UNIVERSITY of DEBRECEN

FACULTY OF INFORMATICS

4028 Debrecen, Kassai út 26., 4002 Debrecen, P.O.Box 400.
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COMPUTER SCIENCE BSC

Mode:	Full-time training
Program Coordinator:	Dr. Márton Ispány (ispany.marton@inf.unideb.hu)
Mentors:	Dr. Márk Kósa (kosa.mark@inf.unideb.hu)
	Dr. Magda Váterész (varteresz.magda@inf.unideb.hu)
Specialization:	-

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

Diploma credit requirements

Matematics and Computer Science		60 credits
Informatics		90 credits
Compulsory topics	54 credits	
Differentiated knowledges	36 credits	
Thesis		20 credits
Free choise subjects		10 credits
Work and fire safety training		0 credit
Physical Education (2 semesters)		0 credit
Total (number of credits required to obtain degree)		**180 credits**

Mathematics and Computer Science – needed 60 credits

Code	Subject name	Credit	Type and number			Assesment	Prerequisites	Period	Semester
			lec.	practice					
				sem.	lab				
INBPA0101E INBPA0101G	Logic in computer science	6	2	2		E S		1	1
INBPA0102E INBPA0102G	Discrete mathematics	6	2	2		PM		1	1
INBPA0103E INBPA0103L	Computer aided mathematics and visualization	6	2		2	PM		1	1
INBPA0206E INBPA0206G	Data structures and algorithms	6	2	2		E S	INBPA0101 INBPA0102	2	2
INBPA0207E INBPA0207G	Calculus	6	2	2		E S		2	2
INBPA0313E INBPA0313L	Applied statistics	6	2		2	E S	INBPA0207	1	3
INBPA0314E INBPA0314G	Introduction to computer science	6	2	2		E S	INBPA0102	1	3
INBPA0417L	Applied mathematics	6			4	PM	INBPA0102	2	4
INBPA0418E INBPA0418L	Foundations of artificial intelligence	6	2		2	E S	INBPA0101 INBPA0212	2	4
INBPA0419E INBPA0419L	Foundations of computer security	6	2		2	E S	INBPA0101 INBPA0210	2	4

Informatics (Compulsory topics) – needed 54 credits

Code	Subject name	Credit	Type and number			Assesment	Prerequisites	Period	Semester
			lec.	practice					
				sem.	lab				
INBPA0104L	Introduction to programming	3			2	PM		1	1
INBPA0105E INBPA0105L	Operating systems	6	2		2	PM		1	1
INBPA0208E	Database systems	3	2			E	INBPA0101	2	2
INBPA0209L	Database systems lab	3			2	PM	INBPA0101	2	2
INBPA0210E INBPA0210L	Network architectures and protocols	6	2		2	E S	INBPA0104 INBPA0105	2	2
INBPA0211E	High-level programming languages 1	3	2			E	INBPA0104	2	2
INBPA0212L	High-level programming languages 1 lab	3			2	PM	INBPA0104	2	2

Code	Subject name	Cre-dit	Type and number			Asses-ment	Prerequisites	Period	Semes-ter
			lec.	practice					
				sem.	lab				
INBPA0315L	High-level programming languages 2	6			4	PM	INBPA0212	1	3
INBPA0316E INBPA0316L	Web technologies	6	2		2	E S	INBPA0104	1	3
INBPA0420E INBPA0420L	Software engineering and technologies	6	2		2	PM	INBPA0315	2	4
INBPA0521L	Software development methodologies	3			2	PM	INBPA0212	1	5
INBPA0522L	Web application development	6			4	PM	INBPA0315 INBPA0316	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				
INBPA0623X	Thesis	20				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				
INBPA9924L	3D printing and modeling	3			2	PM	INBPA0103	2	2
INBPA9925L	Cloud computing	3			2	PM	INBPA0105	2	2
INBPA9926L	Basics of GIS	3			2	PM	INBPA0103	2	2
INBPA9927L	Bioinformatics	3			2	PM	INBPA0206	1	3
INBPA9928L	E-Sport	3			2	PM	INBPA0212	1	3
INBPA9929E INBPA9929L	Operation of infocommunication systems	6	2		2	PM	INBPA0210	1	3
INBPA9930L	Image processing in practice	3			2	PM	INBPA0212	1	3
INBPA9931L	High-level programming languages 3	3			2	PM	INBPA0212	1	3
INBPA9932L	Introduction to 3D game development	3			2	PM	INBPA0103 INBPA0315	2	4
INBPA9933L	Compilers	3			2	PM	INBPA0211 INBPA0212 INBPA0314	2	4

Code	Subject name	Cre-dit	Type and number			Asses-ment	Prerequisites	Period	Semes-ter
			lec.	practice					
				sem.	lab				
INBPA9934L	Machine learning in practice	3			2	PM	INBPA0212 INBPA0313	2	4
INBPA9935L	Advanced database knowledge	3			2	PM	INBPA0209	2	4
INBPA9936L	NoSQL databases	3			2	PM	INBPA0209 INBPA0315	2	4
INBPA9937L	Mobile application development	3			2	PM	INBPA0420	1	5
INBPA9938L	Computer Statistics	3			2	PM	INBPA0313	1	5
INBPA9939L	Software testing	3			2	PM	INBPA0420	1	5
INBPA9940L	Advanced data security	3			2	PM	INBPA0419 INBPA0522	2	6
INBPA9941L	Advanced web technologies	3			2	PM	INBPA0522	2	6

Free choice – needed 10 credits

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

Exam types: E exam
S signature
P practical mark

COMPUTER SCIENCE BSC

Description of Subjects

Mathematics and Computer Science

LOGIC IN COMPUTER SCIENCE

INBPA0101-17

Semester: 1
Type: Lecture / Seminar
Number of Classes: 2+2+0
Credit: 6
Status: Obligatory
Assessment: Exam
Prerequisites: None
Responsible: Dr. Magda Várterész

Topics:
Introduction examples. Exploring the logical structure of statements. Formalization in propositional logic. The language of propositional logic, its alphabet. Inductive definition of propositional formulas. The basic element of syntax: degree, (immediate) subformula, precedence of connectives, scope of connectives in a formula. Unary and binary logical operations, truth table. Concepts of semantics: interpretation, truth valuation in interpretations. Satisfiability and validity. Equivalent formulas. Consequences in propositional logic. Natural language reasoning. First-order logic languages. Examples. Inductive definition of terms and formulas. Syntax and semantics. Formalization in first-order logic. Free and bound occurrence of variables. Renaming bound variables, congruent formulas. Interpretations, variable assignment. Term and formula valuation. Satisfiable and valid first-order formulas and the contradiction. Equivalent first-order formulas. Conjunctive and disjunctive normal forms. Prenex form. First-order consequences. Checking the correctness of reasoning. Logical calculus (e.g. sequent calculus), soundness and completeness. Derivations in calculus. First-order logic languages and the programming languages: parallelism, applications, outlook.

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

Semester: 1
Type: Lecture / Seminar
Number of Classes: 2+2+0
Credit: 6
Status: Obligatory
Assessment: Practical mark
Prerequisites: None
Responsible: Dr. Pál Burai

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: Shaum outline of Theory and problems of discrete mathematics.

COMPUTER AIDED MATHEMATICS AND VISUALIZATION

INBPA0103-17

Semester: 1
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Obligatory
Assessment: Practical mark
Prerequisites: None
Responsible: 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

DATA STRUCTURES AND ALGORITHMS

INBPA0206-17

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

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

CALCULUS

INBPA0207-17

Semester: 2
Type: Lecture / Seminar
Number of Classes: 2+2+0
Credit: 6
Status: Obligatory
Assessment: Exam
Prerequisites: None
Responsible: 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

APPLIED STATISTICS

INBPA0313-17

Semester: 3
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Obligatory
Assessment: Exam
Prerequisites: INBPA0207-17 (Calculus)
Responsible: 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

INBPA0314-17

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

Topics:
Basics of formal languages and automata theory. Operations over words and languages, generative grammars, generated languages. Chomsky hierarchy and language classes. Regular grammars, regular expressions, closure properties. Nondeterministic and deterministic finite automata, linear time algorithms. Push-down automata, polinomial time algorithms, Chomsky normal form, CYK and Early algorithm. Deterministic context-free languages, LL(k) and LR(k) parsers, compilers and iterpreters.
Deterministic Turing machines, algorithm models. Linear bounded automaton, context-sensitive grammars. Undecidable problems, time/memory complexity. Nondeterministic Turing machines, NP, P, and other problems.

Compulsory/Recommended Readings:
• John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullman, Introduction to Automata Theory, Languages, and Computation (3rd ed.). Addison-Wesley, 2006.
• Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, Introduction to Algorithms (3rd ed.). MIT Press, 2009.
• Géza Horváth, Benedek Nagy, Formal Languages and Automata Theory, Typotex, 2014.

APPLIED MATHEMATICS

INBPA0417-17

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

Topics:
Floating point arithmetic, errors. Perturbed linear systems, condition numbers of matricies. 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 assignement 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

FOUNDATIONS OF ARTIFICIAL INTELLIGENCE

INBPA0418-17

Semester:	4
Type:	Lecture / Laboratory
Number of Classes:	2+0+2
Credit:	6
Status:	Obligatory
Assessment:	Exam
Prerequisites:	INBPA0101-17 (Logic in computer science) and INBPA0212-17 (High-level programming languages 1 lab)
Responsible:	Dr. Magda Várterész

Topics:
Problem representations, state-space representation, state-space graph, examples. Irrevocable search strategies, and applying in constraint satisfaction problems. Backtracking strategies, and applying in constraint satisfaction problems. Graph-search procedures: depth-first, breadth-first, optimal search strategies. Heuristic search algorithms: best-first and the A algorithms. Two-player games, representation of the game, game tree. Winning strategy. Min-max procedure, the alpha-beta pruning procedure. Problem-reduction representations and AND/OR graphs. Search procedures for AND/OR graphs. Knowledge representation techniques and uncertainty management (fuzzy logic). The resolution principle. Logic programming and SLD-resolution. Basic techniques in logic programming.

Compulsory/Recommended Readings:
• Peter Norvig, Stuart J. Russell: Artificial Intelligence: A Modern Approach, 3rd edition, Pearson Education Limited, 2013. ISBN 129-202-420-8.
• Peter Norvig, Stuart J. Russell: Artificial Intelligence: A Modern Approach

FOUNDATIONS OF COMPUTER SECURITY

INBPA0419-17

Semester:	4
Type:	Lecture / Laboratory
Number of Classes:	2+0+2
Credit:	6
Status:	Obligatory
Assessment:	Exam
Prerequisites:	INBPA0101-17 (Logic in computer science) and INBPA0210-17 (Network architectures and protocols)
Responsible:	Dr. Attila Pethő

Topics:
Computer security concepts. The CIA traid. Physical and infrastructure security. Malicious software, DOS, firewalls. Encryption schemes, Ceasar-, Vigenére-, 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

Informatics (Compulsory topics)

INTRODUCTION TO PROGRAMMING

INBPA0104-17

Semester: 1
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Obligatory
Assessment: Practical mark
Prerequisites: None
Responsible: Dr. Szilvia Szeghalmy

Topics:
Basic elements of operating systems, user-level operating system knowledge. Using the command line, manual pages, development tools. From the source code to execution. Compilers, interpreters, and the hybrid approach. Errors, types of errors, error messages. Syntax and semantics. Structural components of algorithms: sequencing, selection. Structural components of algorithms: iteration. Abstract data structures and elementary algorithms (traversal, searching, sorting). Program codes during execution (e.g., VisualGo). Basic programming language knowledge: data management, the concept of a variable. Working with standard input/output. Types, operations. Practice (simple data management). Basic programming language knowledge: expressions, statements. Basic programming language knowledge: working with arrays, pointer as a programming tool. Practice (control structures). Basic programming language knowledge: introducing the concept of a function, parameters, parameter passing, return value, environment. Scope of names. Recursion, recursive algorithms, self-referential structures. Practice (recursive codes). Interpreting, analyzing source codes.

Compulsory/Recommended Readings:

• Ivor Horton: Beginning C, 5th edition, Apress, 2013, ISBN-13: 978-1430248811.
• Brian W. Kernighan, Dennis M. Ritchie: C Programming Language, 2nd edition, Prentice Hall, 1988, ISBN-13: 978-0131103627.
• Narasimha Karumanchi: Data Structures and Algorithmic Thinking with Python, CareerMonk Publications, 2015, ISBN-13: 978-8192107592.
• Robert Sedgewick: Algorithms in C, Parts 1-5 (Bundle): Fundamentals, Data Structures, Sorting, Searching, and Graph Algorithms, 3rd edition, Addison-Wesley Professional, 2001, ISBN-13: 978-0201756081.

OPERATING SYSTEMS

INBPA0105-17

Semester: 1
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Obligatory
Assessment: Practical mark
Prerequisites: None
Responsible: 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. Virtualization. Cloud computing. 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.

DATABASE SYSTEMS

INBPA0208-17

Semester: 2
Type: Lecture
Number of Classes: 2+0+0
Credit: 3
Status: Obligatory
Assessment: Exam
Prerequisites: INBPA0101-17 (Logic in computer science)
Responsible: 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 relaional 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 enhanded entity-relationship model. Mapping the enhanced entity-relationship model into relational data model. Object-relational databases, Transaction, privileges and concurency controll, 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.

DATABASE SYSTEMS LAB

INBPA0209-17

Semester: 2
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Obligatory
Assessment: Practical mark
Prerequisites: INBPA0101-17 (Logic in computer science)
Responsible: Dr. Márton Ispány

Topics:
With using the selected relational database management system using and getting acuainted 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.

NETWORK ARCHITECTURES AND PROTOCOLS

INBPA0210-17

Semester:	2
Type:	Lecture / Laboratory
Number of Classes:	2+0+2
Credit:	6
Status:	Obligatory
Assessment:	Exam
Prerequisites:	INBPA0104-17 (Introduction to programming) and INBPA0105-17 (Operating systems)
Responsible:	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.

HIGH-LEVEL PROGRAMMING LANGUAGES 1

INBPA0211-17

Semester: 2
Type: Lecture
Number of Classes: 2+0+0
Credit: 3
Status: Obligatory
Assessment: Exam
Prerequisites: INBPA0104-17 (Introduction to programming)
Responsible: Dr. János Pánovics

Topics:
Evolution and classification of high-level programming languages. About programming paradigms. Formal syntax definition tools. Character set. Lexical units (delimiters, symbolic names, labels, comments, literals). Rules of constructing the source code, the role of space. Data types. Named constants. Variables. Expressions, operands and operators, precedence table. Declaration statements. Executable statements. Assignment, empty statement, jump statements. Two-way and multiple selection. Loop statements, types of loops and their applications. Control statements. Program units. Subprograms (procedures and functions). Call stack, recursion. Services of the runtime system. Parameter evaluation, parameter passing. Block. Scoping, accessibility. Compile unit. Abstract data type. Generic programming. I/O tools of programming languages, file handling. Basic concepts of exception handling, approaches and tools. Concepts of parallel programming. Foundations of the functional programming paradigm. Pros and cons of functional paradigm compared to imperative paradigm. Semantics of function evaluation (lazy, eager), interpreting functional programs. Functional language elements. Functions as values. Higher-order functions.

Compulsory/Recommended Readings:

• Robert W. Sebesta: Concepts of Programming Languages, 11th edition, Pearson, 2016, ISBN-13: 978-1292100555.
• Ivor Horton: Beginning C, 5th edition, Apress, 2013, ISBN-13: 978-1430248811.
• Brian W. Kernighan, Dennis M. Ritchie: C Programming Language, 2nd edition, Prentice Hall, 1988, ISBN-13: 978-0131103627.
• Tomas Petricek: Real-World Functional Programming: With Examples in F# and C#, Manning, 2010, ISBN-13: 978-1933988924.

HIGH-LEVEL PROGRAMMING LANGUAGES 1 LAB

INBPA0212-17

Semester: 2
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Obligatory
Assessment: Practical mark
Prerequisites: INBPA0104-17 (Introduction to programming)
Responsible: Dr. János Pánovics

Topics:
Introductory examples, writing simple C programs. Using constants and variables, data input, displaying data on the standard output. The relationship between a variable and the memory. Elementary arithmetic operations on integer and real numbers. Using named constants. The sizeof operator. Explicit type conversion. Further numeric types. Assignment using the op= operators. Mathematical functions. Two-way and multiple selection. Loop statements (for, while, do-while). Arrays. The & operator. Strings. Pointers. The relationship between pointers and arrays. Multidimensional arrays. Dynamic memory allocation. Program structure, writing own functions. Function pointers. Recursive functions. Functions for handling standard input and standard output. Structures. Working with files. The preprocessing system. Language tools for debugging and error handling. C++ language elements and programming tools.

Compulsory/Recommended Readings:
• Ivor Horton: Beginning C, 5th edition, Apress, 2013, ISBN-13: 978-1430248811.
• Brian W. Kernighan, Dennis M. Ritchie: C Programming Language, 2nd edition, Prentice Hall, 1988, ISBN-13: 978-0131103627.
• Bjarne Stroustrup: The C++ Programming Language, 4th edition, Addison-Wesley Professional, 2013, ISBN: 978-0321563842.

HIGH-LEVEL PROGRAMMING LANGUAGES 2

INBPA0315-17

Semester: 3
Type: Laboratory
Number of Classes: 0+0+4
Credit: 6
Status: Obligatory
Assessment: Practical mark
Prerequisites: INBPA0212-17 (High-level programming languages 1 lab)
Responsible: Dr. János Pánovics

Topics:
Basic concepts of object-oriented paradigm. Class, object, instantiation. Inheritance, class hierarchy. Polymorphism, method overloading. Scoping. Information hiding, accessibility levels. Abstract classes and interfaces. Modeling tools and languages. UML and its class diagram. Programming language elements of object-oriented languages: character set, lexical units, expressions, statements. The type system of object-oriented languages (e.g., Java, C#). Members of types: fields, (named) constants, properties, methods, events, operators, indexers, constructors, destructors, embedded types. Interfaces. Collections. Functional language elements. Lambda expressions. Handling data streams. Exception handling. I/O, file handling. Serialization. Reflection. Language elements supporting compilation and code generation (annotations, attributes). Multiparadigm languages. Programming in multiparadigm languages.

Compulsory/Recommended Readings:
• Robert W. Sebesta: Concepts of Programming Languages, 11th edition, Pearson, 2016, ISBN-13: 978-1292100555.
• Y. Daniel Liang: Introduction to Java Programming, 10th edition, Pearson, 2014, ISBN-13: 978-0133813463.
• Dan Clark: Beginning C# Object-Oriented Programming, Apress, 2013, ISBN-13: 978-1430249351.
• Bjarne Stroustrup: The C++ Programming Language, 4th edition, Addison-Wesley Professional, 2013, ISBN-13: 978-0321563842.

WEB TECHNOLOGIES

INBPA0316-17

Semester:	3
Type:	Lecture / Laboratory
Number of Classes:	2+0+2
Credit:	6
Status:	Obligatory
Assessment:	Exam
Prerequisites:	INBPA0104-17 (Introduction to programming)
Responsible:	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.

SOFTWARE ENGINEERING AND TECHNOLOGIES

INBPA0420-17

Semester: 4
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Obligatory
Assessment: Practical mark
Prerequisites: INBPA0315-17 (High-level programming languages 2)
Responsible: Dr. Péter Jeszenszky

Topics:
The aim of the subject is to make the student able to design, implement and test – less complex – software as parts of a team. The concepts and processes of advanced version control and build automation are also introduced. Besides these the students are introduced to more advanced programming language specific topics such as the tools of persistent data management (object-relational mapping, NoSQL, XML, JSON), basics of software testing, documentation, logging, internationalization (i18n) localization (l10n) and user interface design. During the course the fields of object oriented design, software metrics and software licenses are also introduced.

Compulsory/Recommended Readings:
• Norman Fenton, James Bieman: Software Metrics: A Rigorous and Practical Approach, Third Edition. CRC Press, 2014.
• Erich Gamma, Ralph Johnson, Richard Helm, John Vlissides: Design Patterns: Elements of Reusable Object-Oriented Software, Addison-Wesley Professional, 1994.
• Bernd Bruegge, Allen H. Dutoit: Object-Oriented Software Engineering Using UML, Patterns, and Java (3rd Edition), Pearson, 3rd edition, 2009.
• Christian Bauer, Gavin King: Java Persistence with Hibernate, Manning Publications, 2015.

SOFTWARE DEVELOPMENT METHODOLOGIES

INBPA0521-17

Semester:	5
Type:	Laboratory
Number of Classes:	0+0+2
Credit:	3
Status:	Obligatory
Assessment:	Practical mark
Prerequisites:	INBPA0212-17 (High-level programming languages 1 lab)
Responsible:	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.

WEB APPLICATION DEVELOPMENT

INBPA0522-17

Semester:	5
Type:	Laboratory
Number of Classes:	0+0+4
Credit:	6
Status:	Obligatory
Assessment:	Practical mark
Prerequisites:	INBPA0315-17 (High-level programming languages 2) and INBPA0316-17 (Web technologies)
Responsible:	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

Differentiated Knowledges

3D PRINTING AND MODELING

INBPA9924-17

Semester: 2
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0103-17 (Computer aided mathematics and visualization)
Responsible: 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, healtcare, 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.

CLOUD COMPUTING

INBPA9925-17

Semester: 2
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0105-17 (Operating systems)
Responsible: 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 com-puting (C2) system and foundations. Get acquainted with the functioning of the Clouds, pro-gramming 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.

BASICS OF GIS

INBPA9926-17

Semester:	2
Type:	Laboratory
Number of Classes:	0+0+2
Credit:	3
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INBPA0103-17 (Computer aided mathematics and visualization)
Responsible:	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

BIOINFORMATICS

INBPA9927-17

Semester: 3
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0206-17 (Data structures and algorithms)
Responsible: 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.

E-SPORT

INBPA9928-17

Semester:	3
Type:	Laboratory
Number of Classes:	0+0+2
Credit:	3
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INBPA0212-17 (High-level programming languages 1 lab)
Responsible:	Dr. Norbert Bátfai

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.

OPERATION OF INFOCOMMUNICATION SYSTEMS

INBPA9929-17

Semester: 3
Type: Lecture / Laboratory
Number of Classes: 2+0+2
Credit: 6
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0210-17 (Network architectures and protocols)
Responsible: 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. T1)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.

IMAGE PROCESSING IN PRACTICE

INBPA9930-17

Semester:	3
Type:	Laboratory
Number of Classes:	0+0+2
Credit:	3
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INBPA0212-17 (High-level programming languages 1 lab)
Responsible:	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
• Laganiere, 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.

HIGH-LEVEL PROGRAMMING LANGUAGES 3

INBPA9931-17

Semester:	3
Type:	Laboratory
Number of Classes:	0+0+2
Credit:	3
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INBPA0212-17 (High-level programming languages 1 lab)
Responsible:	Dr. Márk Szabolcs Kósa

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.

INTRODUCTION TO 3D GAME DEVELOPMENT

INBPA9932-17

Semester:	4
Type:	Laboratory
Number of Classes:	0+0+2
Credit:	3
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INBPA0103-17 (Computer aided mathematics and visualization) and INBPA0315-17 (High-level programming languages 2)
Responsible:	Dr. Roland Imre Kunkli

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
• Geremy 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

COMPILERS

INBPA9933-17

Semester:	4
Type:	Laboratory
Number of Classes:	0+0+2
Credit:	3
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INBPA0211-17 (High-level programming languages 1) and INBPA0212-17 (High-level programming languages 1 lab) and INBPA0314-17 (Introduction to computer science)
Responsible:	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 Mogersen: Basics of Compiler Design 2010.

MACHINE LEARNING IN PRACTICE

INBPA9934-17

Semester:	4
Type:	Laboratory
Number of Classes:	0+0+2
Credit:	3
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INBPA0212-17 (High-level programming languages 1 lab) and INBPA0313-17 (Applied statistics)
Responsible:	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.

ADVANCED DATABASE KNOWLEDGE

INBPA9935-17

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

NOSQL DATABASES

INBPA9936-17

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

Topics:
The emergence of NoSQL databases, types of NoSQL databases (like graph, key-value, document, column-family), distributed models, consistency, feautes 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: Sulliva: NoSQL for Mere Mortals, Addison-Wesley, 2015.

MOBILE APPLICATION DEVELOPMENT

INBPA9937-17

Semester: 5
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0420-17 (Software engineering and technologies)
Responsible: Tibor Balla

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.

COMPUTER STATISTICS

INBPA9938-17

Semester: 5
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0313-17 (Applied statistics)
Responsible: 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.

SOFTWARE TESTING

INBPA9939-17

Semester: 5
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0420-17 (Software engineering and technologies)
Responsible: 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

ADVANCED DATA SECURITY

INBPA9940-17

Semester:	6
Type:	Laboratory
Number of Classes:	0+0+2
Credit:	3
Status:	Optional
Assessment:	Practical mark
Prerequisites:	INBPA0419-17 (Foundations of computer security) and INBPA0522-17 (Web application development)
Responsible:	Dr. Andrea Huszti

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.

ADVANCED WEB TECHNOLOGIES

INBPA9941-17

Semester: 6
Type: Laboratory
Number of Classes: 0+0+2
Credit: 3
Status: Optional
Assessment: Practical mark
Prerequisites: INBPA0522-17 (Web application development)
Responsible: 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.