inter-VLAN routing. Static and dynamic routing (RIP). Single-area OSPF. Standard and extended access control lists. DHCP. Network Address Translation for IPv4 (NAT). LAN design problems (exercises).

#### Compulsory/Recommended Readings:

- Wendell, Odom: CCENT/CCNA ICND1 100-105 Official Cert Guide, Cisco Press, 2016, ISBN: 978-1-58720-580-4.
  - Scott, Empson: CCNA Routing and Switching Portable Command Guide, 4th Edition, Cisco Press, 2016, ISBN: 978-1-58720-588-0.
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## IMAGE PROCESSING IN PRACTICE

INBPA9930-17

<b>Semester:</b>	3
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0211-21 (High-level programming languages 1)
<b>Responsible:</b>	Dr. Szilvia Szeghalmy

### Topics:

Overview of an image processing library. Basic structures. Loading, writing and displaying images. Working with video streams. Colour spaces, colour space conversions. Enhancement methods in spatial and frequency domain. Common morphological operators. Edge detectors. Image segmentation. Object detection/recognition using classifiers. Case studies.

### Compulsory/Recommended Readings:

- Kaehler, A., Bradski, G.: Learning OpenCV 3, O'Reilly Media, 2016, Ebook ISBN:978-1-4919-3794-5
  - Laganieri, R.: OpenCV 3 Computer Vision Application Programming Cookbook, 3rd ed., Packt Publishing, 2017, ISBN: 978-1-78646-971-7
  - Gonzales, R.C., Woods, R.E.: Digital image processing, 3rd ed. Prentice-Hall, Inc., 2008. ISBN-13: 978-0131687288.
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## HIGH-LEVEL PROGRAMMING LANGUAGES 3

INBPA9931-17

<b>Semester:</b>	3
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0211-21 (High-level programming languages 1)
<b>Responsible:</b>	Dr. János Pánovics

### Topics:

The basics of the functional programming paradigm (recursion, statelessness, referential transparency, function as value). General properties of languages implementing the elements of the functional programming paradigm (LISP, CLOS, ML, Scala, F#, Haskell, Clojure). Type systems in functional languages. Higher-order functions. Expressions. List handling. Tail recursion. Partial function application (currying). Function composition. Closure. Memoization. Pattern matching, evaluation strategies (lazy, eager). Functional data structures. Functional design patterns. Monoids, monads. Parallel and concurrent programming. Programming in multiparadigm languages.

### Compulsory/Recommended Readings:

- Paul Chiusano, Rúnar Bjarnason: Functional Programming in Scala, Manning, 2014, ISBN-13: 978-1617290657.
  - Tomas Petricek, Jon Skeet: Real-World Functional Programming: With Examples in F# and C#, Manning, 2010, ISBN-13: 978-1933988924.
  - Chris Smith: Programming F# 3.0, 2nd edition, O'Reilly, 2012, ISBN-13: 978-1449320294.
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## SCRIPTING LANGUAGES

**INBPA9942-17**

<b>Semester:</b>	3
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0211-21 (High-level programming languages 1)
<b>Responsible:</b>	Dr. László Szathmáry

### **Topics:**

Features of scripting languages. Classification of scripting languages. Fundamental data structures of scripting languages: string, dynamic array, associative array. Advanced string handling, regular expressions. Writing command-line applications. Replacing Bash scripts with higher level scripting languages. Connection with the operating system. Mixing procedural and object-oriented approaches. Functional and parallel programming in scripting languages. Connecting to databases. Writing simple graphical user interfaces (GUIs). Writing web applications with scripting languages.

After this course, students will be able to implement simple programs in a modern scripting language.

### **Compulsory/Recommended Readings:**

- Guido van Rossum: Python Tutorial, 2020
  - Brian d Foy, Tom Christiansen, et al.: Programming Perl, O'Reilly, 2012
  - David Flanagan, Yukihiro Matsumoto: The Ruby Programming Language, O'Reilly, 2008
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## INTRODUCTION TO 3D GAME DEVELOPMENT

INBPA9932-17

<b>Semester:</b>	4
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0103-17 (Computer aided mathematics and visualization) and INBPA0315-21 (High-level programming languages 2)
<b>Responsible:</b>	Dr. Kinga Tünde Kruppa

### Topics:

Introduction, game design principles, the most commonly used game engines and development platforms. The possibilities of the used game engine. Some key concepts from computer graphics, transformations, projections, animations, material properties, lighting, camera. Tools and software for using effects, sounds and models. Camera and scene settings. Physics models for describing movements, animations. Controlling objects. Graphical user interface. Scripts. Particle systems. Implementing the mentioned topics separately and all together through examples.

### Compulsory/Recommended Readings:

- Vahe Karamian: Introduction to Game Programming: Using C# and Unity 3D, Noorcon Inc., 2016. ISBN: 978-0997148404
  - Fletcher Dunn, Ian Parberry: 3D Math Primer for Graphics and Game Development (2nd Edition), A K Peters/CRC Press, 2011, ISBN: 978-1568817231
  - Jesse Schell: The Art of Game Design: A Book of Lenses (2nd Edition), A K Peters/CRC Press, 2014, ISBN: 978-1466598645
  - Jeremy Gibson Bond: Introduction to Game Design, Prototyping, and Development: From Concept to Playable Game with Unity and C# (1st Edition), Addison-Wesley Professional, 2014, ISBN: 978-0321933164
  - Katie Salen Tekinbaş, Eric Zimmerman: Rules of Play: Game Design Fundamentals, The MIT Press, 2003, ISBN: 978-0262240451
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## COMPILERS

### INBPA9933-17

<b>Semester:</b>	4
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0211-21 (High-level programming languages 1) and INBPA0314-21 (Introduction to computer science)
<b>Responsible:</b>	Dr. Géza Horváth

#### Topics:

Structure of the compilers, reader, extender, grammars, parsing, syntax tree, domain specific languages, source-source compilers, interpreters.

#### Compulsory/Recommended Readings:

- Matthew Butterick: Beautiful Racket 2017.
  - Torben Aegidius Mogensen: Basics of Compiler Design 2010.
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## MACHINE LEARNING IN PRACTICE

INBPA9934-17

<b>Semester:</b>	4
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0211-21 (High-level programming languages 1) and INBPA0313-17 (Applied statistics)
<b>Responsible:</b>	Dr. Márton Ispány

### Topics:

Mathematical foundations and basic Python skills. Overview of Python ecosystem. Scientific Python distributions (Anaconda) IDE: IPython, Jupyter notebooks. Numpy, Scipy, Matplotlib. A machine learning toolbox. Data reading and preprocessing. Dimension reduction and data visualization. Classification. Model selection. Application of classification: spam-filtering, image processing. Regression. Clustering. Clustering performance evaluation. Clustering applications: vector quantization, image segmentation, customer segmentation, text processing.

### Compulsory/Recommended Readings:

- A. C. Müller, S. Guido, Introduction to Machine Learning with Python: A Guide for Data Scientists. O'Reilly Media, 2016.
  - S. Raschka, Python Machine Learning. Packt Publishing Ltd. 2015.
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## ADVANCED DATABASE KNOWLEDGE

### INBPA9935-17

<b>Semester:</b>	4
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0209-17 (Database systems lab)
<b>Responsible:</b>	Dr. Anikó Vágner

#### Topics:

Getting acquainted with the structure (memory, storage, background processes) of the selected database management system (like Oracle), designing relational databases, creating and using advanced database objects, tuning techniques.

#### Compulsory/Recommended Readings:

- Mullins: Database Administration, Addison-Wesley, 2013
  - Ramez Elmasri, Shamkant B. Navathe: Fundamentals of Database Systems, Pearson, 2015.
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## NOSQL DATABASES

### INBPA9936-17

<b>Semester:</b>	4
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0209-17 (Database systems lab) and INBPA0315-21 (High-level programming languages 2)
<b>Responsible:</b>	Dr. Anikó Vágner

#### Topics:

The emergence of NoSQL databases, types of NoSQL databases (like graph, key-value, document, column-family), distributed models, consistency, features of each types of databases, case studies, creating the data structure, insert, update, delete data, query data, realization of distributed models, Map-reduce, developing a simple application.

#### Compulsory/Recommended Readings:

- NoSQL: Sadalage és Fowler: NoSQL Distilled, Addison-Wesley, 2013.
  - NoSQL: Sullivan: NoSQL for Mere Mortals, Addison-Wesley, 2015.
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## FUNDAMENTALS OF INFORMATION AND CODING THEORY

**INBPA9943-17**

<b>Semester:</b>	4
<b>Type:</b>	Lecture
<b>Number of Classes:</b>	2+0+0
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Exam
<b>Prerequisites:</b>	INBPA0313-17 (Applied statistics)
<b>Responsible:</b>	Dr. Sándor Baran

### **Topics:**

General scheme of telecommunication systems. Fundamentals of source coding (uniquely decipherable and prefix codes, efficiency, basic encoding algorithms). Universal source coding, Lempel-Ziv algorithms. Measure of information, entropy, conditional entropy, mutual information and their properties. Channel capacity. Search strategies. Encoding of general information sources, block encoding. Differential entropy. Fundamentals of error correcting coding. Linear codes.

### **Compulsory/Recommended Readings:**

- Cover, Thomas M. and Thomas, Joy A.: Elements of Information Theory. Wiley, 2006.
  - Togneri, Roberto and de Silva, Christopher J. S.: Fundamentals of Information Theory and Coding Design. Chapman & Hall/CRC, 2006.
  - Ash, Robert B.: Information Theory. Dover Publications, 1990.
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## MOBILE APPLICATION DEVELOPMENT

INBPA9937-17

<b>Semester:</b>	5
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0420-21 (Software engineering and technologies)
<b>Responsible:</b>	Renátó Besenczi

### Topics:

The aim of the subject is to introduce a mobile platform and the basics of mobile application development for the students.

### Compulsory/Recommended Readings:

- Kyle Mew: Android 5 Programming by Example, Packt Publishing, 2015.
  - Hoc Phan: Ionic 2 Cookbook, Packt Publishing, 2016.
  - Nathanael J. Anderson: Getting Started with NativeScript, Packt Publishing, 2016.
  - Dan Hermes: Xamarin Mobile Application Development: Cross-Platform C# and Xamarin. Forms Fundamentals, Apress, 2015.
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## COMPUTER STATISTICS

**INBPA9938-17**

<b>Semester:</b>	5
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0313-17 (Applied statistics)
<b>Responsible:</b>	Dr. Kinga Sikolya-Kertész

### **Topics:**

Solution of statistical problems, statistical data analysis, describing of database with the help of a statistical software.

### **Compulsory/Recommended Readings:**

- Montgomery, D. C. and Runger, G. C.: Applied Statistics and Probability for Engineers, Wiley, 2010.
  - P. Dalgaard: Introductory Statistics with R. Springer, 2008.
  - Everitt, B.S., Hothorn, T.: A Handbook of Statistical Analysis Using R, Chapman & Hall, 2014.
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## SOFTWARE TESTING

### INBPA9939-17

<b>Semester:</b>	5
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0420-21 (Software engineering and technologies)
<b>Responsible:</b>	Dr. Gergely Kocsis

#### Topics:

By this class the student are introduced to software testing, especially test automation and to the role of these topics. The students will know their place in the system development process and will be able to contribute in them. They will understand the methods and will be able to apply them.

#### Compulsory/Recommended Readings:

- Agile Testing: A Practical Guide for Testers and Agile Team, Addison-Wesley Professional, 2009.
  - Matt Wynne, Aslak Hellesøy: The Cucumber Book, Behaviour-Driven Development for Testers and Developers, Pragmatic Bookshelf, 2012.
  - Bayo Erinle: Performance Testing with Jmeter, Packt Publishing, 2015.
  - Greg Paskal: Test Automation in the Real World: Practical Lessons for Automated Testing, Independently published, 2017
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## ADVANCED DATA SECURITY

### INBPA9940-17

<b>Semester:</b>	6
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0419-17 (Foundations of computer security) and INBPA0522-21 (Web application development)
<b>Responsible:</b>	Dr. Csanád Bertók

#### Topics:

Wireshark network packet analyzer, Problems of web server configuration, Web server authentication, SSL certificates, Web application security, The OpenSSL cryptographic library: Digital signatures, Encrypting files, Secure communication.

#### Compulsory/Recommended Readings:

- Dafydd Stuttard, Marcus Pinto: The Web Application Hacker's Handbook: Finding and Exploiting Security Flaws, 2nd Edition, Wiley, 2011, ISBN: 978-1-118-02647-2.
  - Ivan Ristić: OpenSSL Cookbook, Second Edition, Feisty Duck, London, 2015.
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## ADVANCED WEB TECHNOLOGIES

### INBPA9941-17

<b>Semester:</b>	6
<b>Type:</b>	Laboratory
<b>Number of Classes:</b>	0+0+2
<b>Credit:</b>	3
<b>Status:</b>	Optional
<b>Assessment:</b>	Practical mark
<b>Prerequisites:</b>	INBPA0522-21 (Web application development)
<b>Responsible:</b>	Dr. Attila Adamkó

#### Topics:

In the class the students are introduced to the tools and processes of the development of web applications through the presentation and practice of technologies widely applied in the industry, especially front-end web application frameworks.

#### Compulsory/Recommended Readings:

- Ethan Brown: Learning JavaScript: JavaScript Essentials for Modern Application Development. O'Reilly Media, 2016.
  - Asim Hussain: Angular 4: From Theory To Practice: Build the web applications of tomorrow using the new Angular web framework from Google, CodeCraft, 2017.
  - Nathan Rozentals: Mastering TypeScript, Packt Publishing, 2017.
  - Shelley Powers: Learning Node: Moving to the Server-Side, O'Reilly Media, 2016.
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## BLOCKCHAIN TECHNOLOGY

**INBPA9951-17**

**Semester:**

**Type:** Lecture

**Number of Classes:** 2+0+0

**Credit:** 3

**Status:** Optional

**Assessment:** Exam

**Prerequisites:**

**Responsible:** Dr. Andrea Pintér-Husztí

**Topics:**

The primary aim of the course is to help students learn the basics of blockchain technology.

Week 1: Introduction to the basics of the blockchain - the history of the blockchain, the properties of the blockchain, the CAP theorem, the problem of Byzantine generals

Week 2: The cryptographic background of the blockchain - hash functions

Week 3: Blockchain structure and operation

Week 4: Blockchain transactions

Week 5: Blockchain consensus mechanisms

Week 6: Blockchain related applications - cryptocurrencies

Week 7: Blockchain related applications - contracts

Week 8: Technical challenges of the blockchain, suggestions and improvements

Week 9: Case studies: Ripple, WeTrade, Santander, Lo3 energy, Smartresume

Week 10: Blockchain-based applications

Week 11: The future of blockchains

Week 12: End-term Test

**Compulsory/Recommended Readings:**

- Nakamoto, Satoshi. "Re: Bitcoin P2P e-cash paper." The Cryptography Mailing List (2008).
- Swan, Melanie. Blockchain: Blueprint for a new economy. " O'Reilly Media, Inc.", 2015.
- Lacity, Mary C. Blockchain foundations: for the internet of value. Epic Books, 2020.



## INTRODUCTION TO REINFORCEMENT LEARNING

INBPA9955-17

**Semester:**

**Type:** Laboratory

**Number of Classes:** 0+0+2

**Credit:** 3

**Status:** Optional

**Assessment:** Practical mark

**Prerequisites:**

**Responsible:** Dr. László Kovács

### Topics:

By completing this course, students will learn about reinforcement learning (RL), its various applications and will also gain the minimum theoretical background of algorithms needed to solve real-world problems. Students will acquire knowledge in the following areas: the history of RL, similarities and differences between traditional machine learning and RL, basic concepts of RL (reward, exploration, exploitation, etc.), difficulties of RL, classic RL algorithms (Q-learning), deep learning-based RL algorithms (deep Q-learning, PPO, etc.). The algorithms presented in this course will be used in a variety of interactive, realistic environments (e.g. OpenAI Gym and Unity ML-Agents), providing students with important hands-on experience in implementing, fine-tuning and debugging several unique environments.

### Compulsory/Recommended Readings:

- Sutton, Richard S., and Andrew G. Barto. Reinforcement learning: An introduction. MIT press, 2018.
  - Wiering, M., & Van Otterlo, M. (2012). Reinforcement learning. Adaptation, learning, and optimization, 12(3).
  - Felicia, P. (2017). Unity From Zero to Proficiency (Foundations): A step-by-step guide to creating your first game with Unity (Vol. 1). Patrick Felicia.
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