

UNIVERSITY OF DEBRECEN  
**FACULTY OF INFORMATICS**



**BSc degree courses**  
**MSc degree courses**  
**PhD courses**

**Research**

Computer Science MSc



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## Foreword by the Dean

Dear Reader,



We are introducing here the Faculty of Informatics at the University of Debrecen. Our faculty is new, having been established in 2004 as a result of a long process of organic growth. The teaching of information technology began in 1972 at the Kossuth Lajos University, one of the predecessors to the University of Debrecen, when 29 students enrolled for studying a particular part of mathematics called software engineering. Today, some of those first students are highly respected instructors at the Faculty. In 1972, the Computer Science Department was established as a sub-division of the Institute of Mathematics, with a teaching staff of seven instructors, later in 1994 the Department of Information Technology. The pace of change has been breathtaking over the past decades, especially in the field of information technology. The computer has

become a common household object. Today, computers and software are not only integral elements of companies' managements and civil administrations, but have become an inseparable part of our everyday lives, and the Internet gives us virtually instantaneous access to an almost limitless pool of information.

The changes undergone by society have not left our University unaffected either. Indeed, they have been one of the driving forces behind our growth. The numbers of IT students, instructors and departments, have been multiplied, and the range of courses we offer has also expanded. At the end of the 1980s, we began providing university-level education in software engineering, IT Teaching and Library IT. We have also played an active role in the founding and running PhD School of Informatics. Today, six departments of the Faculty employ a total of 70 instructors, who are supported in their work by the Dean's Office, the Systems Administration Group and the special library, which is shared with the Institute of Mathematics, Faculty of Natural Science. The Faculty of Informatics currently has more than 2,300 students.

The formation of our Faculty has coincided with implementation of the Bologna process, which has fundamentally determined the direction for future development of higher education in Hungary. We have successfully completed accreditation of the basic specialisations, and in 2004 we were the first institution in Hungary to offer a degree in Software Engineering BSc. In 2005 we launched the System Engineering BSc course, and from 2006 we are running Business Information Management BSc and Library Information Management BSc courses. The curricula of the master's degree courses have also been formulated, with the assistance and cooperation of several other faculties: the Faculty of Economics and Business Administration, the Faculty of Technical Engineering and the Faculty of Sciences. After gaining their master's degrees, our students also have the opportunity to study for their PhD at the PhD School of Informatics, or at Mathematics and Computer Sciences PhD School.

The Faculty of Informatics fulfils an important role with regard to higher education and scientific research in the region. Our instructors have decades of experience in training IT professionals to internationally recognised standard. We consider it a key priority to cooperate with local industry and service providers. We aim to ensure that specialists who graduate from Debrecen do not feel compelled to pursue a career elsewhere, but that as many as possible are able to find employment in the region. To this end we have initiated the Debrecen InfoPark, the "Szilícium Mező" and other important projects like "FUTURE INTERNET", and work as closely as possible with local enterprises.

Sincerely,

Dr. Tamás Mihálydeák, Dean

## University of Debrecen



The University of Debrecen, like other integrated institutions of higher education in Hungary, was formed, on 1 January 2000, through the (re)merging of several hitherto autonomous institutions. Its historical roots stretch back to the foundation of the Reformed College of Debrecen (1538), the three academic sections of which later served as the foundation for the Hungarian Royal University of Sciences,

created by Statute XXXVI of 1912. This makes the University of Debrecen, with its uninterrupted 450-year history, the oldest institute of higher education in the country to have operated continuously in the same town. Higher education in agriculture began in 1868, when the National Higher School of Agriculture was formed in Debrecen.

With a student body of 30,000 and a 1,700-strong teaching staff, the University of Debrecen is without a doubt one of the largest higher-education institutions in the country, and with its 15 faculties, two independent institutes and 25 doctoral schools (both these figures are highest in the country), it also offers the widest range of educational and research opportunities.

The quality of teaching, and especially of research, is illustrated by the fact that more than half the instructors have a doctorate, and 23 are full or corresponding members of the Hungarian Academy of Sciences. According to the results of the Ministry of Education's annual complex performance report (which serves as the basis for allocating performance-related research funding), the University is the best institution outside of Budapest, and among the top three institutions in the country in terms of research performance, accounting for around 14-15% of the country's overall research volume.

This outstanding centre of academic excellence, with its vast educational and R+D capacity, is an increasingly important factor influencing the economic and social development, and the cultural progress, of the region. It devotes special attention to serving the needs of a knowledge-based economy, and fulfilling the role of a regional knowledge centre. UD is one of the five Hungarian universities that have been awarded the prestigious 'research university' title by the Ministry of Education.

Information: <http://www.unideb.hu/portal/en>

## Faculty of Informatics



The **Faculty of Informatics** at the **University of Debrecen** boasts the only accredited university-level educational program for IT specialists in the east-Hungarian region. The six professors, 19 associate professors (senior staff), 29 assistant professors (staff), 16 teaching assistants and 5 graduate computer scientists working at the faculty's seven departments (Department of Applied Mathematics and Probability Theory, Information Technology, Computer Graphics and Image Processing, Library

Informatics, Informatics Systems and Networks, Computer Science, Affiliated Department of ICT Systems Operation), represent a formidable pool of intellectual potential, which has earned recognition even at international level.

The aim of the Software Information Technology (Software Engineering), Engineering Information Technology and Business Information Technology majors is to produce IT professionals who possess the complex vocational and theoretical skills needed to scientifically model the practical problems that they will face in the course of their day-to-day work, and to identify and respond to them by selecting or developing the appropriate solutions. Students who graduate from these courses will be capable of supervising teams of specialists assembled for the purpose of performing these tasks, and will possess the basic theoretical, methodological and linguistic skills to conduct research in their chosen field.

The number of students at the faculty increased till 2010. There are currently around 2,000 students studying the specialisations in Hungarian. We started to teach our courses in English in 2007, the number of students is growing year by year.



Number of Students at Faculty of Informatics

## Computer equipment at the Faculty



In August of 2011 our Faculty moved to a modern, new building. In this building there are 3 large lecture halls, 8 seminar rooms and 11 well equipped computer laboratories with 195 computers and workstations.

### The data network

The building is equipped with a high-speed data network constructed from CAT6a AMP S/FTP cabling with a bandwidth of 10 Gbps. The cables run from 1092 end-points to converge in six rack cabinets. The bulk of data traffic is controlled by 10 Gbit manageable network switches, which are in turn linked via 2\*10 Gbps SM connection to a central switch, which connects to the University's backbone at 2\*10 Gbit/s.

The building is covered by EDUROAM wireless network, which is servicing the staff and students' requirements.

All computer laboratories are equipped by overhead projectors and we have some mobile projectors too. Some of the machines are connected to peripherals such as multifunctional devices, printers and scanners, to further assist the staff and students in their work. The pool of computer equipment used by staff and students is constantly being improved and upgraded.



## Library



The University and National Library University of Debrecen (UNL) was established January 1, 2001 as a result of the university integration with the union of the libraries of the predecessor institutions.

The seven library units of the UNL (see *Libraries*) can be found on the five campuses of the university.

The two main parts of the UNL holdings include the legal deposit collection and the *scientific* collection supporting the educational, research and medical work of the university. The holdings divided among seven research libraries (the Agricultural Science Library, the Arts and Sciences Library, the Kenézy Life Sciences Library, the Engineering Library, the Library of the Faculty of Education, the Social Sciences Library, and the Library of the Conservatory) are available for the employees and students of the University and for the citizens of Debrecen. The collections of the related fields are complemented with valuable special collections.

The largest proportion of the valuable collection of the library (more than 2.700.000 documents) comprises of books and bound periodicals. The digital periodical collection is also significant; with the help of this our users are able to access more than 27.000 periodicals. Above these more than 100.000 music scores, audio files (30.681), images (2874), cartographic materials and other types of documents are available for the users.

Besides the so called traditional services like reading room or circulation the University and National Library provides users with numerous modern services. A major part of the electronic services are available for our users in any part of the world.

The Library collects and manages information on the scientific products of the University of Debrecen. The full texts of the publications are maintained in the University of Debrecen Electronic Archive (DEA).



## BSc Degree Courses

### Computer Science

#### Aim of the course:

To train IT professionals who, possessing the solid theoretical grounding necessary to further develop their skills over the long term, are capable of performing, at an advanced level, the typically *software-oriented* development, implementation and servicing tasks related to IT equipment and systems, working either independently or as part of a team. Participants in this course will also learn the interaction and modelling skills required to solve IT tasks in all the main areas of application.

#### Length of course

- Number of semesters: 6.
- Total hours (total student study time): min. 5,400 hours, of which the number of teaching (contact) hours: min. 1,800.
- Number of credits required to obtain degree: 180.

Language: Hungarian, English

### Computer Science Engineering

#### Aim of the course:

To train IT engineers who have the IT-related skills needed to plan, develop and service technical installations that utilize IT-based solutions, especially with regard to technical IT and IT infrastructure systems and services, as well as their data and software systems, and who have assimilated the practical engineering techniques associated with the installation and commissioning of IT infrastructure.

#### Length of the course

- Number of semesters: 7
- Total hours (total student study time): min. 6,300 hours, of which the number of teaching (contact) hours: min. 2,100
- Number of credits required to obtain degree: 210

The differentiated compulsory vocational subjects and optional vocational subjects are grouped into specialisations. Students who select a particular specialisation may only obtain the compulsory 40 credits from subjects associated with their chosen specialisation.

Language: Hungarian, English

#### Specialisations:

Info-communication networks (English)  
Measurement and process management  
Corporate IT systems

## **Business Informatics**

### Aim of the course:

To train IT professionals who are capable of understanding and resolving the specific business processes underlying the information-based society, managing the IT tasks that support value-creating processes, and, making the best use of the opportunities presented by modern information technology in order to increase the knowledge base and business intelligence of organisations, to model processes based on interaction between information communication processes and technologies, to regulate and plan processes, identify problems, define problem areas, develop and operate applications, and monitor their operation in accordance with the requisite quality standards. Graduates will also possess the depth of theoretical knowledge necessary to continue their training in the second cycle.

### Length of the course

- Number of semesters: 7
- Number of teaching (contact) hours: 2,450
- Number of credits required to obtain degree: 210

Language: Hungarian, English

### Specialisations:

Corporate management  
E-business

## **Library and Information Science**

### Aim of the course

The aim of the Library Information Technology course is to train highly qualified specialists with a knowledge of the latest library and information science theory, as well as the skills required for its practical application, including information management and the methodology of research in this field.

### Length of course:

- Number of semesters: 6
- Number of credits required to obtain degree: 180
- Number of teaching (contact) hours: 2.250
- Compulsory vocational practice: 120 hours after the second semester and 220 hours in the 5-6th semesters.

Language: Hungarian

### Specialisation:

Web programmer  
Public library

## Master's Degree Courses

### Computer Science

#### Aim of the course:

To train IT professionals who, possessing the solid theoretical grounding necessary to further develop their skills over the long term, are capable of performing, at an advanced level, the typically *software-oriented* development, implementation and servicing tasks related to IT equipment and systems, working either independently or as part of a team. Participants in this course will also learn the interaction and modelling skills required to solve IT tasks in all the main areas of applications. Graduates will also possess the depth of theoretical knowledge necessary to continue their studies in PhD Schools.

#### Length of course:

- Number of semesters: 4
- Total hours (total study time): 3,600, of which the number of contact hours: 1,200.
- Number of credits required to obtain degree: 120

Language: Hungarian, English

#### Specialisations:

1. Healthcare IT management
2. Information management systems
3. Information systems
4. Image processing and computer graphics
5. Artificial intelligence
6. Computer science

### Business Informatics

#### Aim of the course:

To train IT professionals who are capable of understanding and resolving the specific business processes underlying the information-based society, managing the IT tasks that support value-creating processes, and, making the best use of the opportunities presented by modern information technology in order to increase the knowledge base and business intelligence of organisations, to model processes based on interaction between information communication processes and technologies, to regulate and plan processes, identify problems, define problem areas, develop and operate applications, and monitor their operation in accordance with the requisite quality standards. Graduates will also possess the depth of theoretical knowledge necessary to continue their training in PhD Schools.

#### Length of the course

- Number of semesters: 4
- Total hours (total study time): 3,600, of which the number of contact hours: 1,200.
- Number of credits required to obtain degree: 120

Language: Hungarian

Specialisations:

- Informatics for Business Administration
- Economic Modelling
- Informatics for Public Sector
- Informatics for Rural Development

## Computer Science Engineering

Aim of the course:

To train IT engineers who have the IT-related skills needed to plan, develop and service technical installations that utilize IT-based solutions, especially with regard to technical IT and IT infrastructure systems and services, as well as their data and software systems, and who have assimilated the practical engineering techniques associated with the installation and commissioning of IT infrastructure.

Length of the course

- Number of semesters: 4
- Total hours (total student study time): min. 3,600 hours, of which the number of teaching (contact) hours: min. 1,200
- Number of credits required to obtain degree: 120

The differentiated compulsory vocational subjects and optional vocational subjects are grouped into specialisations. Students who select a particular specialisation may only obtain the compulsory 40 credits from subjects associated with their chosen specialisation.

Language: Hungarian

Specialisations:

Info-communication networks (English)  
Hardware programming

## Library Information Sciences

Aim of the course

The aim of the Library Information Technology course is to train highly qualified specialists with a knowledge of the latest library and information science theory, as well as the skills required for its practical application, including information management and the methodology of research in this field.

Length of course:

- Number of semesters: 4
- Number of credits required to obtain degree: 120
- Number of teaching (contact) hours: 1200

Language: Hungarian

**Teacher – Teacher of Informatics**

Course in Hungarian

**Teacher – Teacher of Library-pedagogy**

Course in Hungarian



## PhD School of Informatics

Head of the School: Dr. Attila Pethő, DSc, full professor

### Programs:

- Discrete mathematics, image processing and computer graphics (Director: Prof. András Kruppa)
- Theoretical basis and applications of the information technology and the stochastic systems (Director: Prof. István Fazekas)
- Theoretical computer science, data security and cryptography (Director: Prof. Attila Pethő)
- Information technology systems and networks (Director: Prof. János Sztrik)
- Applied IT and its theoretical background (Director: Prof. György Terdik)
- Industrial and scientific applications of the informatics (Director: Prof. Gábor Halász)

Length of the program: 6 semesters

The staff of the IT Faculty also plays an important part in the work of the Mathematics and Computer Science PhD School, which runs 9 programs.



## CISCO Regional Academy



Computer networks appeared 20 years ago as a standalone and well separated topic of computer science studies. After some years of teaching networking it could be discovered, that the theoretical and practical topics covered in the “Computer networks” course are not fully adequate and not specialized to the workplace market requests. At this point (in 1999) the Cisco Networking Academy Program appeared in Hungary, and it was recognized, that introducing the CNAP into the teaching would help the students in solving computer networking problems, so their knowledge will be much more closer and adequate to the workplace market requests. University of Debrecen was the first university in Hungary, who joined to the Cisco Networking Academy Program as a Regional Academy in 1999.

Following the so called “Bologna’ Process” structure, two levels (Bachelor and Master level) higher education appeared in the computer science teaching, too. In 2004 the bachelor courses of “Computer Engineering” were accredited and started at the Faculty. The Computer Engineering contains three kind of specialization direction, including the “Communication technologies”. The CCNA courses are offered for the students of the “Communication technologies” direction as a “direction mandatory course”. The CCNA courses take high number of lectures, practical and labor studies: two semesters, 120 hours per semester. Usually there are two groups for full-time students (10-16 students per group), and one group for part-time students. The clear aim of the CCNA courses is to get theoretically and practically strong and deep internationally accepted level of networking knowledge for the students.



The most important and most interesting parts of the CCNA courses are the practical and labor lessons. The study catalogs show, that almost 100 percent of the students are present on all of the labors. Students work in a team to solve different configuration and error detection/correction labor tasks during the semester. We recognized the high students’ interest for the laboratory work, and also it was clear to see, that the equipment (router and switch) usage of the Cisco laboratory is very low (only 30-40 hours per week). In order to

solve this “bottleneck problem”, a software system was developed, which opened the possibility for the students to use the equipments of the Cisco laboratory from home (according to a well prepared scheduling). The remote access system works perfectly since 2005, and it has duplicated the usage ratio of our laboratory equipments.

Each student must solve a quite complicated practical exam at the end of the semesters (applying a 3 hours time limit), which needs very strong and deep knowledge both on the theoretical and practical fields. As a result, 50-60 percent of the students successfully pass the international VUE CCNA (640-802) exam for the first trial. This ratio is one of the highest in the Hungarian Cisco Academies, but it is very high in the international context too.

The faculty would like to increase further the networking knowledge of the informatics professional students, so a CCNP teaching environment was established (certified instructors, equipments, etc.), and the CCNP courses for students were started in February of 2010.

In 2009 the Faculty of Informatics University of Debrecen won the “Academy of Excellence” award (the winning process of this award is based on objective measurement numbers/facts of the last years’ performance; actually only two universities were able to reach this level).



CNAP technical background: More than 20 Cisco routers dedicated for the CNAP laboratory (mainly of type 28xx); more than 10 Cisco switches dedicated for the CNAP laboratory (mainly of type 2960).



## Research

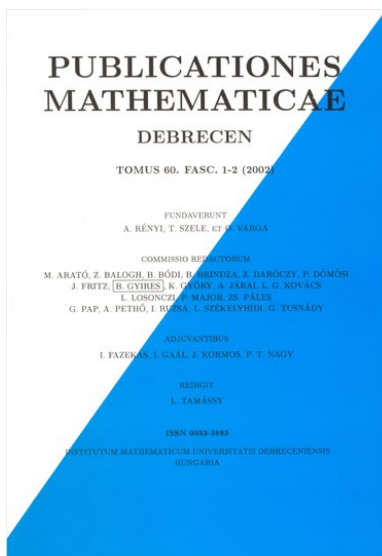
The scientific research conducted at the Faculty of Informatics has steadily broadened in scope and increased in depth over the past decades. Our international reputation for excellence has been further strengthened by the work of our leading scientists in the following areas: stochastic processes and modelling, multivariable statistics, time line analysis, business mathematics, queuing and mass service theory, numerical mathematics, operation research, system theory, databases and information systems, system management, software technology, computer graphics, computerised image processing, form recognition, efficiency studies, quality assurance, code theory, decision theory, computerised text processing and linguistics., formal languages and systems, artificial intelligence, computational number theory, computer algebra, cryptography, statistical inference of stochastic processes and random fields applications of statistics.

Besides the considerable financial contribution made by the Faculty itself, the OTKA, FEFA, OMFB, TEMPUS and other (NKFP, IKTA) subsidies that have been awarded continuously since 1986 play a key role in funding the research.

A number of successful research and development projects have already been based on intensive international cooperation, closely related to specific areas of application. The researchers working on these projects are always prepared to cooperate with local and international partners in order to achieve further results and develop new dedicated applications. Besides the unwavering commitment of the senior staff, the following factors are also highly conducive to the formation of cooperative partnerships of this nature:

- the specialist library, containing more the 25,000 volumes, run jointly with the Institute of Mathematics
- the well-structured institutional LAN, which links around 300 personal computers and contains several hardware and software platforms (Sun Sparc, INTEL, RS6000, Unix, Microsoft, Novell), and which is connected to the internet via a high-speed datalink
- the research team's wealth of experience in international projects, cooperation, and project management
- the involvement of high numbers of outstandingly capable information technology students in the actual (software) development work, through the formation of development teams headed by talented young members of staff.

## Periodicals

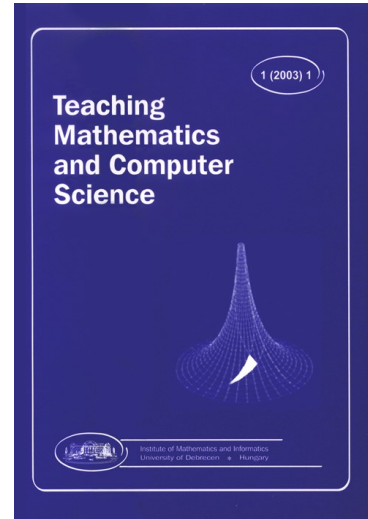


### Publicationes Mathematicae Debrecen

The journal appears quarterly and publishes original research papers on pure mathematical topics. It welcomes contributed papers that develop interesting, or important, new mathematical ideas and results or solve outstanding problems. All papers are refereed for correctness and suitability for publication. Publicationes Mathematicae Debrecen is covered by the Mathematical Reviews, the Zentralblatt der Mathematik, the Science Abstracts and the Science Citation Index.

## Teaching Mathematics and Computer Science

The aim of this journal is to publish high quality papers on teaching and education in two fields: Mathematics and Computer Science. Papers are expected to deal with issues related to classroom activities or any other aspect of educational work in one of these fields. Contributions can be concerned with problems relevant to all types of schools, running from elementary schools to universities. Papers should be written mainly in English, but also in French or German, with an abstract in English.



## The Béla Gyires IT Lectures



**Béla Gyires (1909-2001)** was a key personality at the Mathematics and Information Technology Institute of the Kossuth Lajos University of Science, which was a predecessor to the University of Debrecen. For many years he was director of the institute. He founded, and headed for 30 years, the Department of Probability Calculation and Applied Mathematics. It was under his direction that the Computing Centre was formed in 1967. He was instrumental in ensuring that subjects as important and modern as probability calculation, mathematical statistics, computer science and information technology were incorporated into the university's curriculum. In 1972, it was at his instigation and under his direction that the courses in Programming Mathematics were introduced. He was the highly regarded mentor of generations of mathematics students.

In his honour, the Béla Gyires IT Lectures are held once a year. At the event, each department of the Faculty gives a presentation of its research activities, in the form of a scientific lecture.



## Departments

### Department of Applied Mathematics and Probability Theory

Head of Department: Dr. habil István Fazekas, Full professor

Email: [fazekas.istvan@inf.unideb.hu](mailto:fazekas.istvan@inf.unideb.hu)

www: <http://w1.inf.unideb.hu/en/web/alkalmazott-matematika-es-valoszinusegszamitas-tanszek/home>

#### Research fields

- Probability theory
  - Mathematical statistics
  - Operation research
  - Numerical mathematics
  - JAVA technology
  - Statistical inference of stochastic processes and random fields
  - Applications of statistics.
- 

### Department of Informatics Systems and Networks

Head of Department: Dr. János Sztrik, Full professor

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www: <http://w1.inf.unideb.hu/web/informatikai-rendszerek-es-halozatok-tanszek>

#### Research fields

- Performance evaluation of information systems
  - Queueing systems
  - Stochastic modeling of computer architectures and networks
  - Reliability investigation of complex systems
  - Stochastic simulation
-

## Department of Information Technology

Head of Department: Dr. habil Márton Ispány, Associate professor

Email: [ispany.marton@inf.unideb.hu](mailto:ispany.marton@inf.unideb.hu)

www: <http://w1.inf.unideb.hu/en/web/informacio-technologia-tanszek/home>

### Research fields

- Mathematical models and statistical studies of systems
  - Combinatorial coding theory
  - Pattern recognition, image processing, discrete mathematical methods and their application
  - Object-oriented technologies and beyond, database systems, web modelling, software analysis
  - Quantum chemistry and atom physics calculations
  - Computer-aided applied linguistic research
  - Didactic questions related to the teaching of information science
  - Other developments and applications
- 

## Department of Computer Science

Head of Department: Dr. habil György Vaszil Associate professor

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### Research fields

- Mathematical logic, modal and intensional logic, type-theory logic, partial logic, formal semantics, temporal logic, logical philosophy, automated theorem proving
- Operation research
- Artificial intelligence, expert systems, knowledge depiction, descriptive logics
- Formal languages and automata
- Multi-modal man-machine relationship, skeletonization algorithms, Support Vector Machine, face recognition, neighborhood sequences
- Neighborhood sequences, digital geometry
- Linear recursive sequences, random number generators
- Cryptography, computer algebra

## Department of the Computer Graphics and Image Processing

Head of Department: Dr. habil András Hajdu Associate professor

Email: [hajdu.andras@inf.unideb.hu](mailto:hajdu.andras@inf.unideb.hu)

www: <http://w1.inf.unideb.hu/en/web/komputergrafika-es-kepfeldolgozas-tanszek/home>

### Research fields

- Linear mappings
- Descriptive geometry, cyclographic mapping, central-axonomerty
- Application of artificial neural networks in computer graphics
- Free-form modelling
- Geometric correction of digital images
- Applied mathematical methods in dentistry

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## Department of Library Informatics

Head of Department: Dr. habil Attila Gilányi, Associate professor

Email: [gilanyi.attila@inf.unideb.hu](mailto:gilanyi.attila@inf.unideb.hu)

www: <http://w1.inf.unideb.hu/en/web/konyvtarinformatika-tanszek/>

### Research fields

- Information Supply for Teachers
- Project-based Learning Processes
- New trends in Library Education
- Hypertext and Hypermedia Applications
- Using Concordances in the Interpretation of Library Texts
- Automated Libraries
- Integrated Library Information Systems
- MARC Standards, New Medias and Electronic Documents
- Formats of International Data Exchange
- Electronic Libraries

## Affiliated Department of ICT Systems Operation

Head of Department: András Harman

Email: [Andras.Harman@t-systems.com](mailto:Andras.Harman@t-systems.com)

www: <http://www.it-services.hu/?lang=en>

## Computer Science MSc Course

### Aim of the course:

To train IT professionals who, possessing the solid theoretical grounding necessary to further develop their skills over the long term, are capable of performing, at an advanced level, the typically *software-oriented* development, implementation and servicing tasks related to IT equipment and systems, working either independently or as part of a team. Participants in this course will also learn the interaction and modeling skills required to solve IT tasks in all the main areas of application. The course is a good basic to PhD studies.

### Length of course

- Number of semesters: 4.
- Number of credits required to obtain degree: 120.

|                               | Credits |
|-------------------------------|---------|
| Common Science basic subjects | 30      |
| Vocational basic subjects     | 48      |
| Vocational subjects           | 16      |
| Vocational subjects of choice | 6       |
| Thesis                        | 20      |

The grade of diplom will be calculated from the final grade for the state exam and the grade of the next subjects:

|         |                            |
|---------|----------------------------|
| INNK110 | Applied Mathematics        |
| INNK120 | Computer Science           |
| INNK130 | Applied Statistics         |
| INNK140 | Computer Algorithms        |
| INNK150 | Modelling Data and Systems |

### Common Science basic subjects

| Code    | Subject                    | Credit | Hrs/week |          |    | Exam   | Prere-<br>quisites | Period |
|---------|----------------------------|--------|----------|----------|----|--------|--------------------|--------|
|         |                            |        | Theory   | Practice |    |        |                    |        |
|         |                            |        |          | CR.      | CL |        |                    |        |
| INNK110 | Applied Mathematics        | 6      | 2        |          |    | K<br>A |                    | 1      |
| INNK120 | Computer Science           | 6      | 2        | 2        |    | K<br>A |                    | 1      |
| INNK130 | Applied Statistics         | 6      | 2        |          | 2  | K<br>A |                    | 1      |
| INNK140 | Computer Algorithms        | 6      | 2        |          | 2  | K<br>A |                    | 1      |
| INNK150 | Modelling Data and Systems | 6      | 2        |          | 2  | K<br>A |                    | 1      |

**Compulsory vocational subjects (Information Systems-specialization)**

| Code    | Subject                              | Credit | Hrs/week |          |    | Exam   | Prerequisites   | Period |
|---------|--------------------------------------|--------|----------|----------|----|--------|---|--------|
|         |                                      |        | Theory   | Practice |    |        |   |        |
|         |                                      |        |          | CR.      | CL |        |   |        |
| INNV410 | Software System Design               | 6      | 2        |          | 2  | K<br>A | INNK150   | 2      |
| INNV321 | Managing Information Systems         | 6      | 2        |          | 2  | K      | INNK150   | 2      |
| INNV430 | Software Quality Management          | 4      | 2        |          |    | K<br>A | INNK150   | 2      |
| INNV320 | Architectures of Information Systems | 4      | 2        |          |    | G      | INNK120,<br>INNK150                                     | 2      |
| INNV360 | Datamining                           | 6      | 2        |          | 2  | K<br>A | INNK110,<br>INNK130,<br>INNK150                         | 2      |
| INNV630 | Knowledge- based Tech                | 4      | 2        |          |    | K<br>A | INNK120   | 2      |
|         |                                      |        |          |          |    |        |   |        |
| INNV450 | Enterprise and Project Management    | 4      | 2        |          |    | K      |   | 3      |
| INNV460 | Advanced Database Technologies       | 2      |          |          | 2  | G      | INNK140,<br>INNK150                                     | 3      |
| INNV361 | Datamining Applications              | 6      | 2        |          | 2  | K<br>A | INNK110,<br>INNK140,<br>INNV360                         | 3      |
| INNV470 | Database Security                    | 2      |          |          | 2  | G      | INNK110,<br>INNK120,<br>INNK130,<br>INNK140,<br>INNK150 | 3      |
|         | Free choice of Subjects              | 6      |          |          |    |        |   | 3      |
| INND010 | Thesis 1                             | 10     |          |          |    | G      | INNK110,<br>INNK120,<br>INNK130,<br>INNK140,<br>INNK150 | 3      |
|         |                                      |        |          |          |    |        |   |        |
| INNV480 | Implementing Information Systems     | 4      | 2        |          |    |        |   | 4      |
|         | Free choice of Subjects              | 16     |          |          |    |        |   | 4      |
| INND011 | Thesis 2                             | 10     |          |          |    | G      | INNK110,<br>INNK120,<br>INNK130,<br>INNK140,<br>INNK150 | 4      |

Exam: TE – terminal examination

S – sign

P – practical sign

## Subject programs

### APPLIED MATHEMATICS

Complex numbers. Number sequences, power series. Generator functions. Method of partial fractions. Multivariable differential and integral calculus. Analysis of multivariable functions, Extremes, conditional extremes. Matrix calculus, eigenvectors and eigenvalues. Quadratic forms. Principal axis transformation, Jordan normal form of matrices, singular decomposition.

#### Compulsory/Recommended Readings:

- Schreier, O. – Sperner, E.: Introduction to Modern Algebra and Matrix Theory. 2nd Edition, Chelsea, 1959.
- Tucker, A.: Applied Combinatorics. (2nd Edition), John Wiley and Sons, New York, 1984.

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### COMPUTER SCIENCE

First order languages, terms, formulas. Quantified and free variables. Interpretation. Satisfiable formulas, logical laws, contradictions. Logical equivalence. Normal forms and prenex form. Logical consequence. Logical calculi, correctness, completeness, Gentzen-type calculi.

Grammars and languages. Operations on languages. Chomsky hierarchy. Formal languages and automata. Algorithms. Kleene theorem, Bar-Hillel lemma, Early algorithm, Lyon algorithm. Applications in computer science.

Turing machine, time and space complexity. Simulations and simulation theorems. Recursive and recursively enumerable languages. Universal Turing machine. Church theory. Algorithmically non-solvable problems. The halting problem. RAM machines. Kolmogorov complexity and its applications. Complexity classes. Non-deterministic Turing machines. Space-time theorem. P versus NP. NP-complete problems.

Definition of program semantics. Methods for proving correctness: Hoare logic, Dijkstra weakest precondition calculi. Analysis of non-sequential programs. Parallel programs. Owicki-Gries and Stirling methods. Non-deterministic programs. Recursive programs. Abstract data types and their specifications.

#### Compulsory/Recommended Readings:

- Hopcroft, J. E. and Ullmann, J. D.: Introduction to Automata Theory, Languages, and Computation. Addison-Wesley, 1979.
- Papadimitriou, C. H.: Computational Complexity, 1994, Addison-Wesley.
- Owicki, Gries, *Verifying properties of parallel programs: An axiomatic approach*, Comm. of the ACM 19, 1976.

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### MODELLING DATA AND SYSTEMS

Theoretical and practical problems of Relational Data Base Systems Functional dependence, standardizing and normal forms. Coupled data manipulations to Relational Data Base models Relational algebra and Relational calculus, SQL. Some problems and some actual issues of data modeling.



Embedded models, ER models OO and OR models. SQL:1999, ODMG 3.0, ODL, OQL. Mapping models with different designs to each other.

Modeling information systems (environmental and conducting data and Object oriented models).

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

- T. M. Connolly – C. E. Begg: *DataBase Systems: A Practical Approach to Design, Implementation and Management*, Addison Wesley, 2005.
- C. J. Date: *An Introduction to Database Systems*, Addison Wesley, 2004.
- M. Kifer – A. Bernstein – P. M. Lewis: *Database Systems: An Application Oriented Approach*, Complete Version, Addison Wesley, 2005.
- R. Elmasri – S. B. Navathe: *Fundamentals of Database Systems*, Addison Wesley, 2004.
- I. Sommerville: *Software Engineering*, Addison Wesley, 2004.
- J. Melton: *Advanced SQL:1999. Understanding Object-Relational and Other Advanced Features*, Morgan Kaufmann, 2003.
- R. G. G. Cattell, D. K. Barry (eds.): *The Object Data Standard: ODMG 3.0*, Morgan Kaufmann. 2000.
- C. J. Date, H. Darwen: *Foundation for Object/Relational Databases. The Third Manifesto*, Addison-Wesley, 1998.

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### **ARCHITECTURES OF INFORMATION SYSTEMS**

Architecture models (static structure, dynamic flow, interface, kapcsolati, distributed model). ADL. The role of UML in describing the architecture. Client-server, stratified, distributed object, component architectures. Distributed computations. Business system architectures. Reference architectures. B2B application architectures. Software bots and spiders. Embedded systems. Asynchronous information system architectures and its models. Web services, SOA.

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

- Sommerville: *Software Engineering*, Addison Wesley, 2004.
- Budgen, D., *Software Design, 2nd Edition*, Addison Wesley, 2003
- Endres, A., Rombach, D., *Handbook of Software and Systems Engineering: Empirical Observations, Laws and Theories.*, Addison Wesley, 2003
- Hohmann L., *Beyond Software Architecture: Creating and Sustaining Winning Solutions.*, Addison Wesley, 2003
- Bass, L., Clements, P., Kazman, R., *Software Architecture in Practice, 2nd Edition.*, Addison Wesley, 2003
- Albin, S. T., *The Art of Software Architecture: Design Methods and Techniques.*, Wiley, 2003

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### **COMPUTER NETWORKS: TECHNOLOGIES AND MODELS**

Network topologies and architectures. Transmission media, analog and digital transmission (modems, coding). Switching methods. The ISO OSI reference model, describing the layers. Channel allocation methods, channel listening (ALOHA protocols, CSMA, collision-free, limited-contention free). The IEEE 802.3 standard and the ETHERNET. Token bus, token ring. Flow control of datalink layer (frames

and sliding window protocols). The routing algorithms of the network layer (shortest path, multicast, centralized - distributed, hierarchical). Internetworking cooperation. Network layer, protocols. Network security, encryption. Application layer, electronic mail, catalogue systems. Examples for specific networks. Using queueing networks in modeling of computer networks.

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

- G. Bolch , S. Greiner, H. de Meer, K.S. Trivedi Queueing Networks and Markov Chains John Wiley & Sons Inc. New York, 2<sup>nd</sup> edition, 2006.
- W. Stallings: Data and Computer Communications, 7th Edition. Prentice-Hall, 2003.
- A. S. Tanenbaum: Computer Networks, 4th Edition, Prentice-Hall, 2003.
- L. Kleinrock Queueing Systems, Volume I: Theory, Wiley-Interscience (New York), 1975
- L. Kleinrock Queueing Systems, Volume II: Computer Applications, Wiley-Interscience (New York), 1976

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### **MANAGING INFORMATION SYSTEMS**

Information Systems as IT service, IT Infrastructure Library (ITIL). Parts of qualitative supporting IT services: configuration management, event management, problem management, change / modification management, server-/ information desk, version - management. Aspects of IT services: layer management, capacity management, continuity management, accessibility management, financing the IT. Security risk analysis, COBRA methodology. Introducing ITIL toolkits.

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

- [Sprague](#), R.H., [McNurlin](#), B., *Information Systems Management In Practice, 7th edition*, Prentice Hall, 2005.
- *The IT Infrastructure Library: Service Support*, published by TSO for the OGC, London, 2000.
- *The IT Infrastructure Library: Service Delivery*, published by TSO for the OGC, London, 2000.
- Marasco, J., *Software Development Edge, The: Essays on Managing Successful Projects*, Addison Wesley, 2005.
- Lejk , M., Deeks, D., *An Introduction to Systems Analysis Techniques, 2nd Edition*, Addison Wesley, 2002
- Adelman, S., Moss, T. L., Abai, M., *Data Strategy*, Addison Wesley, 2005.
- Seacord, R., Plakosh, D., Lewis, G. A., *Modernizing Legacy Systems: Software Technologies, Engineering Processes, and Business Practices*, Addison Wesley

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### **ADVANCED DATABASE TECHNOLOGIES**

Native and embedded XML databases. XQuery and XForm. Generic architectures of XML documents in relational databases. XML-based data warehouses. Construct of XML-based web sites in databases context. Effectiveness. Portal building. Webservices. XML-based reusable components. The role of OO languages by database applications. Application servers. Frameworks.

**Compulsory/Recommended Readings:**

- Scardina, Mark, Chang, Ben: *Oracle Database 10g XML & SQL Design, Build, & Manage XML Applications in Java, C, C++, & PL/SQL.*, McGraw, 2004.
- Ostrowski, Chris, Brown, Bradley: *Oracle Application Server 10g Web Development*, McGraw, 2004.
- Chaudhri, Akmal B., Rashid, Awais, Zicari, Roberto: *XML Data Management: Native XML and XML-Enabled Database Systems*, Addison-Wesley, 2004.

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**DATA MINING**

The role of data mining in the informatics. Problem and methods in data mining. The five steps of the data mining process. Assessing of models: statistics and graphical tools. Sampling methods, training, validation, and test data sets. Exploring and modifying. Predictive modelling. Linear and nonlinear regression. Prediction of binary target: logistic regression. Decision trees: CHAID, CART, and C4.5 (C5) algorithms. Neural networks: multilayer perceptron and radial basis function. Memory based methods. Association rules, apriori algorithm. Automatic clustering. Using SAS/Enterprise Miner in practice.

**Compulsory/Recommended Readings:**

- Berry, M. J. A., Linoff G., *Data Mining Technique. For Marketing, Sales and Customer Support.* Wiley, New York, 1997.
- Hastie, T., Tibshirani, R., Friedman, J., *The Elements of Statistical Learning. Data Mining, Inference, and Prediction.* Springer, New York, 2001.

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**KNOWLEDGE BASED TECHNOLOGIES**

Architecture and developing of knowledge based systems. Expert systems. Knowledge base and reasoning. Knowledge representation: semantic net, frame based and rule based systems, description logic. Uncertainty, ambiguity - sources, models to treat uncertainty. Reasoning models. Case studies.

**Compulsory/Recommended Readings:**

- J. D. Ullman: *Principles of Database and Knowledge-Base Systems*, Computer Science Press, 1989.
- Liebowitz, J. (ed.): *The Handbook of Applied Expert Systems*, CRC Press, 1998.

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**NUMERICAL MATHEMATICS**

Solution of ordinary differential equations (ODE). (first and higher order ODEs) Initial-value problems, boundary-value problems. Explicit and implicit single-, and multi-step methods. Speed of the convergence, estimation and propagation of the error. Optimal step-size, adaptive step-size control. Numerical methods for linear and non-linear PDEs. Boundary-value PDE-problems. Monte-Carlo methods. Finite Element Methods. The use of different methods are shown by the programs in the Numerical Recipes

**Compulsory/Recommended Readings:**

- W. H. Press, B. P. Flannery, S. A. Teukolsky, W. T. Vetterling, Numerical Recipes, Cambridge University Press, Cambridge, 1989.
- L. Gr. Ixaru, Numerical Methods for Differential Equations and Application, D. Reidel Publ. Comp. Dordrecht/Boston/Lancaster, 1984.
- J. D. Lambert, Numerical Methods for Ordinary Differential Systems, Wiley, London, 1881.
- K. E. Atkinson, Elementary Numerical Analysis, Wiley, New York, 1993.

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**NON-LINEAR OPTIMIZATION**

Introduction to NLP – main problem, sample applications, graphical illustration of nonlinear programming problems. Introductory concepts- convex and concave functions. Types of NLP problems. One-variable unconstrained optimization. Multivariable unconstrained optimization. The method of steepest ascent. Lagrange function and multipliers. Using Solver add-in for MS-Excel to solve an NLP problem. The Karush-Kuhn-Tucker (KKT) conditions for constrained optimization. The method of feasible directions. Linear-fractional programming – problem, theory, methods. Using WinGULF package for linear-fractional programming problems. Common fractional problems. Charnes-Cooper transformation. Piece-wise linear-programming. Piece-wise functions modeling. Quadratic programming. Separable programming. Convex programming. Non-convex programming. Using LINGO package for solving NLP problems.

**Compulsory/Recommended Readings:**

- Bajalinov E.: Linear-fractional programming: Theory, Methods, Applications and Software. Kluwer Academic Publishers, 2003.
- Hiller F.S., Lieberman G.J.: Introduction to Operations Research, McGraw. 1990
- Pardalos P.M. (ed.): Handbook of Applied Optimization. Oxford University Press, 2002
- Sposito V.A.: Linear and Nonlinear Programming. The IOWA State University Press, 1975.
- Stancu-Minosian I.M.: Fractional programming: Theory, Methods and Applications. Kluwer Academic Publishers, 1997.
- Winston W.L.: Introduction to mathematical programming. PWS-Kent, 1991.

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**CONTROL SYSTEMS I.**

Basic notions in control systems: input, output and state dependence, discrete and continuous time-dependence, differential system, system-diagram. Linear difference equations and difference equations systems. The z-transform and its properties. The inverse of the matrix

zl-A. Solution, controllability and observability of the state equation of discrete time linear stationary systems. Laplace transform and its properties. Solution of linear differential equations with constant coefficient using Laplace transforms. System stability and system analysis in frequency-domain. Multidimensional systems. The inverse of the matrix sl-A

and the exponential function of the matrix  $tA$ . The Control Systems Toolbox of MATLAB (on seminars).

**Compulsory/Recommended Readings:**

- J.J. D’Azzo, C.H. Houpis: *Linear Control System, Analysis and Design*, McGraw-Hill, New York, 1981.
- M. Athans, P.L. Falb: *Optimal Control*, McGraw-Hill, New York, 1966.
- D. Hanselman, B. Littlefield: *Mastering MATLAB 6 : a comprehensive tutorial and reference*. Prentice Hall, Upper Saddle River, N.J., 2001.

**CONTROL SYSTEMS II**

Controllability and observability of continuous time linear stationary systems. Controllability of deterministic systems. Hamilton function, free endpoint control. Pontrjagin’s maximum principle. State control of linear systems under quadratic loss. Linear stochastic systems and their stationarity. White noise, AR, MA and ARMA processes, Wiener process. Kalman filter in discrete and continuous time. Optimal control of linear stochastic systems. Optimal control of AR and ARMA processes under quadratic loss. Optimal properties of sequential methods, Bellman equations.

**Compulsory/Recommended Readings:**

- M. Athans, P.L. Falb: *Optimal Control*, McGraw-Hill, New York, 1966.
- K.J. Aström: *Introduction to Stochastic Control Theory*, Academic Press, New York, 1970.
- Mátyás Arató: *Linear Stochastic Systems with Constant Coefficients, A Statistical Approach*, Springer, Berlin, 1982.

**STATISTICAL LEARNING ALGORITHMS**

Basic concepts of neural networks: neuron, activation function. Network architectures, learning algorithms. Linearly separable patterns and the perceptron. Adaptive filtering. Multilayer perceptron, back-propagation algorithm. Radial-basis function networks. Support vector machine and its applications. Self organising map, Kohonen network. Methods presented at lectures are applied for data at practices.

**Compulsory/Recommended Readings:**

- Haykin, S., *Neural Networks. A Comprehensive Foundation*. Prentice Hall, New Jersey, 1999.
- Titterington, D.M., Kay, J.W., *Statistics and Neural Networks*. Oxford University Press, Oxford, 1999.
- Vapnik, V.N., *Statistical learning theory*. Wiley, New York, 1998.
- *Matlab Neural Network Toolbox*. The Mathworks, Inc., Natick, 1998.

**DATA MINING APPLICATIONS**

Supervised learning. Nonlinear optimization: Levenberg-Marquardt, quasi-Newton, conjugated gradient. Comparing the methods on real datasets. Link analysis. Self-organizing maps. Genetic algorithms. Text-mining: parsing, singular value

decomposition, EM clustering. Web-mining. The structure of the WWW. Searching on the Web: PageRank and HITS. Modelling the Web by random graph.

**Compulsory/Recommended Readings:**

- Berry, M. J. A., Linoff G., *Data Mining Technique. For Marketing, Sales and Customer Support.* J. Wiley, 1997.
- Bishop, C. M., *Neural Networks for Pattern Recognition.* Oxford, 1995.
- Breiman, L., Friedman, J. H., Olshen, R. A., Stone, C. J., *Classification and Regression Trees.* Wadsworth, 1984.
- Chakrabarti, S., *Mining the WEB. Discovering Knowledge from Hypertext Data.* Morgan Kaufmann, 2002.
- Berry, M. W., Browne, M., *Understanding Search Engines: Mathematical Modeling and Text Retrieval.* Society for Industrial and Applied Mathematics, Philadelphia, 1999.

**BIOINFORMATICS**

Biological basics, genomics, expression of genetic information. Microarrays. Gene expression (profiles) analysis by clustering, gene prediction. Phylogenetic algorithms, evolution models, tree reconstruction. Text mining. Biological and medical data and knowledge bases: EMBL, GenBank, SWISS-PROT/TrEMBL,

**Compulsory/Recommended Readings:**

- Durrett, R., *Probability Models for DNA Sequence Evolution.* Springer, 2002.
- Baldi, P., Brunak, S., *Bioinformatics. The Machine Learning Approach,* 2nd Edition, Bradford Books, 2001.
- Murray , J. D., *Mathematical Biology I+II,* Springer, 2002.

**ENTERPRISE AND PROJECT MANAGEMENT**

*Project management.* Methodology of project management, life cycle of projects, Project models, type of Projects. Project planning, estimation, limitation, timing and és documentation. Project organization, rolls in a project, information tools for project-control and for team-work support. Requirement-, change- and riskmanagement. Managing sub-contractors. Project resource-economy, cost-economy, portfolio management, multi-project management. Project quality management. Closing Projects, guarantee, maintenance, debugging, helpdesk. Human resource management.

**Compulsory/Recommended Readings:**

- Royce , W., *Software Project Management,* Addison-Wesley, 1998.
- Stutzke, R., *Estimating Software-Intensive Systems: Projects, Products, and Processes,* Addison Wesley, 2005
- Ahern, D. M., Clouse A., Turner R., *CMMI® Distilled: A Practical Introduction to Integrated Process Improvement, 2nd Edition,* Addison Wesley, 2003.
- Ahern, D. M., Armstrong, J., Clouse A., Ferguson J., Hayes W., Nidiffer K., *CMMI® SCAMPI Distilled: Appraisals for Process Improvement,* Addison Wesley, 2005.

- Bush M., Dunaway D., *CMMI® Assessments: Motivating Positive Change*, Addison Wesley, 2005
- Chrissis M. B., Konrad M., Shrum S., *CMMI®: Guidelines for Process Integration and Product Improvement*, Addison Wesley, 2003.
- Hass, A., *Configuration Management Principles and Practice*, Addison Wesley, 2002.

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## ENGINEERING OF SOFTWARE SYSTEMS

UML, MetaObject Facility, XML Metadata Interchange, Common Warehouse Metamodel. UML profiles. ClearCase. Component-based architectures. Design of software cubes, microarchitectures and infrastructures. Interface-based design. Standards of B2B applications. On-line commerce and communication protocols. Design of automation processes. Design of software bots and spiders. Dynamic evolution of systems. Webservice technologies. XML registries. Model and designs of embedded, domain-based, event-based systems. Open source backfork-based processes and models. Multicycle regression testing standards. Metamodels and metaprogramming.

### Compulsory/Recommended Readings:

- Sommerville: *Software Engineering*, Addison Wesley, 2007.
- Rozanski, N., Woods E., *Software Systems Architecture: Working With Stakeholders Using Viewpoints and Perspectives*, Addison Wesley, 2005.
- Rumbaugh J., Jacobson I., Booch G., *Unified Modeling Language Reference Manual, The, 2nd Edition*, Addison Wesley, 2004.
- Buckley C., Pulsipher, D., *Art of ClearCase® Deployment, The: The Secrets to Successful Implementation*, Addison Wesley, 2004.
- Mellor, S. J., Scott K., Uhl, A., Weise, D., *MDA Distilled*, Addison Wesley, 2004.
- Bergström, S., Råberg, L. *Adopting the Rational Unified Process: Success with the RUP*, Addison Wesley, 2003.
- Kruchten, P., *Rational Unified Process, The: An Introduction, 3rd Edition.*, Addison Wesley, 2003.
- Evans, E., *Domain-Driven Design: Tackling Complexity in the Heart of Software*, Addison Wesley, 2003.
- Fowler, M., *UML Distilled: A Brief Guide to the Standard Object Modeling Language, 3rd Edition*, Addison Wesley, 2003.
- Warmer, J., Kleppe, A., *Object Constraint Language, The: Getting Your Models Ready for MDA*, Addison Wesley, 2003.

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## IMPLEMENTING INFORMATION SYSTEMS

Basic issues of implementing Information systems. Aspects of selections for hardware operation systems, developing environments, programming language, database systems, CASE- tools and technologies. Purchasing of ready to use systems and developing systems. Models for programming. Working up a User interface. Integration of a system into some operating systems. Integrating systems with different paradigm and technologies. Primitive systems. Data migrations.

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

- Rick Greenwald, Robert Stackowiak, Gary Dodge, David Klein, Ben Shapiro: *Professional Oracle Programming*, McGraw, 2005.
- Hardman, Ron McLaughlin, Michael : *Expert Oracle PL/SQL.* , McGraw, 2005.
- Shee, Richmond Deshpande, Kirtikumar Gopalakrishnan, K : *Oracle Wait Interface A Practical Guide to Performance Diagnostics & Tuning.*, McGraw, 2004.
- Keller, Horst, Kruger, Sascha: *ABAP Objects: Introduction to Programming SAP Applications*, Addison Wesley Professional, 2002.
- Sharma, Rahul, Stearns, Beth, Ng, Tony: *J2EE™ Connector Architecture and Enterprise Application Integration*, Addison Wesley Professional, 2002.

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## **NEW PROGRAMMING PARADIGM**

Introduction to new programming paradigm. Aspect-oriented, domain-based, event-based paradigms and methodologies. Application of concepts of metaprogramming in OO languages. Application of concepts of process-oriented paradigm in OO languages. Features of functional programming languages. Service-centric programming.

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

- Scyperski, C.: *Component software. Beyond object-oriented programming*, Addison Wesley, 2002.
- Evans, E., *Domain-Driven Design: Tackling Complexity in the Heart of Software*, Addison Wesley, 2003.
- Savitch, W., *Absolute Java*, Addison Wesley, 2005.
- Kiselev, I., *Aspect-Oriented Programming with AspectJ*, Sams, 2002.
- Morrison, J. P., *Flow-Based Programming: A New Approach to Application development*, Van Nostrand Reinhold, 2004.

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## **PROGRAMMING WITH LOGIC**

Lists, operators and arithmetic in Prolog. Structured information retrieving from databases. Simulation of a non-deterministic automata. Managing the backtrack. Sorting programs in Prolog. Prolog representation an procedures of graphs and trees. Simulation of elementary searching methods: depth-fist, breadth-first, heuristic. Planning and Prolog in Expert Systems.

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

- I. Bratko: *Prolog Programming for Artificial Intelligence*, Addison-Wesley, 1990.
- S. K. Das: *Deductive databases and logic programming*. Addison Wesley, 1992.
- Sterling, Shapiro: *The Art of Prolog*, The MIT Press, 1994

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## **KNOWLEDGE REPRESENTATION**

A knowledge representation tool, the description logic is discussed in details. Reasoning: classification, instantiation, tableaux calculus.



**Compulsory/Recommended Readings:**

- Franz Baader, Diego Calvanese, Deborah I. McGuinness, Daniele Nardi, Peter F. Patel-Schneider : *The Description Logic Handbook*, Cambridge University Press, 2003, ISBN 0521781760

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**CASE STUDY FOR KNOWLEDGE BASED SYSTEMS**

The students prepare two expert systems using rules based and object oriented knowledge representation tools. Proposed tools: Clips, Level5, M1.

**Compulsory/Recommended Readings:**

- Harmon, P. and Sawyer, B.: *Creating Expert Systems for Business and Industry*, Wiley&Sons, Inc. 1990.

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**GEOMETRIC BASES FOR COMPUTER GRAPHICS**

Description

Vector algebra

Basic concepts of projective geometry.

Elements of descriptive geometry.

Expression of spatial relations in drawings.

Main theorems of axonometry.

Basic concepts of differential geometry.

Analytical creation of curves and surfaces.

**Compulsory/Recommended Readings:**

- Bácsó Sándor – Hoffmann Miklós: *Fejezetek a geometriából*, Licium Kiadó, 2003.

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**GIS & Science**

The process of data modelling in a geographical information system. Representing the real-world in a GIS. The most important reference systems and data collection methods. The quality of data. Main types of the vector, raster and hybrid data models. Operations in geographical information systems. Outline of some interesting algorithms related to GIS. Usage a GIS software (currently AutoCAD Map 3D) in practice (querying, thematic mapping, topologies and its operations).

**Compulsory/Recommended Readings:**

- P.A. Longley, M. F. Goodchild, D. J. Maguire, D. W. Rhind, *Geographic Information Systems and Science*, John Wiley & Sons, England, 2005.
- C. Jones: *Geographical Information Systems and Computer Cartography*, Addison Wesley Longman, England, 1997.
- Ott, Swiaczny: *Time-Integrative Geographic Information Systems*, Springer-Verlag Berlin, 2001.
- Brimicombe, A. Li, Ch. (2009): *Location-Based Services and Geo-Information Engineering*, John Wiley & Sons, Inc.
- Hanan Samet, *Application of Spatial Data Structures*, Addison-Wesley, 1993.
- User Guides, Manuals of GIS Softwares

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## ADVANCED SEARCHING ALGORITHMS

Graph searching and combinatorial optimization problems. Constructive searching algorithms. Local searching techniques: simulated annealing, taboo searching, Hungarian method etc. Constraint satisfaction problems and their representation. Constraint propagation, node and edge consistency, k-consistency. Backjumping, backchecking, backmarking, best-first searching etc. Local methods.

### Compulsory/Recommended Readings:

- Futó Iván (szerk.): *Mesterséges intelligencia*, Aula Kiadó, 1999.
- S. J. Russell, P. Norvig: *Mesterséges intelligencia modern megközelítésben*, Panem-Prentice Hall, Budapest, 2000.

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## AUTOMATED THEOREM PROVING

Normal forms, prenex form, skolemization. Herbrand's theorem. Substitution, unification. The most general unifiers, unification algorithms. Hilbert systems, natural deduction. The sequent calculus, cut elimination. Semantic tableaux. Resolution, important resolution strategies. Soundness and completeness of calculi.

### Compulsory/Recommended Readings:

- M. Fitting, *First-Order Logic and Automated Theorem Proving*, Springer, 2nd edition, 1996.
- A. Nerode, R.A. Shore, *Logic for Application*, 2nd edition, Springer, 1997.

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## LOGIC PROGRAMMING AND DEDUCTIVE DATABASES

First-order resolution principle, some important resolution strategies. Principle of logic programming. Relation between logic and logic programming. The logic program. Formalization problems. The relation between PROLOG like logic programs and linear input resolution. The depth first strategy and the parsing of the complete deduction tree in the classical PROLOG systems. Problems coming from the speciality of the PROLOG interpreters / compilers and of the built-in processes. The semantics of PROLOG programs. The Herbrand models, fixpoints. The least fixpoint and the least Herbrand model. Negative information, strategies to treat it and the fixpoints. PROLOG and DATALOG.

### Compulsory/Recommended Readings:

- S. K. Das: *Deductive databases and logic programming*. Addison Wesley, 1992.
- U. Nilsson, J. Maluszinski: *Logic, Programming and Prolog*, Wiley and Sons, 2000.

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## KNOWLEDGE BASED TECHNOLOGIES

Architecture and developing of knowledge based systems. Expert systems. Knowledge base and reasoning. Knowledge representation: semantic net, frame based and rule based systems, description logic. Uncertainty, ambiguity - sources, models to treat uncertainty. Reasoning models. Case studies.

**Compulsory/Recommended Readings:**

- J. D. Ullman: *Principles of Database and Knowledge-Base Systems*, Computer Science Press, 1989.
- Liebowitz, J. (ed.): *The Handbook of Applied Expert Systems*, CRC Press, 1998.

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**SEMANTIC WEB**

The notion and layers of semantic web. The semantic web, a set of design principles expressed in formal specifications. Some of these include Resource Description Framework (RDF), a variety of data interchange formats (e.g. XML) and notations such as RDF Schema and Web Ontology Language (OWL). Reasoning in the semantic web, description logic. Web services.

**Compulsory/Recommended Readings:**

- Asuncion Gomez-Perez, Oscar Corcho, Mariano Fernandez-Lopez: *Ontological Engineering with examples from the areas of Knowledge Management, e-Commerce and the Semantic Web* (Series: Advanced Information and Knowledge Processing). 2004, Springer.
- Franz Baader (szerk): *The Description Logic Handbook: Theory, Implementation and Applications*. 2003, Cambridge University Press.
- Steffen Staab, R. Studer (eds.): *Handbook on Ontologies* (Series: International Handbooks on Information Systems). 2004, Springer.

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**DIGITAL SPEECH PROCESSING**

Review of mathematics for speech processing. Speech production and acoustic-phonetics. Hearing. Speech perception. Speech analysis. Coding of Speech Signals, linear predictive coding. Speech synthesis. Speech and speaker recognition.

**Compulsory/Recommended Readings:**

- O'Shaugnessy, D.: *Speech Communication: Human and Machine*, Addison-Wesley, 1987.
- Olaszky Gábor: *Elektronikus beszédelőállítás*, Műszaki Kiadó, 1989.
- Zwicker, E. Fastl, H.: *Psychoacoustics: Facts and Models*, Springer 1999.

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**NEW COMPUTING PARADIGMS**

Classical computing theory: Turing Machine, Neumann architecture, bits and bytes, operations. Introduction to DNA computing: the structure of DNA, operations on DNA. Adleman's experiment. Computing with membranes. The cell as a membrane system. Catalysts and priority on the evolution rules. Active membranes. Multiset computations. Introduction to Quantum computing. Interval-valued computing: interval-valued logic, generalization of bytes, simulations, list-representation.

**Compulsory/Recommended Readings:**

- C. Calude, G. Paun: *Computing with cells and atoms: an introduction to Quantum, DNA and Membrane Computing*, Taylor & Francis/Hemisphere, 2001.

- G. Paun: *Computing with membranes*, Journal of Computer and System Sciences 61 (2000), pp. 108-143.
- G. Paun, G. Rozenberg, A. Salomaa: *DNA computing*, Springer, 1998.
- Nagy, Benedek: *An interval-valued computing device*, CiE 2005, "Computability in Europe": New Computational Paradigms, Amsterdam, Hollandia, 166-177.
- Nagy, Benedek, Vályi, Sándor: *Solving a PSPACE-complete problem by a linear interval-valued computation*, CiE 2006 Computability in Europe 2006: Logical Approaches to Computational Barriers, University of Wales Swansea, UK, 216-225..

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## NON-CLASSICAL LOGICS

General characterization of classical logic. Intensional logics as non-classical logics. First attempts of logical treatment of modality: modal syllogisms. Problems of conditionals. C. I. Lewis' modal calculi: systems of strict implication (S1...S5). Modal semantics of propositional modal logic, Kripke frames. Consequence-relation in possible world semantics. Connection between modal calculi and modal semantics: completeness theorems.

First order modal semantics. De re, de dicto, Barcan schemes. Modal semantics permitting semantic value gap. Type-theoretical intensional logic as a generalization of modal logic.

### Compulsory/Recommended Readings:

- D. Gabbay, F. Guenther: *Handbook of Philosophical Logic*, D. Reidel, 1986.
- D. Gabbay, F. Guenther: *Handbook of Philosophical Logic*, Second Edition, D. Reidel, 2002.

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## MANY-VALUED LOGICS

General characterization of classical logic. Many-valued logics as non-classical logics. The origin of many-valued logics: Aristotle's sea battle argument. Łukasiewicz's three-valued propositional logic. Łukasiewicz's n-valued and infinite-valued logics. Post's many-valued systems.

Kleene's three-valued logic. General theory of many-valued logics, matrix method. Different sorts of consequence-relations: Bochvar-, Kleene-, Łukasiewicz-style consequence-relations.

Many-valued predicate logic. Quantification in many-valued logic. Descriptions in logic. Unicity formula of descriptions. Semantic value gap. Propositional logic permitting semantic value gap: truth functions permitting semantic value gap. First order logic permitting semantic value gap: problems of quantification. Semantic consequence-relations of logical systems permitting semantic value gap.

### Compulsory/Recommended Readings:

- D. Gabbay, F. Guenther: *Handbook of Philosophical Logic*, D. Reidel, 1986.
- D. Gabbay, F. Guenther: *Handbook of Philosophical Logic*, Second Edition, D. Reidel, 2002.

## COMBINATORIAL AND ALGORITHMIC FEATURES OF FORMAL LANGUAGES

Combinatorics of words. Fine and Wilf theorem. Lyndon-Schützenberger theorem. Primitive, repetitive, palindromic, Lyndon words. Partial words. Berstel and Boisson theorem, Blanchet-Sadri theorem. Languages and codes. Multi-set languages. Combinatorics of languages. Thin languages, palindromic languages. Pumping Lemmas for context-free and regular languages. Homomorph mapping of Context-free Languages. Chomsky-Schützenberger-Stanley Theorem. The Language of Primitive Words. Word-problem. Primitive Multi-sets.

### Compulsory/Recommended Readings:

- Salomaa, A: Formal languages, Academic Press, New York, 1973.
- Salomaa, A.: Jewels of formal language theory, Computer Science Press, 1981.
- Pál Dömösi, Sándor Horváth, Masami Ito: Primitive Words and Context-Free Languages, kézirat

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## PROGRAMMING THEORY

Rewriting systems, algebraic and logical approach. Functional programming and lambda calculi. Type theory and programming languages. Recursive applicative program schemas. Algebraic type specification. Parallelism, distributed systems, concurrent processes, Petri nets.

### Compulsory/Recommended Readings:

- J. van Leeuwen ed.: Handbook of Theoretical Computer Science, Elsevier Sci. Pub. 1990.

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## GRAPH-ALGORITHMS

Representation of graphs, search and traverse in graphs, topological sorting, strongly connected components, 2-coloring. Diameter of a graph, minimum spanning tree, shortest path problem.

### Compulsory/Recommended Readings:

- T.H. Cormen, C.E. Leiserson, R.L. Rivest: Introduction to Algorithms. MIT Press, 2001.
- Gabriel Valiente: Algorithms on Trees and Graphs, Springer, 2002

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## SYSTEMS OF FORMAL LANGUAGES

Lindenmayer systems and their main variations. Context-free grammars and programmed grammars. Mildly context-sensitive and context-sensitive languages. Grammar systems. (Marcus) contextual grammars and languages. Pattern languages. Tree grammars and languages. Graph grammars. Two dimensional languages. Language families. Decidability.

### Compulsory/Recommended Readings:

- G. Rozenberg, A. Salomaa (eds.): Handbook of formal languages 1-3. Springer, 1997.

- J.E. Hopcroft, J.D. Ullman: Introduction to automata theory, languages and computation, Addison-Wesley, 1979.
- C. Martin-Vide, V. Mitrana, G. Paun (eds.): Formal Languages and Applications, Studies in Fuzziness and Soft Computing 148, Springer 2004.

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## **AUTOMATA NETWORKS**

Completeness of directed graphs. Semigroup and group of automaton mappings. Automata and semigroups. Automata networks and products of automata. Glushkov's and Letichevsky's theorems. Krohn-Rhodes theory and holonomy decomposition theorems. Homomorphically complete classes under quasi-direct and cascade products. Product hierarchy of automata. Networks without any Letichevsky criteria. Automata networks with half Letichevsky criteria. Automata networks and Letichevsky criteria. Primitive product. Temporal products. Homogeneous networks. Asynchronous networks.

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

- Pál Dömösi - Chrystopher L. Nehaniv: Algebraic Theory of Automata Network, Siam, 2005.

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## **DNS COMPUTING**

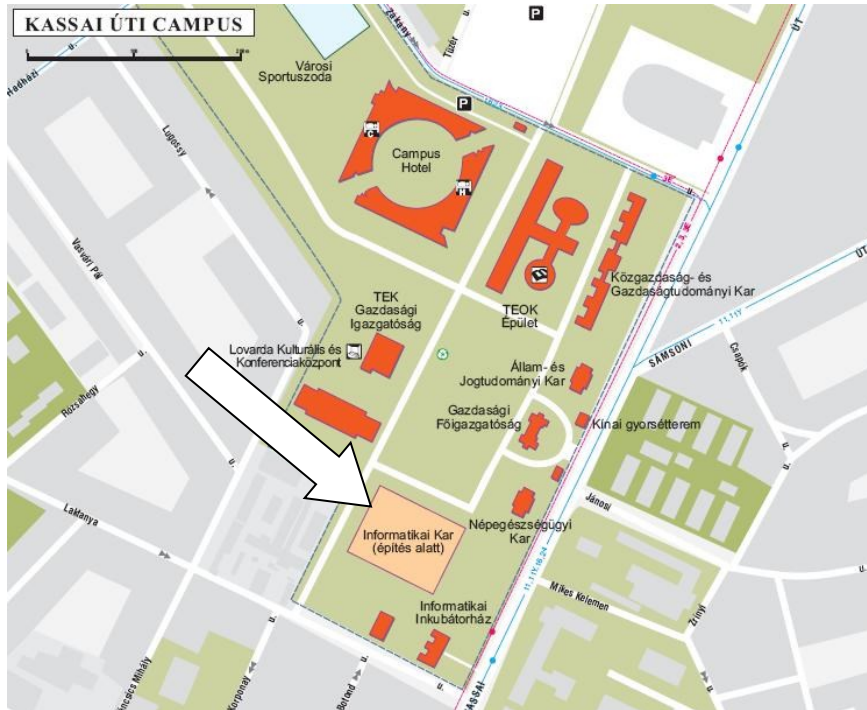
The structure of DNA, operations on DNA. Formal models: insertion-deletion systems. Splicing systems. H-systems. DNA solution of SAT and Hamiltonian path problems. Watson-Crick automata. Computation in a living cell. Gene assembly in ciliates. Micronuclear and macronuclear DNA, linked lists. Basic operations. Abstractions: legal strings and overlap graphs.

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

- G Paun, G. Rozenberg, A. Salomaa: DNA computing, Springer, 1998.
- A. Ehrenfeucht, T. Harju, I. Petre, D.M. Prescott, G. Rozenberg: Computation in Living Cells. Gene assembly in Ciliates. Springer, 2004.

## The map of the campus

The new building of Faculty of Informatics at Kassai Campus



## Photos



The largest lecture hall for 196 persons



Seminar room



Inside the building





“Green wave” park in front of our building



Professional Student's Days at Faculty







Publisher: Prof. Dr. Tamás Mihálydeák  
Editor: Mrs Katalin Rutkovszky  
Photos: Katalin Rutkovszky, Sándor Bódi, Krisztián Kaltenecker

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