BSc in Computer Science

Mandatory Courses

Title of Course Unit	**Introduction to informatics**
Code	NBT_IM740K2, NBT_IM741G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2+2 (lectures +seminars)/60
Prerequisites	Good command of English
ECTS Credits	2 + 2
Language	English
Mandatory/Elective	Mandatory
Contact Person	Emőd Kovács (Responsible for Course: Emőd Kovács)
Course Description	Attributes of information, its transmission. Coding and decoding. Analogous and digital systems. Numerical systems, conversion rules. Main concepts of informatics, the digital computer as an information processing machine. Information representation on computer: bit, byte and their orders of magnitude; pointer, logic, textual and numerical data representations and their operations; code representation. Programming methods. Computer programming. Main concepts of machine code. Assembly and higher level programming languages. Computer architectures. Hardware, software: central processing unit, peripheral devices, storage devices. Operating systems. Developmental softwares, compilers, interpreters, syntax, semantics, programming languages.

	Common applications: word processing, presentations, spreadsheets, database management. Network basics. Using the Internet.
Readings	• H. H. Goldstine: A számítógép Pascaltól Neumannig. Műszaki Könyvkiadó, Budapest, 2003. • Csala P. - Csetényi A. - Tarlós B.: Informatika alapjai. Computerbooks, Budapest, 2001. • Andrew S.Tanenbaum: Számítógép architektúrák. Panem Könyvkiadó, Budapest 2001. • L. Snyder: Fluency with Information Technology: Skills, Concepts, and Capabilities
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**High-level programming languages 1**
Code	NBT_IM812K3, NBT_IM813G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2+2 (lectures +seminars)/60
Prerequisites	Good command of English
ECTS Credits	3 + 2
Language	English

Mandatory/Elective	Mandatory
Contact Person	Gergely Kovásznai (Responsible for Course: Gergely Kovásznai)
Course Description	Evolution of high-level programming languages. Classification of programming languages: imperative (procedural and object-oriented), declarative (functional and logic), and special languages. The use of a compiler, an interpreter and a virtual machine. Variables and constants. Data types (primitive and compound ones). Declarations. Literals, operators, expressions. Assignment statements. Conditional statements, multiple selections. Iteration statements, pre-test and post-test loops, the for-loop. Statement blocks. Scope and lifetime. Arrays (one-dimensional and multidimensional). List, stack and queue. Reference type, class and record, enumeration type. Methods (procedures and functions). Passing parameters, types of parameters. Input and output, dealing with files. The aim is to get acquainted with a procedural programming language.
Readings	● Neil Smyth: C# Essentials. Payload Media, 2012. ● C Sharp Programming. Wikibooks.org, 2013. ● Bruce Eckel: Thinking in Java. Prentice Hall, 2006. ● Robert W. Sebesta: Concepts of Programming Languages. Addison-Wesley, 2012.
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Automata and Formal Languages**

Code	NBT_PI110K3
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 (lectures)/30
Prerequisites	Good command of English
ECTS Credits	3
Language	English
Mandatory/Elective	mandatory
Contact Person	Roland Király (Responsible for Course: Roland Király)
Course Description	Main types of formal systems and automatons. Languages, grammars and normal forms. Relations between languages and automatons. Chomsky's language classification. Operations with languages and language algebra. Analysers and interpreters. Grammatical algorithms. How formal languages are linked to translational algorithms. The use of Chomsky's languages in IT. Lexers, parsers and syntax checking algorithms.
Readings	• John E. Hopcroft, Rajeev Motwani,Jeffrey D. Ullman: Introduction to Automata Theory, Languages, and Computation, 3/E, Prentice Hall 2006. • Király Roland: Formal languages and automatons TAMOP jegyzet TÁMOP-412/08/1/A-2009-0046 http://aries.ektf.hu/~hz/pdf-tamop/index.html

Assessment	Lecture: end-of-term oral exam.

Title of Course Unit	**Logical foundations of Computer Science**
Code	NBT_PI111K3, NBT_PI112G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures and seminars)/60
Prerequisites	Good command of English
ECTS Credits	3 + 2
Language	English
Mandatory/Elective	mandatory
Contact Person	Gábor Kusper (Responsible for Course: Gábor Kusper)
Course Description	This course covers two logics: propositional logic and predicate logic. It covers their syntax and semantics. We introduce the following notions: atomic formula, logical connectives, well-formed formula, interpretation of a formula, tautology, contradiction, satisfiable formula, literal, clause, conjunctive normal form (CNF), disjunctive normal form (DNF). We show how to transform any formula into CNF or DNF. In case of predicate logic we introduce the

	following notions: term, constant, variable, function symbol, predicate symbol, atomic formula, logic connectives, for-all quantifier, exists quantifier, well-formed formula, interpretation of a formula. We show how to prove the validity of a formula by Sequent calculus.
Readings	• Logic for Computer Science, http://en.wikibooks.org/wiki/Logic_for_Computer_Science, Publisher: Wikibooks 2010. • Uli Furbach: Logic for Computer Scientists, http://en.wikibooks.org/wiki/Logic_for_Computer_Scientists, Publisher: Wikibooks 2010.
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Calculus I**
Code	NBT_PI132K2, NBT_PI133G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures and seminars)/60
Prerequisites	Good command of English
ECTS Credits	2 + 2

Language	English
Mandatory/Elective	mandatory
Contact Person	Zay Béla (Responsible for Course: Zita Czapné Makó)
Course Description	Real sequences. Special limits, number e. Operations on convergent sequences. Monotonic and bounded sequences. Infinite sequences. Limit of a function, some important limits. Continuity. Differentiation: rules, derivatives of elementary functions. Mean value theorems, L'Hospital's rule, Taylor theorem. Curve sketching for a function, local and absolute extrema.
Readings	● Sterling K. Berberian: A First Course in Real Analysis, 1994 ● Howard Anton: Calculus 1989.
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Computer Architectures**
Code	NBT_PI157K3
Department	Department of Information Technology
Semester	Winter semester

Contact Hours Weekly/Total	2 (lectures)/30
Prerequisites	Good command of English
ECTS Credits	3
Language	English
Mandatory/Elective	mandatory
Contact Person	Péter Keresztes (Responsible for Course: Péter Keresztes)
Course Description	Computer generations. The internal structure of computers: storage,controller, processor, I / O system, channel, concept and system of bus parts. General microprocessor architecture model. Logical operations, values, logical functions. Graphic minimization, Karnaugh Veitch-. Simple combination of logical networks: multiplexer, demultiplexer, encoders, decoders, code converters, comperative units, parity creators and parity check units, adders. Risk of logic circuits. Elementary sequential networks: RS flip-flop, JK flip-flops, T flip-flop, flip-flop multi-vibrator, registers. Synchronous and asynchronous counters. Semiconductor memories: classification, working principle. Classification of machine-level instructions and execution, memory and I / O cycles. Execution of machine level control commands. Processor controlled and independent server operating condition. The computer I / O system. AD and DA converters, serial and parallel interfaces. Character and graphic visualization. Peripherals: keyboard, mouse, scanners, printers. Storages: magnetic disk, magnetic tape, optical storage devices. Classification of computers: SISD, SEMD, MED, MIMD, RISC, CISC machines. The structure and operation of transputer, machine-level instructions. Classification of the use of computers, parallel events, a parallel processor systems, parallel processing mechanisms. Parallel computer structures: pipeline computers, array processors,

	multiprocessor systems, execution of instructions. The structure and function of stream computers. I/O subsystems of multiprocessor systems: classification of interrupts. Skalar and vector processors. Vectorized processing features. SIMD array processors: the concept of connection network, data tuning mechanisms, topology of comnnection networks. Associative memory, associative array processing, associative processors.
Readings	● P. Theisz, G. Gunber, L. Jagudits, Digitális technika I., BME ● Patterson D.A., Henessy J.L.: Computer organization & Design, Morgan Kaufmann Publ. (2 ed.) 1998. ● Rob Williams: Computer System Architecture (A Networking Approach), Addison Wesley, 2001.
Assessment	Lecture: end-of-term oral exam.

Title of Course Unit	**Introduction to HTML**
Code	NBT_PI163K3
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 (lectures)/30
Prerequisites	Good command of English

ECTS Credits	3
Language	English
Mandatory/Elective	mandatory
Contact Person	Péter Szigetváry
Course Description	HTML5, syntax of tags and attributes. Writing standards-compliant and valid HTML pages. A comprehensive list and detailed usage patterns of elements in the following categories: sectioning, grouping, text-level, table, form, interactive and embedded. CSS syntax, fields of usage. Selectors, using CSS rules, specificity. Formatting and positioning of HTML elements and structures. CSS1/CSS2.1 extended with the CSS3 modules and attributes that are already implemented and commonly (browser independently) usable.
Readings	• http://www.w3.org/TR/html5/ • https://developers.whatwg.org/ • http://www.w3.org/TR/CSS21/ • http://www.w3.org/TR/CSS/#css3 • http://www.webplatform.org/
Assessment	Lecture: end-of-term oral exam.

Title of Course Unit	**Data structures and algorithms**
Code	NBT_IM711K3, NBT_IM712G2

Department	Department of Information Technology
Semester	Summer semester
Contact Hours Weekly/Total	2+2 (lectures +seminars)/60
Prerequisites	Good command of English and NBT_IM740K2 or any equivalent course.
ECTS Credits	3 + 2
Language	English
Mandatory/Elective	Mandatory
Contact Person	Gábor Geda (Responsible for Course: Gábor Geda)
Course Description	Steps of task resolution on a computer. Main concepts: principle of algorithm, structural units, attributes, data, data types. Algorithm describing tools. Classification of basic algorithms, implementations with describing tools and in an actual programming language. Theorems of summation, selection, decision, picking; searching (linear and logarithmic search) and sorting (direct, selection, bubble, insertion, shell, quicksort) algorithms. Basic concepts of algorithm efficiency. Principles of data types, their classification. Operations on data types (create, insert, delete, swap, sort, search, access, iterating , processing). Representation of data structures (continuous and distributed). Implementing data structures. Using data structures.
Readings	• T. H. Cormen, C. E. Leiserson, R. L. Rivest, C. Stein: Új algoritmusok. Scolar, 2003. • D. E. Knuth: A számítógépprogramozás művészete, 1. Kötet, Műszaki Könyvkiadó, 1988. • D. E. Knuth: A számítógépprogramozás művészete, 3. Kötet, Műszaki Könyvkiadó, 1990. • Bognár K.: Adatszerkezetek és algoritmusok. Egyetemi jegyzet. Debrecen, 1998.

	• Rónyai L., Ivanyos G., Szabó R.: Algoritmusok. Typotex, 1998. • Programozási feladatok I-II., Kossuth Kiadó, 1997. • G. Gonnet, R. Baeza-Yates: Handbook of algorithms and data structures. In Pascal and C., Addison-Wesley. 1991. • R. Sedgewick: Algorithms in C++, Addison-Wesley. 1991. • E. Horowitz, S. Shani: Fundamentals of Computer Algorithms, Computer Science Press, 1998.
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**High-level programming languages 2**
Code	NBT_IM814K3, NBT_IM815G2
Department	Department of Information Technology
Semester	Summer semester
Contact Hours Weekly/Total	2+2 (lectures +seminars)/60
Prerequisites	Good command of English and NBT_IM812K3, NBT_IM815G2, or any equivalent courses.
ECTS Credits	3 + 2
Language	English
Mandatory/Elective	Elective
Contact Person	Gergely Kovásznai (Responsible for Course: Gergely Kovásznai)

Course Description	Tools of object-oriented languages. Class, instance, encapsulation, information hiding. Instance resp. class variables and methods. Inheritance, polymorphism, early and late binding. Namespaces. Constructor, destructor, garbage collection. Abstract class, interface. Exception handling. Boxing and unboxing. Operator overloading. Generic types. Callback functions. The aim is to get acquainted with a object-oriented programming language.
Readings	● Neil Smyth: C# Essentials. Payload Media, 2012. ● C Sharp Programming. Wikibooks.org, 2013. ● Bruce Eckel: Thinking in Java. Prentice Hall, 2006.
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Discrete Mathematics I**
Code	NBT_PI116K2, NBT_PI117G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures and seminars)/60
Prerequisites	Good command of English

ECTS Credits	2 + 2
Language	English
Mandatory/Elective	mandatory
Contact Person	Tibor Juhász (Responsible for Course: Tibor Juhász)
Course Description	Sets, relations, functions. The concept of numbers. Natural numbers, integers, rationals and real umbers. Complex numbers, operations, polar coordinates, n-th roots. Polynomials, operations, evaluation, roots. Algebraic equations, the Fundamental Theorem of Algebra. Enumerative combinatirics, permutations and combinations, the Binomial and the Multinomial theorems. Operations with matrices. Determinant and its properties, expansion theorems. Vector spaces, subspaces, linear independence, generator system, basis, dimension. System of linear equations.
Readings	• T. Juhász: Discrete Mathematics, electronic lecture notes • L. Lovász, J. Pelikán, K. Vesztergombi: Discrete Mathematics, Elementary and Beyond, Springer, 2003, ISBN 978-0-387-21777-2 • P. Petersen, Linear Algbera, Springer, 2012, ISBN 978-1-4614-3612-6 • S. Treil: Linear algebra (Done wrong) http://www.math.brown.edu/~treil/papers/LADW/LADW.html
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Calculus 2**

Code	NBT_PI134K2, NBT_PI135G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures and seminars)/60
Prerequisites	Good command of English, and NBT_PI132K2 or equivalent course
ECTS Credits	2 + 2
Language	English
Mandatory/Elective	mandatory
Contact Person	Béla Zay (Responsible for Course: Zita Czapné Makó)
Course Description	Integral of functions of a single variable, properties of the Riemann integral. Methods of integration, integration by parts, integration by substitution. Integration in special classes of functions. The fundamental theorem of calculus (Newton-Leibniz formula), applications of the integral, improper integrals. Functions of two or more variables, partial derivatives, total differentials for functions of two variables. Double and triple integrals. Differential equations .
Readings	● Sterling K. Berberian: A First Course in Real Analysis, 1994 ● Howard Anton: Calculus 1989.

Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Operating Systems**
Code	NBT_PI148K3, NBT_PI149G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures and seminars)/60
Prerequisites	Good command of English and NBT_IM740K2, or equivalent course.
ECTS Credits	3 + 2
Language	English
Mandatory/Elective	mandatory
Contact Person	Ferenc Koczka (Responsible for Course: Ferenc Koczka)
Course Description	Hardware basic concepts in the view of operating systems: processors, memories, storage devices, peripherals, system interruption. Classification of operating systems. Components and functions of operating systems: system administration (CPU scheduling, interrupt handling, synchronization, process management, memory management, peripheral management, data management, networking, security system, operation records, operator interface), program development support (text editors, compilers, interpreters, library management, editor / loader, frameworks, runtime

	environments), application support (batch job control command language system, graphical user interface, system services, utilities, application software packages). Students will be introduced to basic tools and services in a modern operating system (for example:. Unix Windows Server).
Readings	● Silberschatz, Abraham, Operating system concepts, Addison-Wesley, c1994, xvi, 780 p.: ill.; 25 cm, ISBN 0 201 59292 4 ● Andrew S. Tanenbaum, Albert S. Woodhull, Operating systems; ● Upper Saddle River, NJ : Prentice-Hall, 1999, 980 p.: ill.; 24 cm ISBN 963 545 189 X ● Nutt, Gary J., Operating systems : a modern perspective, Addison-Wesley, 1997. - XXII, 630 S., ISBN 0-8053-1295-1
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Linear Algebra**
Code	NBT_GN100K2, NBT_GN101G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures and seminars)/60
Prerequisites	Good command of English, and NBT_PI116K2 or equivalent course
ECTS Credits	2 + 2

Language	English
Mandatory/Elective	mandatory
Contact Person	Tibor Juhász (Responsible for Course: Tibor Juhász)
Course Description	Linear mappings of vector spaces of finite dimension. Inner product. Euclidean space, ortogonality. Eigenvalues and eigenvectors, quadratic forms. Basic concepts in graph theory. Introduction to coding theory,
Readings	• R. E. Blahut: Algebraic codes for data transmission, Cambridge University Press, 2003, ISBN 0-521-55374-1 • S. Treil: Linear algebra (Done wrong) http://www.math.brown.edu/~treil/papers/LADW/LADW.html
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Probability Theory**
Code	NBT_GN102K2, NBT_GN103G2
Department	Department of Information Technology
Semester	Winter semester

Contact Hours Weekly/Total	2 + 2 (lectures and seminars)/60
Prerequisites	Good command of English, and NBT_PI134K2 or equivalent course
ECTS Credits	2 + 2
Language	English
Mandatory/Elective	mandatory
Contact Person	Tibor Tómács (Responsible for Course: Tibor Tómács)
Course Description	Elementary events, events, frequency, probability. Kolmogorov's axioms, probability space, properties of the probability. Classical probability space, combinatorics. Geometry probability space. Conditional probability, Bayes's theorem, independent events. Random variables and their properties. Discrete random variables and their distribution. Distribution function an their properties. Density function, absolutely continuous random variables. Important distributions (binomial, Poisson, hypergeometric, continuous uniform, exponential, normal). Weak laws of large numbers, Central Limit Theorem, De Moivre-Laplace Theorem.
Readings	● Charles M. Grinstead, J. Laurie Snell: Introduction to Probability. American Mathematical Soceity, 1998. ● A. N. Shiryayaev: Probability. Springer-Verlag New York Inc. 1984.
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Database systems**
Code	NBT_IM709K3, NBT_IM710G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2+2 (lectures +seminars)/60
Prerequisites	Good command of English and NBT_IM711K3 or any equivalent course.
ECTS Credits	3 + 2
Language	English
Mandatory/Elective	Mandatory
Contact Person	Tibor Radványi (Responsible for Course: Tibor Radványi)
Course Description	Traditional topics of data processing, the significance of database approach. The architecture of a general database system. Database administration, user groups. Levels of database design, data independence. Data modelling strategies. CODASYL recommendation, concepts of net modelling. The ER model: entity, attribute, relationship, type, occurrence, discriminator, model design tools. The relational model: relational scheme, relationship, integrity restrictions. Practical topics in relational modelling. Functional dependency, normalization, normal forms. Attributes of data definition (DDL) and data manipulation (DML) languages, separate and host language systems. Data manipulation in the relational model. Relation algebra and relation calculus. SQL language. Some theoretical questions and actual topics about data modelling. Realization of functional dependencies. Embedded models. Object-oriented techniques, parts of ODL.

	Familiarization with a specific database management system.
Readings	• R. Elmasri, S.B. Navathe, Fundamentals of Database Systems, The Benjamin/Cummings Publ. Co., Addison-Wesley World Student Series, 1994. • T. Radvanyi: Database Management System, lecture notes in http://aries.ektf.hu/~dream/e107/e107_files/downloads/dbms.pdf • Bob Bryla, Kevin Loney: Oracle Database 12c The Complete Reference, Oracle Press, 2013 • Ben Prusinski, Steve Phillips, Richard Chung: Expert Oracle GoldenGate, 2011
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Introduction to Computer Graphics**
Code	NBT_IM735K2, NBT_IM736G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures and seminars)/60
Prerequisites	Good command of English, and NBT_IM812K3, NBT_PI132K2 or equivalent courses
ECTS Credits	2 + 2
Language	English
Mandatory/Elective	mandatory
Contact Person	Emőd Kovács (Responsible for Course: Emőd Kovács)

Course Description	
Readings	•
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Design and Analysis of Algorithms**
Code	NBT_PI106K3, NBT_PI107G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures and seminars)/60
Prerequisites	Good command of English, and NBT_IM711K3 or equivalent course

ECTS Credits	3 + 2
Language	English
Mandatory/Elective	mandatory
Contact Person	Gábor Geda (Responsible for Course: Gábor Geda)
Course Description	
Readings	●
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Operating Systems 2**
Code	NBT_PI150K2, NBT_PI151G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures and seminars)/60
Prerequisites	Good command of English, and NBT_PI148K3 or equivalent course
ECTS Credits	2 + 2
Language	English
Mandatory/Elective	mandatory
Contact Person	Ferenc Koczka (Responsible for Course: Ferenc Koczka)
Course Description	Practical implementation of operating systems. Comparison of different types of operating systems and ones that running in different hardware platforms. Distributed systems. Comprehensive study of several system components (strategies, algorithms, tools, data structures): processes.
Readings	● Silberschatz, Abraham, Operating system concepts, Addison-Wesley, c1994, xvi, 780 p.: ill.; 25 cm, ISBN 0 201 59292 4 ● Andrew S. Tanenbaum, Albert S. Woodhull, Operating systems; Upper Saddle River, NJ : Prentice-Hall, 1999, 980 p. ISBN 963 545 189 X ● Nutt, Gary J., Operating systems : a modern perspective, Addison-Wesley, 1997. - XXII, 630 S., ISBN 0-8053-1295-1

	• William Stallings: Operating systems (Internals and design principles), Prentice Hall (4. ed.) 2001.
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Introduction to Statistics**
Code	NBT_GN104K2, NBT_GN105G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures and seminars)/60
Prerequisites	Good command of English, and NBT_GN102K2 or equivalent course
ECTS Credits	2 + 2
Language	English
Mandatory/Elective	mandatory
Contact Person	Tibor Tómács (Responsible for Course: Tibor Tómács)
Course Description	Introduction to mathematical statistical problems. Statistical spaces, simple random sample. Empirical distribution function, Glivenko–Cantelli theorem, empirical distribution of discrete random variable, empirical density function of absolutely continuous random variable by histogram. Statistic as function of the sample, important statistics. Parameters and statistics. Point estimation, unbiased and biased estimation of a parameter, better estimator in mean

	squared error. Interval estimation, confidence interval estimators of parameters of the normal distribution. Introduction to hypothesis testing. u-test, t-test, F-test, Scheffé-method, Chi-square-test. Simple linear regression and correlation.
Readings	• David M. Lane, David Scott, Mikki Hebl, Rudy Guerra, Dan Osherson, Heidi Ziemer: Introduction to Statistics, http://onlinestatbook.com/Online_Statistics_Education.pdf • Roger C. Plaffenberger, James H. Patterson: Statistical methods for business and economics, 1987, IRWIN, Homewood, Illinois.
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Numerical Methods**
Code	NBT_IM840K2, NBT_IM841G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures and seminars)/60
Prerequisites	Good command of English, and NBT_GN102K2 or equivalent course
ECTS Credits	2 + 2

Language	English
Mandatory/Elective	mandatory
Contact Person	Gábor Geda (Responsible for Course: Gábor Geda)
Course Description	
Readings	•
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Artificial Intelligence**
Code	NBT_PI100K3, NBT_PI101G2
Department	Department of Information Technology
Semester	Summer semester

Contact Hours Weekly/Total	2+2 (lectures +seminars)/60
Prerequisites	Good command of English and NBT_PI111K3, NBT_IM812K3 or any equivalent courses.
ECTS Credits	3 + 2
Language	English
Mandatory/Elective	Mandatory
Contact Person	Gábor Kusper (Responsible for Course: Gábor Kusper)
Course Description	AI researches, methods and achievements. Representing problems in state space, examples. Graph representation. Classification and setup of search systems. Not modifiable strategies. Backtrack algorithm. Graph search methods: breadth-first, depth-first, optimal searches. Heuristic graph searches: best-first and the A algorithm. Wholeness of the A algorithm. Problem reductive approach, represented with AND/OR graph. Solution in AND/OR graphs. Search strategies in an AND/OR graph: breadth, depth, AO algorithm. Listening for termination with labels. Fully described two player games, their representation with game trees. Existence of winning strategy. Minimax theorem, alpha-beta pruning. Basics of logic programming.
Readings	• Futó Iván (szerk.): Mesterséges intelligencia, Aula Kiadó, 1999. • S. J. Russell, P. Norvig: Mesterséges intelligencia modern megközelítésben, Panem-Prentice Hall, Budapest, 2000. ● Kósa Márk, Várterész Magda: A mesterséges intelligencia alapjai, elektronikus jegyzet, Debreceni Egyetem, 2003.
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Realization of Database Systems**
Code	NBT_PI105K2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 (lectures)/30
Prerequisites	Good command of English, and NBT_IM709K3 or equivalent course
ECTS Credits	2
Language	English
Mandatory/Elective	mandatory
Contact Person	Tibor Radványi (Responsible for Course: Tibor Radványi)
Course Description	Transaction and its properties. Error management system. The types of errors. Logging Techniques: nullity logging, logging, remedial, nullity / remedial logging. Archiving. Concurrency Control. Schedules and properties. Conflict sequencing legibility, prevention graphs. Blocking techniques. Two-phase locking. Different lock type and the compatibility matrix. Table of lock. The scheduler lock operation. Warning protocol. Tree Protocol. Scheduler based on the time-stamping operation. Variant timestamps. Scheduler based on the validation operation. The problem of dirty data. View-sequencing legibility. Deadlock management. Distributed databases, distributed commit, split lock. Long transactions.

Readings	● Hector Garcia, H. G. Molina, Jeffrey D. Ullman, Jennifer Widom : Database System Implementation
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Development Environments**
Code	NBT_PI152G2
Department	Department of Information Technology
Semester	Summer semester
Contact Hours Weekly/Total	2 (seminars)/30
Prerequisites	Good command of English and NBT_IM815G2 or any equivalent course.
ECTS Credits	2
Language	English
Mandatory/Elective	Mandatory
Contact Person	Gergely Kovásznai (Responsible for Course: Gergely Kovásznai)

Course Description	The aim: Getting acquainted with the usage and the services of integrated development environments (IDEs) and design tools. Getting to know the modern object-oriented technologies and to acquire practical skills. Learning about the evolution of programming languages and development tools. The content: Survey on the modern object-oriented technologies. Visual programming and graphical user interfaces (GUIs). GUI design. Simple and compound controls, layout, brushes, transformations, effects, animation, styles, templates, data binding. Developing rich internet applications, corresponding technologies (e.g., Flash, Silverlight). Object-relational mapping (ORM) technologies, on different platforms and XML data. Visual development and design tools. Debugging.
Readings	• Gergely Kovásznai, Csaba Biró: .NET Programming Technologies. EKF, 2014. • Matthew MacDonald: Pro WPF 4.5 in C# - Windows Presentation Foundation in .NET 4.5. Apress, 2012. • Adam Nathan: Windows Presentation Foundation Unleashed. Sams Publishing, 2006. • Robert Lair: Beginning Silverlight 5 in C#, Apress, 2012. • ActionScript 3.0 for Adobe Flash Professional CS5 – Classroom in a Book. Adobe Press, 2010.
Assessment	Seminars: student presentations, assignments.

Title of Course Unit	**Programming Technologies**
Code	NBT_PI153K2, NBT_PI154G2
Department	Department of Information Technology
Semester	Winter semester

Contact Hours Weekly/Total	2 + 2 (lectures and seminars)/60
Prerequisites	Good command of English, and NBT_IM815G2 or equivalent course
ECTS Credits	2 + 2
Language	English
Mandatory/Elective	mandatory
Contact Person	Gábor Kusper (Responsible for Course: Gábor Kusper)
Course Description	This course covers the following topics: object oriented design (OOD), design patterns, and best practices in software development. In the field of OOD we learn the following principles: Program to an interface, not an implementation (GOF1), Favor object composition over class inheritance (GOF2), Single Responsibility Principle (SRP), Open-Closed Principle (OCP), Liskov Substitutional Principle (LSP), Dependency Inversion Principle (DIP), and Hollywood Principle. In case of design patterns we learns the most basic patterns from the Gang-of-four book, like Strategy, Template Method, Observer, Factory Method, Singleton, Proxy, Decorator, Command. In case of best practices we learn about clean code and test driven development.
Readings	● Erich Gamma, Richard Helm, Ralph Johnson, John Vlissides: Design Patterns: Elements of Reusable Object-Oriented Software, 1995. ● Robert C. Martin: Clean Code, A Handbook of Agile Software Craftsmanship, 2008. ● Robert C. Martin, Micah Martin: Agile Principles, Patterns, and Practices in C#, July 30, 2006.
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Theory of Computation**
Code	NBT_PI156K3
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 (lectures)/30
Prerequisites	Good command of English, and NBT_IM711K3 or equivalent course
ECTS Credits	2
Language	English
Mandatory/Elective	mandatory
Contact Person	Gergely Kovásznai (Responsible for Course: Gergely Kovásznai)
Course Description	This course gives an introduction to computational complexity theory and covers the following topics: Turing machines, time and space complexity. The concept of simulation, corresponding theorems. Recursive languages and recursively enumerable languages, the connection between those language classes. Universal Turing machine and the proof of its existence. Church's thesis. Algorithmically unsolvable problems. RAM machines. Kolmogorov complexity and its applications. Complexity classes. Non-deterministic Turing machines. Theorems on time and space. The classes P and NP, and their relation to each other. The concept of a witness and the witness theorem for NP. Examples of NP languages. NP-complete problems. The SAT problem and other NP-complete problems.

Readings	● C. H. Papadimitriou: Computational Complexity. Addison-Wesley, 1993. ● T. H. Cormen, C. E. Leiserson, R.L. Rivest: Introduction to Algorithms. The MIT Press, 2009.
Assessment	Lecture: end-of-term oral exam.

Title of Course Unit	**Functional Programming Langugages**
Code	NBT_PI164G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	4 (seminars)/60
Prerequisites	Good command of English, and NBT_IM812K3 or equivalent course
ECTS Credits	2
Language	English
Mandatory/Elective	mandatory
Contact Person	Roland Király (Responsible for Course: Roland Király)

Course Description	The λ calculus calculating model serves the mathematical basis for functional languages. The most wide spread functional languages are Scheme, Haskell, F# and Erlang. The program constructs of functional languages are list comprehensions, tuples, partial function evaluation, pattern matching, tail recursion, strict and lazy function evaluation. Concurrent programming. Industrial usage of functional languages.
Readings	• Roland Király: Functional languages TÁMOP-412/08/1/A-2009-0046 http://aries.ektf.hu/~hz/pdf-tamop/index.html • Joe Armstrong.: Programming Erlang, Software for a Concurrent World 536 pages, 2007-07-01 ISBN: 978-1-93435-600-5 • Rinus Plasmeijer, Marko van Eekelen.: Clean Language Report Department of Software Technology University of Nijmegen Hilt - High Level Software Tools B.V. Nijmegen
Assessment	Seminars: two written tests

Title of Course Unit	**Operational Research**
Code	NBT_IM845K2, NBT_IM846G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures and seminars)/60
Prerequisites	Good command of English

ECTS Credits	2 + 2
Language	English
Mandatory/Elective	mandatory
Contact Person	Tibor Juhász (Responsible for Course: Tibor Juhász)
Course Description	History, mathematical modelling. Linear programming, graphical method, Fourier-Motzkin elimination. Standard form, simplex method. Duality. Transportation problem. Discrete programming, assignment problem. Branch & Bound method.
Readings	• T.S. Fergusson: Linear Programming, http://www.math.ucla.edu/~tom/LP.pdf • S.I. Gass: Linear programming: Methods and Applications (Fifth edition), Dover Publications INC. 2003.
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Software Development Technologies**
Code	NBT_PI102K2

Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 (lectures)/30
Prerequisites	Good command of English, and NBT_IM812K3 or equivalent course
ECTS Credits	2
Language	English
Mandatory/Elective	mandatory
Contact Person	Gábor Kusper (Responsible for Course: Gábor Kusper)
Course Description	This course covers the following topics: software crisis, software development methodologies, tools for software development. We learn the following methodologies: the waterfall method, V-model, Prototype model, Iterative methodologies, Rational Unified Process, Rapid Aplication Developmen, Agile methods, Extream Programming, Scrum, Kanban. In the field of tools we learn issue tracking, version tracking, ticket systems, bug tracking. We learn in details about GIT.
Readings	● Henrik Kniberg: Scrum and XP from the Trenches, InfoQ, 2007. ● Robert C. Martin: The Clean Coder, A Code of Conduct for Professional Programmers, 2011.

Assessment	Lecture: end-of-term oral exam.

Title of Course Unit	**Compilers**
Code	NBT_PI120K2, NBT_PI121G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures and seminars)/60
Prerequisites	Good command of English, and NBT_PI153K2 or equivalent course
ECTS Credits	2 + 2
Language	English
Mandatory/Elective	mandatory
Contact Person	Roland Király (Responsible for Course: Roland Király)
Course Description	The translation methods of imperative programming languages are analysed in this course. It deals with the theoretical construct of transation languages. The relationship between formal languages and translation programs. Lexical analysers. Table of symbols. Syntactic analysis, recursive method, stack automaton with table-driven analyser. Semantical analysers. Attribute translation grammars. Code generation and optimalization. Analysis algorythms. Constructing translation programs. Putting the lecture material into practice. The use of regular expressions for analysis. The program of C2 grammars.

Readings	• Király Roland: Formal languages and automatons TAMOP jegyzet TÁMOP-412/08/1/A-2009-0046 http://aries.ektf.hu/~hz/pdf-tamop/index.html
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Network Architectures and Protocols**
Code	NBT_PI126K2, NBT_PI127G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures and seminars)/60
Prerequisites	Good command of English, and NBT_PI150K2 or equivalent course
ECTS Credits	2 + 2
Language	English
Mandatory/Elective	mandatory
Contact Person	Roland Király (Responsible for Course: Roland Király)

Course Description	Network topologies and architectures. Transferring mediums, analogue and digital transfers (modems, coding systems). Switching systems. ISO OSI reference model, attributs of the layers in the TCP/IP model. ISDN architecture, ADSL interface. Channel distribution method (ALOHA protocols, CSMA, collision free, restricted protocols. Routing protocols and WLSM, NAT, PAT protocols. Services of the internet layer and session layer. TCP/IP protocol pair. (ARPANET, USENET, CSNET, BITNET, SNA). Modern wifi based technologies, sensors and sensor networks.
Readings	• Andrew S. Tanenbaum: Computer Networks, Fourth Edition, Prentice-Hall, 2002. • Fred Halsall: Data Communications, Computer Networks and Open Systems, Fourth • Edition. Addison-Wesley Publishers Ltd. 1996. • RFC Documentation - http://www.rfc-editor.org/
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Assembly**
Code	NBT_PI109K2, NBT_PI108G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures and seminars)/60
Prerequisites	Good command of English, and NBT_PI148K3 or equivalent course

ECTS Credits	2 + 2
Language	English
Mandatory/Elective	mandatory
Contact Person	Péter Keresztes (Responsible for Course: Péter Keresztes)
Course Description	The processor. Historical overview. The processor architecture. Memory Management. Interruptions. Peripherals. Addressing modes. Instruction set. The arithmetic co-processor. The compiler. Compilers. The structure of assembly source programs. Terms and symbols. Program segmentation. Symbolic constants. Data types and variables. Procedures, program modules. Macros. Control of compiling. Creating executable programs. The relationship between the operating system and software. Adjusting to high-level programming languages
Readings	• Randall Hyde: The Art of Assembler Language, Randall Hyde, 2003 • Randall Hyde: The Art of Assembler Language Programming, http://webster.cs.ucr.edu • Osborne: 80386/80286 Assembly Language Programming, Mc Graw-Hill, 1986. • T. Swan: Mastering Turbo Assembler, Howard W. Sams and Co. Carmel, IN, 1990
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Internet Tools and Services**

Code	NBT_PI113K2, NBT_PI165G1
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 1 (lectures and seminars)/45
Prerequisites	Good command of English, and NBT_IM814K3, NBT_PI126K2, NBT_PI150K2 or equivalent courses
ECTS Credits	2 + 2
Language	English
Mandatory/Elective	mandatory
Contact Person	Sándor Király (Responsible for Course: Sándor Király)
Course Description	The role, usage and implementation of the current assets of Internet on programming-oriented bases. Client-server and multi-tier architectures and the Internet. Text, image, audio, video management. Standards and protocols. Security and defense issues. Server-side and client-side programming. The role of databases. Web technologies: TCP/IP, HTTP, HTML, XML, DOM, CORBA. CGI scripts. JavaScript, PHP, Perl. Web services: SOAP, UDDI, WSDL. WCF applications.
Readings	● Tomas Erl, Service-Oriented Architecture: A Field Guide to Integrating XML and Web Services, Published Apr 16, 2004 by Prentice Hall. Part of the The Prentice Hall Service Technology Series from Thomas Erl series,SBN-10: 0-13-142898-5, ISBN-13: 978-0-13-142898-0 ● A.A.Puntambekar: Web technologies, Technical Publications, 2009, ISBN: 9788184316674 ● A.A.Puntambekar: Programming the Web, Technical Publications, 2009.

Assessment	Seminars: two practical tests Lecture: end-of-term oral exam.

Elective courses

Title of Course Unit	**Realization of Database Systems 2**
Code	NBT_PI104K2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 (lectures)/30
Prerequisites	Good command of English, and NBT_PI105K2 or equivalent course
ECTS Credits	2
Language	English
Mandatory/Elective	elective
Contact Person	Tibor Radványi (Responsible for Course: Tibor Radványi)
Course Description	Indices, the role of secondary structure indices, B trees, multi-dimensional indexes. Data cubes, OLAP. Fragment-based data structure. One-, two- and multi-threaded algorithms based on the wrapping. Sort-based algorithms.

	Automatic identification technology and its relationship databases. The bar code and RFID technology basics. Bar codes and the RFID. Automatic identification.
Readings	● Hector Garcia, H. G. Molina, Jeffrey D. Ullman, Jennifer Widom : Database System Implementation ● Robert C. Palmer: The Bar Code book ● Syed A. Ahnson, Mohhamad Ilyas: RFID Handbook: Applications, Technology, Security, and Privacy by Syed A. Ahson and Mohammad Ilyas ● Klaus Finkenzeller: RFID Handbook: Radio-Frequency Identification Fundamentals and Applications, ISBN-10: 0471988510
Assessment	Lecture: end-of-term oral exam.

Title of Course Unit	**Advanced DBMS**
Code	NBT_PI124K2, NBT_PI125G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures + seminars)/60
Prerequisites	Good command of English, and NBT_IM709K3 or equivalent course
ECTS Credits	2 + 2
Language	English

Mandatory/Elective	elective
Contact Person	Tibor Radványi (Responsible for Course: Tibor Radványi)
Course Description	PL / SQL, Oracle's procedural language management. The PL / SQL core. Data Types and conversions. Expressions. Executable instructions, control structure. SQL Statements in PL / SQL. The structure of a PL / SQL program. Blocks and subprograms. Managing Scope and life. Running a PL / SQL program. Built-in functions. Exception handling. Stored subprograms. Cursors, kurzorváltozók. Packages. Transaction management. Triggers. Testing. The native dynamic SQL. Built-in packages. Application Development in PL / SQL. Oracle to achieve Visual.Net system. The C # language elements, and opportunities. Application Development in C #.
Readings	● Bob Bryla, Kevin Loney: Oracle Database 12c The Complete Reference ● Ben Prusinski, Steve Phillips, Richard Chung: Expert Oracle GoldenGate
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**SQL Server Programing**
Code	NBT_PI167K2, NBT_PI166G2
Department	Department of Information Technology

Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures + seminars)/60
Prerequisites	Good command of English, and NBT_IM709K3 or equivalent course
ECTS Credits	2 + 2
Language	English
Mandatory/Elective	elective
Contact Person	Tibor Radványi (Responsible for Course: Tibor Radványi)
Course Description	TSQL, MSSQL procedural interface languages. The basic elements of TSQL. Data types, conversions. Expressions. Executable instructions and control structure. TSQL in SQL statements. The structure of a TSQL program. Blocks and subprograms. Manage Scope and life. TSQL run a program. Built-in functions. Exception handling. Stored subprograms. Cursors, kurzorváltozók. Transaction management. Triggers. Testing. Visual Studio and MSSQL relationship
Readings	● Leonard Lobel, Andrew J. Brust, Stephen Forte: Programming Microsoft SQL Server 2008 (PRO-Developer) 950 p. ● Ross Mistry, Stacia Misner: Introducing Microsoft SQL Server 2012 ● Itzik Ben-Gan: Microsoft SQL Server 2012 T-SQL Fundamentals, 2012
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Dynamic Web Programing**
Code	NBT_PI115G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 (seminars)/30
Prerequisites	Good command of English
ECTS Credits	2
Language	English
Mandatory/Elective	elective
Contact Person	Sándor Király (Responsible for Course: Gergely Kovásznai)
Course Description	Creation of dynamic websites. HTML-code generating with PHP programs. Implementation of PHP and HTML. Creation of web applications, creation of system–administration interfaces. Introduction to the remote-access of databases, creation of forms for database fields. Login and registration system, and usage of user interactions. Practical programming tasks on the Web with PHP and JavaScript languages. HTML output generator, creation of database-based websites. Introduction to creating web portals.
Readings	● David Powers: PHP Solutions: Dynamic Web Design Made Easy, Friendsof and Apress company, ISBN-13: 978-1430232490 ● Kevin Tatroe, Peter MacIntyre, Rasmus Lerdorf: Programming PHP, 3rd Edition Creating Dynamic Web Pages, O'Reilly Media, 2013, ISBN:978-1-4493-9277-2 ISBN 10:1-4493-9277-6

	• David Sawyer McFarland: JavaScript & jQuery: The Missing Manual, 3rd Edition, O'Reilly Media, 2014, ISBN: 978-1-4919-4707-4 ISBN 10:1-4919-4707-1
Assessment	Seminars: two practical tests

Title of Course Unit	**Effectiveness of Networks**
Code	NBT_PI129K2, NBT_PI128G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures + seminars)/60
Prerequisites	Good command of English, and NBT_PI126K2 or equivalent course
ECTS Credits	2 + 2
Language	English
Mandatory/Elective	elective
Contact Person	(Responsible for Course: Roland Király)
Course Description	

Readings	●
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Server Administration**
Code	NBT_PI159G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 (seminars)/30
Prerequisites	Good command of English, and NBT_PI126K2 or equivalent course
ECTS Credits	2
Language	English

Mandatory/Elective	elective
Contact Person	Gábor Kovács (Responsible for Course: Roland Király)
Course Description	The main objective of this course is the acquisition of deep knowledge of current server environment (eg. operating system or database server). During the course students solve special tuning and administration problems and tasks focusing practical applications after mastering the basic theoretical knowledge.
Readings	● Lars Wirzenius, Joanna Oja, Stephen Stafford, Alex Weeks - The Linux System Administrator's Guide; ● Apache Software Foundation - Apache HTTP Server Documentation
Assessment	Seminars: two written tests

Title of Course Unit	**CISCO CCNA1**
Code	NBT_PI168K2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 (lectures)/30

Prerequisites	Good command of English, and NBT_PI126K2 or equivalent course
ECTS Credits	2
Language	English
Mandatory/Elective	elective
Contact Person	Roland Király (Responsible for Course: Emőd Kovács)
Course Description	This course offers a practical lead-in to the world of networks and the internet, with the use of devices most commonly available in home networks and small enterprises. With its numerous applications, the online material helps to acquire the skills for planning and building basic networks. The course prepares for tasks in connection with installing home networks and provides sustainable knowledge for professions linked to home network installment.
Readings	● Cisco.netacad.net
Assessment	Lecture: end-of-term oral exam.

Title of Course Unit	**Geometric Modeling**
Code	NBT_PI122K2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 (lectures)/30
Prerequisites	Good command of English, and NBT_IM735K2 or equivalent course
ECTS Credits	2
Language	English
Mandatory/Elective	elective
Contact Person	Miklós Hoffmann (Responsible for Course: Miklós Hoffmann)
Course Description	Basic concepts of shape design in computer aided geometric modeling and computer graphics. Foundations of CAD systems: spline curves and surfaces, from Bézier curves through B-spline curves to NURBS. Subdivision curves and surfaces: various approximatory and interpolatory subdivision schemes. Data structures for large poyhedra in subdivision: winged-edge and half-edge method. Shading methods: flat shading, Gouraud shading, Phong shading.
Readings	● Piegl, L., Tiller, W.: The NURBS Book, Springer Verlag, Berlin, 2005 ● Subdivision for modeling and animation, SIGGRAPH online course notes, 2000

Assessment	Lecture: end-of-term oral exam.

Title of Course Unit	**Computer Graphics**
Code	NBT_PI138K2, NBT_PI139G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures + seminars)/60
Prerequisites	Good command of English, and NBT_IM735K2 or equivalent course
ECTS Credits	2 + 2
Language	English
Mandatory/Elective	elective
Contact Person	Emőd Kovács (Responsible for Course: Emőd Kovács)
Course Description	

Readings	●
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Multimedia Authoring Systems**
Code	NBP_MI828K2, NBP_MI829G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures + seminars)/60
Prerequisites	Good command of English
ECTS Credits	2 + 2
Language	English
Mandatory/Elective	elective
Contact Person	Péter Tömösközi (Responsible for Course: Bálint Gergely Szabó)

Course Description	**Objectives**: During the course, students will learn about the general characteristics of the authoring systems used in the multimedia development and the usage of a particular system named NeoBook 5. The course is intended to provide a general overview of the features of authoring systems, as well as demonstrating the possibilities of application development by using a specific authoring system. **The curriculum** Types and characteristics of multimedia authoring systems. The characteristics of frame-based systems. An overview of the userinterface of NeoBook 5 Creating the first presentation. Properties lists, inserting and renaming. The Push button and the use of the Image and Scrolling article controllers. Introductions to the NeoBook programming basics. Using the command editor. Goto ... commands. Variables, branches and cycles in NeoBook. Managing arrays, reading lines of text files with NeoBook commands. Using the built-in text editor of NeoBook. Characteristics of RTF files and their roles in multimedia authoring systems. Using List fields and Combo boxes. Using Radio buttons and selection boxes. Creation and evaluation of closed-end test. Use of TrackBar, Web browser, flash movie and animated gif. Container and Polygon tools. Creation of own menu and toolbar in presentations. The built-in predefined variables of NeoBook Advanced multimedia presentation design and the steps of the implementation. Application development by using NeoBook. The NeoBook limitations.
Readings	● Neobook: http://www.neosoftware.com/nbw.html

Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Cryptography**
Code	NBT_IM806K3
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 (lectures)/30
Prerequisites	Good command of English
ECTS Credits	2
Language	English
Mandatory/Elective	elective
Contact Person	Tibor Radványi (Responsible for Course: Kálmán Liptai)
Course Description	Basic concepts of cryptography. Symmetric, asymmetric cryptosystems. Offset, linear system, DES, RSA, ECC, AES. Basic cryptographic protocols. Digital signature. Presentation of PGP.

Readings	● H. J. Menezes, P. C. Kis van Oorschot, S. A. Vanstone: Handbook of applied cryptography, CRC Press, 1997. ● Christof Paar , Jan Pelzl, Bart Preneel: Understanding Cryptography: A Textbook for Students and Practitioners ● Jonathan Katz, Yehuda Lindell: Introduction to Modern Cryptography: Principles and Protocols
Assessment	Lecture: end-of-term oral exam.

Title of Course Unit	**Computer Algebra Systems**
Code	NBT_IM800G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 (seminars)/30
Prerequisites	Good command of English, and NBT_GN100K2 or equivalent course
ECTS Credits	2
Language	English
Mandatory/Elective	elective
Contact Person	Tibor Juhász (Responsible for Course: Kálmán Liptai)

Course Description	Historical review. Algorithms for algebraic and number theoretic problems. Introduction to some Computer Algebra Systems (e.g. GeoGebra, Maple, Mathematica). Programming of Computer Algebra Systems.
Readings	• Maple manual: http://www.maplesoft.com/documentation_center/ • GeoGebra manual: http://wiki.geogebra.org/en/Manual • André Heck: Introduction to Maple, Springer-Verlag, 2003 • Geddes-Czapor-Labahn: Algorithms for Computer Algebra, Kluwer Academic, 1992
Assessment	Seminars: two written tests

Title of Course Unit	**Interactive Information Systems**
Code	NBT_PI169K2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 (lectures)/30
Prerequisites	Good command of English, and NBT_PI110K3, NMT_IM812K3 or equivalent courses

ECTS Credits	2
Language	English
Mandatory/Elective	elective
Contact Person	István Fazekas (Responsible for Course: Gergely Kovásznai)
Course Description	
Readings	•
Assessment	Lecture: end-of-term oral exam.

Title of Course Unit	**Foundations of Robotics**
Code	NBT_PI172K2, NBT_PI171G2
Department	Department of Information Technology

Semester	Winter semester
Contact Hours Weekly/Total	2 + 2 (lectures + seminars)/60
Prerequisites	Good command of English, and NBT_PI100K3 or equivalent course
ECTS Credits	2 + 2
Language	English
Mandatory/Elective	elective
Contact Person	Gábor Geda (Responsible for Course: Gábor Geda)
Course Description	
Readings	●
Assessment	Seminars: two written tests Lecture: end-of-term oral exam.

Title of Course Unit	**Artificial Neural Networks**
Code	NBT_PI144K2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 (lectures)/30
Prerequisites	Good command of English, and NBT_PI100K3 or equivalent course
ECTS Credits	2
Language	English
Mandatory/Elective	elective
Contact Person	Tibor Tajti (Responsible for Course: Miklós Hoffmann)
Course Description	Problem solving, learning. Human brain. A model of human brain. The idea of artificial neural network. Typical applications. Perceptron, multilayer perceptron. Feedforward neural network. Recurrent neural network. Supervised learning. Unsupervised learning. Design and development steps of error backpropagation algorithm. Design and development steps of self-organizing map. Performance questions.
Readings	● Raúl Rojas: Neural Networks – A systematic introduction ● Simon Haykin: Neural Networks - A Comprehensive Foundation ● LeCun, Bottou, Orr, Müller: Efficient Backprop

Assessment	Lecture: end-of-term oral exam.

Title of Course Unit	**Digital Image Processing**
Code	NBT_PI114G2
Department	Department of Information Technology
Semester	Winter semester
Contact Hours Weekly/Total	2 (seminars)/50
Prerequisites	Good command of English
ECTS Credits	2
Language	English
Mandatory/Elective	elective
Contact Person	Sándor Király
Course Description	Model of the human vision. Digitalization. Histogram-transformation: scratching, balancing, tresholding. The convolution and its applications: average filters, rank filters, smooth, edge detections, sharpening. Integral transformations: Fourier-transform, Wavelet-transform, and DCT. Transform applications. Morphology: dilation, erosion, opening, closing, Hit-Miss transformation, outline retrieval, gap filling, and related components searching, convex hull, thinning, skeleton, removing outgrowth. Segmentation: tresholding, region based segmentation, textures, Canny edge detector. Digital image formats.

Readings	● R. G. Gonzales, R. E. Woods: Digital Image Processing. Prectice Hall, 2008. ISBN number 9780131687288 ● Wavelets and Filter Banks by Gilbert Strang and Truong Nguyen, Wellesley-Cambridge Press, 1997. ● Maria Petrou, Costas Petrou: Image Processing: The Fundamentals, Wiley, 2010, ISBN-13: 978-0470745861
Assessment	Seminars: two practical tests