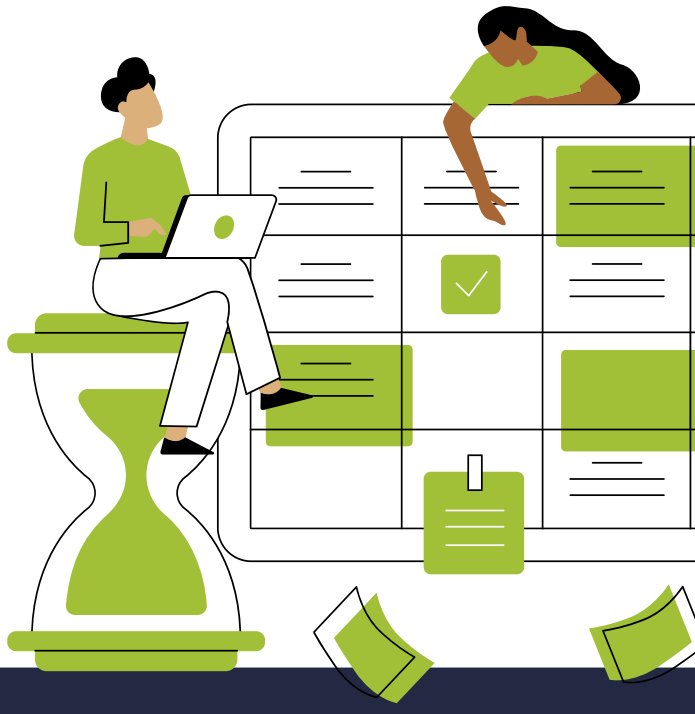
SZÉCHENYI EGYETEM
UNIVERSITY OF GYŐR

HOW TO SUCCEED IN YOUR STUDIES?

Welcome guide for
Computer Science MSc Students



SZÉCHENYI EGYETEM
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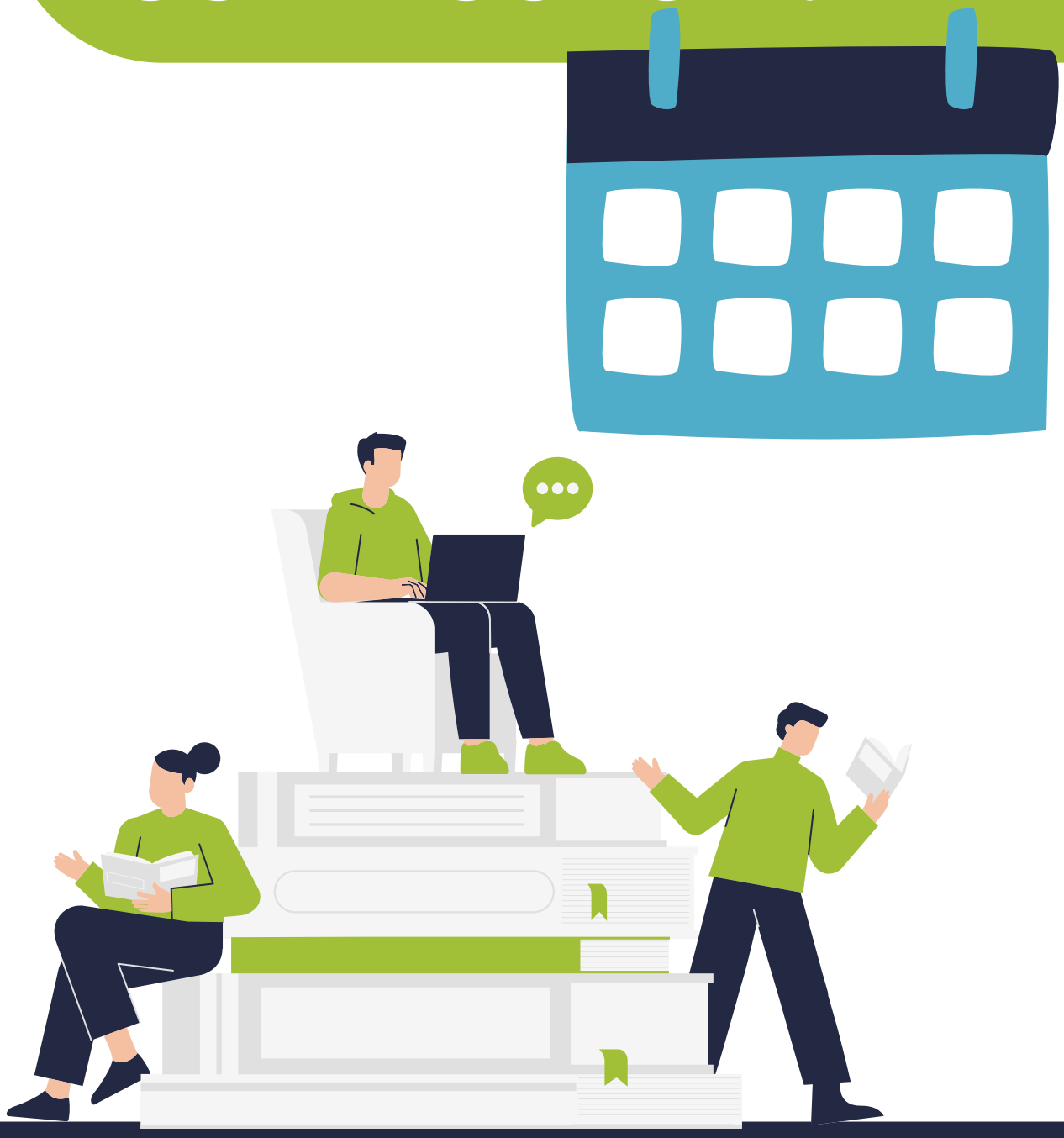
1. PLAN YOUR CURRICULUM!



GOOD TO KNOW

- You need to complete subjects in three category:
  - **compulsory** - 85 credit points
  - **elective** - you need to choose 5 subjects = 25 credit points
  - **optional** - you need to choose 2-3 subjects = 10 credit points

- It is recommended to have an **average workload**. Take 25-35 credit points per semester.

- Choosing specific elective subjects, you can create your own track specialization:
  - an **artificial intelligence track** with Neural networks, Big Data and Cloud computing,
  - a **digital twin track** with Numerical methods for differential equations, Data assimilation, Model order reduction,
  - or **any combination** of elective courses.

- There are some **very important subjects, which are pre-conditions** for other subjects, for example:
  - Python programming
  - Digital twins
  - Project work 1, Project work 2
  - and some other subjects are pre-conditions for electives.

It is highly recommended to focus with special attention on these subjects during the semester and prioritise them in the exam period. You can find them below with **red**.

- For further information on the content and requirements of the subjects please check the **latest datasheet of the subjects** on https://neptun.sze.hu/tantargyi-tematikak. (You can find below a short teaser.)

In the search box on the right, write the name of the subject (Tárgy), than push Enter. You can download the datasheets by clicking on "Letöltés".

TO DO FOR THE REGISTRATION PERIOD

- **First semester, the Academic Registry Office takes up your subjects, in the following semesters you have to take them up yourself after you register for active semester**. Deadlines are sent in Neptun.

In case of any uncertainty, e.g. if you do not know, which subjects to take up, please contact the administrator of the Department of Mathematics and Computational Sciences.

- **If there is no more free slot** for the subject you would like to take, please make sure to request the extension of capacity in time.

Please contact the administrator of the department responsible for the subject / or the teacher during the registration week, latest until Thursday.

- **If taking up the subject is unsuccessful**, please check the pre-conditions. Most likely you have not completed it yet.

- **If you would like to change something after the week of the registration,** you can send a Neptun request for delayed taking up/dropping subjects (Administratin --> Requests).

Taking up a subject or dropping it after the registration week costs 3500 HUF / subject.

- **If you have taken a subject twice,** further occasions cost 6000 HUF.

- **If you have failed a compulsory subject, but you completed mid-term requirements and got signature, you may request a CV course** ("Csak Vizsga", means Exam Only course) in next semester's registration period. (EER §47)

Please contact the administrator of the department responsible for the subject / or the teacher during the registration week, latest until Thursday.

- Students from other BSc than Computer Science might need to complete **MP courses (Mesteren Pótlandó, means MSc supplementary course)**. List of courses is received during admission. (EER §47/A)

First two semesters, MP courses are taken up automatically by the Academic Registry Office, later semesters the student must request it in Neptun (Administration --> Requests).

- Those who have already studied at a higher education institution have the opportunity to **accept credits with credit transfer request**.

Credit transfer: Annex 1 of EER, administrative details and online request form: neptun.sze.hu

- **You may take up subjects from other majors as cross-study** to extend your knowledge.

Detailed rules are in EER §53, a Neptun request should be submitted **before** registration period.

COMPULSORY SUBJECTS

Total credit points: 85

Subject	Weekly lectures	Weekly seminars	Credit points	Semes-ter	Pre-conditions
Digital twins GKNM_MSTA035	2	4	7	1	
Numerical linear algebra GKNM_MSTA036	2	2	5	1	
Nonlinear optimization GKNM_MSTA037	2	2	5	1	
Python programming GKNM_MSTA038	2	4	7	1	
High performance computing GKNM_MSTA039	2	2	5	1	
Machine learning GKNM_MSTA040	2	2	5	2	Python programming
Web technologies GKNM_MSTA041	2	2	5	2	Python programming
Project work 1 GKNM_MSTA042	1	3	6	2	Python programming and Digital twins
Project work 2 GKNM_MSTA043	1	3	5	3	Project work 1
Digitalization for industry GKNM_TATA061	2	2	5	3	
Thesis Consultation GKNM_MSTA052	0	0	30	4	Project work 2

ELECTIVE SUBJECTS

Choose 25 credit points

Subject	Weekly lectures	Weekly seminars	Credit points	Earliest semester	Pre-conditions
Numerical methods for differential equations GKNM_MSTA044	2	2	5	2	Digital twins and Numerical linear algebra
Linear optimization GKNM_MSTA045	2	2	5	2	
Big Data GKNM_MSTA046	2	2	5	2	Python programming
Model order reduction GKNM_MSTA047	2	2	5	3	Numerical methods for differential equations
Data assimilation GKNM_MSTA048	2	2	5	3	Digital twins
Neural networks GKNM_MSTA049	2	2	5	3	Machine learning
Selected topics in Machine Learning GKNM_MSTA050	2	2	5	3	Machine learning
Cloud computing GKNM_MSTA051	2	2	5	3	Web technologies

OPTIONAL SUBJECTS

Choose 10 credit points

Subject	Weekly lectures	Weekly seminars	Credit points	Semes-ter	Pre-conditions
Computational fluid dinamics in vehicle engineering AJNM_JFTA005	0	2	5	3	Numerical methods for differential equations
Logistics AJNM_LSTA024	2	2	6	autumn	
CAE Methods GKNM_AMTA011	2	1	5	spring	
Automatic controls GKNM_AUTA011	2	0	5	spring	
Global economics KGNM_NETA028	2	0	4	autumn	
Advanced Macroeconomics KGNM_NETA054	2	0	4	autumn or spring	
Leadership and Organizational Communication KGNM_VKTA003	2	2	5	autumn or spring	

SCHEDULE PER SEMESTER

Pre-conditions are marked with red

1.Semester	2. Semester	3. Semester	4. Semester
Compulsory subjects (85 credit points)			
Digital twins (7)	Machine learning (5)	Project work 2 (5)	Thesis Consultation (30)
Numerical linear algebra (5)	Web technologies (5)	Digitalization for industry (5)	
Nonlinear optimization (5)	Project work 1 (6)		
Python programming (7)			
High performance computing (5)			
29 credit points	**16 credit points**	**10 credit points**	**30 credit points**
Elective subjects (choose 25 credit points)			
	• Big Data (5) • Linear optimization (5) • Numerical methods for differential equations (5)	• Cloud computing (5) • Data assimilation (5) • Model order reduction (5) • Neural networks (5) • Selected topics in machine learning (5)	
Optional subjects (choose 10 credit points)			
• Logistics (6) • Global economics (4) • Advanced Macroeconomics (4) • Leadership and Organizational Communications (5)	• CAE methods (5) • Automatic Controls (5) • Advanced Macroeconomics (4) • Leadership and Organizational Communications (5)	• Computational fluid dinamics in vehicle engineering (5) • Logistics (6) • Global economics (4) • Advanced Macroeconomics (4) • Leadership and Organizational Communications (5)	• CAE methods (5) • Automatic Controls (5) • Advanced Macroeconomics (4) • Leadership and Organizational Communications (5)

Mathematical modelling

Digital twins

7 credit points* | *compulsory* | *1. semester* | *dr. Zoltán Horváth, dr. Ádám Bácsi

The main goal of the course is to introduce, practice and deepen the necessary mathematical tools for the curriculum and provide the students with a detailed overview of all components of the model based digital twins and construct one actual digital twin at the end of the course.

Topics: The concept of digital twins with examples from industry and global challenges. Vector spaces, norms, scalar product, Hilbert spaces. Function spaces. Ordinary differential equations, initial and boundary value problems, linearization. Linear ordinary differential equations, exact and numerical solutions in the state space. Linear input-output systems, control systems. Laplace transformation, transfer function; approximation with the transfer function. Model order reduction with balanced truncation and proper orthogonal decomposition for linear input-output systems. Parameter dependent problems and their methods. Introduction to optimization and fault detection. Construction of a model based digital twin: thermal predictive maintenance of a simplified motor.

Model order reduction

5 credit points* | *elective* | *3. semester* | *dr. Abdellhakim Lotfi

TThe main goal of the course is to introduce and get learned the most recent and effective methods of the model order reduction technology, including their numerical implementation.

Topics: The model order reduction concept and terminology. Model order reduction for linear input-output systems: modal truncation, balanced truncation and comparision with the substructuring method. Simplification of parametric systems and application for optimization. The proper orthogonal decomposition (POD). Methods improving efficiency of POD (balanced POD, EIM, DEIM). Combination of POD and clustering. The reduced basis method for the finite element methods. Applications using computational software FEniCS and Feel++.

Numerical mathematics

Numerical linear algebra

5 credit points* | *compulsory* | *1. semester* | *dr. Csaba Gáspár

The main goal of the course is to outline the solution techniques for linear systems of equations, eigenvalue problems and matrix decompositions with special focus on the linear algebra needed for data science and numerical methods for differential equations.

Topics. Challenges to be solved with linear algebra (e.g. image compression). Linear systems of equations, direct and iterative solution methods, the Krylov subspace methods. The effect of ill-conditioning, pre-conditioning. Matrix decompositions (LU, Cholesky, QR, SVD). Partial SVD. Computation of eigenvalues. The method of least squares. Efficient implementations and software libraries (BLAS, LAPACK). The SciPy Linear Algebra toolbox. Large scale problems.

5 credit points* | *elective* | *1. semester* | *dr. Csaba Gáspár, dr. Abdelhakim Lotfi

Numerical methods for differential equations

The main goal of the course is to introduce numerical methods for partial differential equations and provide students a practice with FEniCS for problem solution with the finite element methods.

Topics: Some vector analysis. Physical problems resulting PDEs. Weak forms of PDEs. Elliptic partial differential equations. Finite element method for 1D and 2D Poisson problems. Techniques based on the Fourier, finite difference, finite element method, finite volume and some other methods.
Problem solving with FEniCS: Introduction; A simple finite element program; Applications: academic examples; Time discretization: transient heat equation; Nonlinear problems: Newton method; Navier-Stokes equations.

Optimization

Linear optimization

5 credit points* I *elective* I *2. semester* I *dr. Tamás Hajba

Topics: Motivation: vehicle routing problem and production line optimization of large enterprises. Linear programming problems. Solution methods of linear programming problems: graphical method, symplex method. Duality, connection between the primal and dual problems. Multiple objective optimization. Integer linear programming models. The knapsack problem. Transportation problem, assignment problem and their solution methods. Network flows. Algorithms for finding the maximum flow, and the minimal cost flow. Modeling and solving integer programming problems with GAMS. Solution of a vehicle routing problem. Solution of a production line optimization problem.

Nonlinear optimization

5 credit points* I *compulsory* I *1. semester* I *dr. Mihály Csaba Markót

Basic concepts and methods of nonlinear optimization. Optimality conditions for unconstrained optimization. Gradient methods. Newton and quasi-Newton methods, the conjugate gradient method. Nonlinear least squares problems. The Gauss-Newton method. Derivative–free search. Black-box optimization. Directional and symplectic direct search methods. Basics of convex optimization. Lagrange multiplicators. Necessary and sufficient optimality conditions for equality and inequality constrained optimization. NLP duality. Lagrange multiplicator algorithms. Interior point methods for NLPs. Sequential quadratic programming. Basics of multidisciplinary optimization, a priori and a posteriori search methods. PDE-constrained optimization, the adjoint method. Overview of heuristics methods.

Programming fundamentals

Python programming

7 credit points* I *compulsory* I *1. semester* I *dr. Gábor Takács

The goal of the course is to introduce a modern, dynamically typed programming language (Python), and to teach the programming approach and techniques needed to use the language efficiently.

Content: Simple data types, collections. Operators, expressions, conversion. Standard I/O. Control structures: if, while, for. Comprehensions. Searching and sorting. File handling, text file processing schemes. Advanced elements of the language (unpacking, slicing, advanced iteration). Functions. Elements of functional programming. Object oriented programming in Python. Exception handling. Overview of the standard library. Some useful external packages (numpy, pandas, matplotlib).

Web technologies

5 credit points* I *compulsory* I *2. semester* I *dr. Dávid Fülep

The goal of the course is to introduce how the web works, and to teach the basics of web programming and web services.

Content: History of the internet and the web. Some important protocols (IP, TCP, UDP, DNS, HTTP, HTTPS). Web standards. The fundamentals of HTML(5). Document Object Model (DOM). Dynamic web pages, the basics of Javascript. CSS in nutshell. Template engines. Python based web frameworks: Bottle and Flask. The JSON format. RESTful web services.

Computing

5 credit points* I *compulsory* I *1. semester* I *dr. László Környei

High performance computing

The main goal of the course is to introduce the concept and gain personal experience on servers used for high performance computing (HPC) tasks. Theoretical introduction of HPC architetures, find similarities and differences, advantages and disadvantages among different solutions. Job management: job management system, scheduling, creating job, concept of queues, job control, job monitoring. Introduction to some well-known job manager and resource scheduling/balancing systems: torque, openPBS, slurm. Basic concepts of parallel programming and computing: MPI, OpenMP, HPC software libraries, HPC applications. Scalable software concepts. Designing, creating and running simple parallel programs on different architectures.

Cloud computing

5 credit points* I *elective* I *3. semester* I *dr. Gábor Takács

The goal of the course is to introduce the fundamental concepts of cloud computing and to introduce a specific cloud based platform (Google Cloud Platform) via practical exercises.

Content: Definition of cloud computing. Service models (IaaS, PaaS, SaaS). Compute instances. Cloud based storage. Cloud management. VPC networks. Infrastructure as code. Cloud based databases (BigQuery, BigTable). Container technologies, Docker, Kubernetes.

Data science

Machine learning

5 credit points* I *compulsory* I *2. semester* I *dr. Gábor Takács

TThe goal of the course is to introduce the basic methods of machine learning to the students. In addition, the course teaches how to use a specific data analysis tool to process real-life data sets.

Content: The definition, goal and process of data analysis. Some interesting real-life applications. Fundamental problems of machine learning: classicication, regression, clustering. Linear regression. Multivariate case, bias term. Logistic regression. Cross-validation, evaluation metrics for classification and regression. Overfitting, regularization. Decision trees, random forests, gradient boosting. Unsupervised learning, K-means clustering, t-SNE.

Neural networks

5 credit points* I *elective* I *3. semester* I *Albert Tihamér Kocsis

The goal of the course is to introduce the most important types of artificial neural networks, moreover, to teach modern methods for training these networks.

Content: The history of artificial neural networks, shallow and deep networks. Introduction to the Python modules tensorflow and Keras. Multilayer perceptron. Activation functions. Batch normalization, dropout. Variants of the stochastic gradient method. Convolutional networks. The ResNet architecture. Recurrent networks, LSTM. The Generative Adversarial Network (GAN) architecture.

Selected topics in machine learning and Big Data

Big Data

5 credit points* | *elective* | *2. semester* | *dr. Gábor Takács

The course introduces the terminology and the core concepts behind big data problems, applications, and systems. It provides an introduction to the most common Big Data frameworks, Hadoop and Spark, that has made big data analysis easier and more accessible. It describes the Big Data landscape including examples of real world big data problems and explains the V's of Big Data (volume, velocity, variety, veracity, valence, and value) and why each impacts data collection, monitoring, storage, analysis and reporting, identifies what are and what are not big data problems and be able to recast big data problems as data science questions.

5 credit points* | *elective* | *3. semester* | *dr. András Benczúr

Selected topics in machine learning

The course covers additional topics beyond the Machine Learning course, as a continuation of that course. The topics include machine learning over networks, recommendation systems, and reinforcement learning.

Data acquisition and processing

Data assimilation

5 credit points* | *elective* | *3. semester* | *dr. István Harmati

The course introduces the basic methods of data assimilation and their mathematical background with emphasis on applications.

Topics covered:
Basics of probability, random variables, conditional and marginal distributions. Basics of statistics and estimation theory. Bayesian estimation.
Dynamical systems, iterations, differential equations, long-term behaviour. Controlled dynamical systems. Probabilistic view of dynamical systems, ergodicity.
Basic notions, properties and categories of stochastic processes. Correlation measures. Smoothing problems, filtering problems. Linear Gaussian problems. Kalman smoother. Particle filter. Kalman filter, extended Kalman filter. Ensemble Kalman filter. Markov Chain Monte Carlo methodology: deterministic and stochastic dynamics. Linear smoothers. Variational methods. 3D Var, 4D Var, adjoint method. Large-time behaviour of filters.

Digitalization for industry

5 credit points* | *compulsory* | *3. semester* | *Ákos Kovács

The goal of the course is to introduce tha basic concecpt of Computer Networks to understand IoT and Industry 4.0 concept. The participant will get familiar with basic Linux command, shell scripts, filesystems, kernels, and usage of an HPC system, or cloud resource.

Topics: IoT network concepts. Data Protocols and data processing (e.g. MQTT, CoAP, AMQP, LoraWan, LPWAN). Computer networks basics, Transport protocols, network services, IPv4 and IPv6. IP and not IP based Interconnects. Linux basic structure, kernels/modules, basic commands, compiling tools, permissions. Shell scritps, regular expressions, basic text editing tools. Virtualizaton basics, concepts. CPU, Memory, Disk, Network virtualization. HPC Computer architecture, X86, Cray, differences. HPC architecture, key applications, module system. HPC and Cloud computing. Using HPC from WEB interface, TOSCA files, HPC and Cloud orchestrators.

Project work

Project work 1

6 credit points* I *compulsory* I *2. semester

The aim of the course is to teach the students the method of solving a complex problems of digital twins and data science arinsing from real industrial applications or advanced research by the method of doing, enhance their communication skills with industry and enterpreneurship and actually solve challenges with the.

In the first week some methodologies of project work, enterpreneurship and project management are provided; these methodological aspects will be used in practical work and from timet o time evaluated. Then, in the second week several problems from artificial intelligence and digital twins that are relevant for industry and global challenges will be presented and discussed by the teachers of the programme and, typically, an external member of industry. Students of the course select one of the presented challenge under the coordination of the responsible person of the course. Students solve the chosen problem during the semester under the supervision of the promoters of the challenge and present the results in the last 2 weeks. Supervisors may deliver some lectures for the students working on their topics to assist the students solution.

Project work 2

5 credit points* I *compulsory* I *3. semester

In the first 2 weeks, several problems from artificial intelligence and digital twins that are relevant for industry and global challenges will be presented and shortly discussed by teachers of the curriculum. Students of the course select one of them and they solve the chosen problem during the semestre and present the results in the last week.

Requirements for graduation

Compulsory internship

6 weeks internship is compulsory for the students. The internship can be carried out in any government or business organization / enterprise, in research and innovation projects where basic IT technology is used. During the internship, the student must prepare a report detailing the task assigned to him / her, presenting the work done, his / her working method and results, and describing the experience gained. Recommended in summer, after the 2. semester.

Further information on the process for international students:
https://karrier.sze.hu/international-internship

Further information on the process for Hungarian students:
https://karrier.sze.hu/jelentkezesi-segedlet

Thesis and final exam

Further information will be provided by the administrator of the department.

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2. PREPARE FOR EXAM PERIOD!

USEFUL TIPS

- **Prepare a schedule for the exam period.**

- **Offered marks** registered by the tutors can be found, and accepted or rejected under Tárgyak/ Megajánlott jegyek (Subjects/Offered marks) in the Neptun system during exam period. In this case, you do not have to register for an exam.

- **Do not leave important subjects (pre-conditions) for the last exam date**.

- **Do not leave registration or deregistration for the last minute.** You can register for an exam or deregister from it until 12:00 (noon) on the day before the exam.

- If there is a medical reason for **not showing up on the exam**, send a certificate from your doctor to the teacher, otherwise you will be charged 3000 HUF for unverified absence.

- **Always keep some money on your Neptun account.** If you fail an exam twice, you can register for a next exam date only after charging yourself the IV fee in Neptun and paying it through the system. IV fee is 2000 HUF for the 3rd and 4th exam, and 2500 HUF for the 5th and 6th exam. In case of taking the same subject repeatedly, the fails of the previous semesters are added to the exams of the ongoing semester. You may have 3 exams in one exam period.

- **A last chance: leniency exam.** If you have failed a very important exam (e.g. Python programming, which is pre-condition for three subjects in the second semester), you have the opportunity to apply for a leniency exam. This exam is after the last week of the exam period. Date and place are announced by the department responsible for the subject. Leniency exam can be requested once per curriculum, and costs 4000 HUF.

- Give feedback to your teachers: fill in the **Student's Evaluation of Teacher's Work** (Oktatói Tevékenység Hallgatói Véleményezése - OTHV) questionnaires in Neptun system (Administration --> Questionnaires).

Further information on exam rules: EER §59-§72

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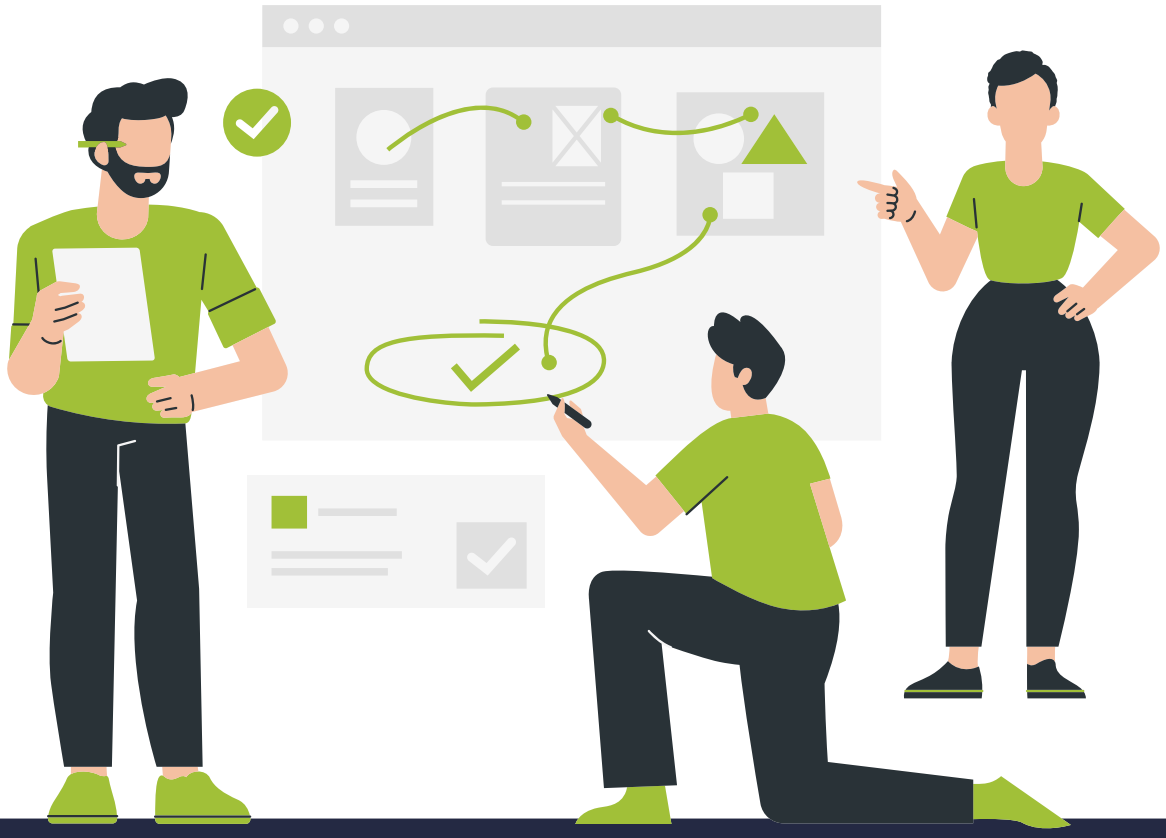
3. PLAN YOUR CARRIER!



HOW TO PREPARE FOR YOUR DREAM JOB?

- Always **have an up to date CV** at hand. You may never know, when a good you might need it. If you don't have relevant job experience, specify the subjects and topics you have learnt at university.

- You can **gain valuable experience and build industrial relations during your curriculum**: with Project work 1, Project work 2, compulsory internship and thesis. You can complete all of these in one topic, which gives you the **opportunity for specialization**.

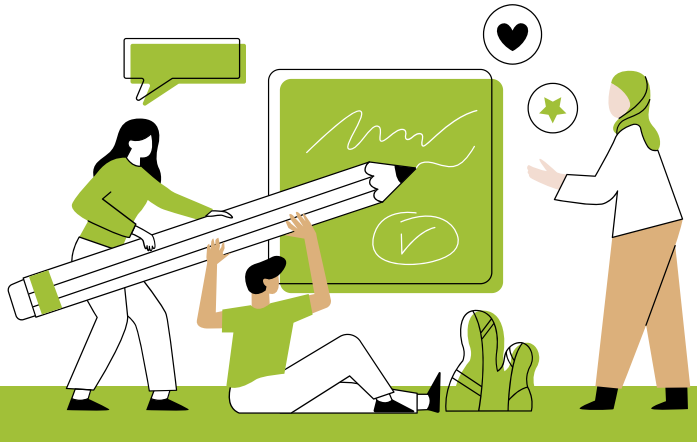
- We also recommend to attend **Scientific Students' Associations Conference** (Tudományos Diákköri Konferencia - **TDK**).

- There are always several ongoing **international research projects** at the university, also we have two **competence centers**: Vehicle Industry Research Center (Járműipari Kutatóközpont - JKK) and Digital Development Center (Digitális Fejlesztési Központ - DDC).

- **Student organizations** are the best place to look for friends and experience: e.g. SZEnergy, SZEngine, Arrabona Racing Team, SZESAT and so on.

- Talented students can apply as a **teaching assistant** (demonstrátor) or **reasearch assistant** at the Department of Mathematics and Computational Sciences.

- You can continue your studies even after the MSc programme at **Doctoral School of Multidisciplinary Engineering Sciences** (Műszaki Tudományi Doktori Iskola - MMTDI).



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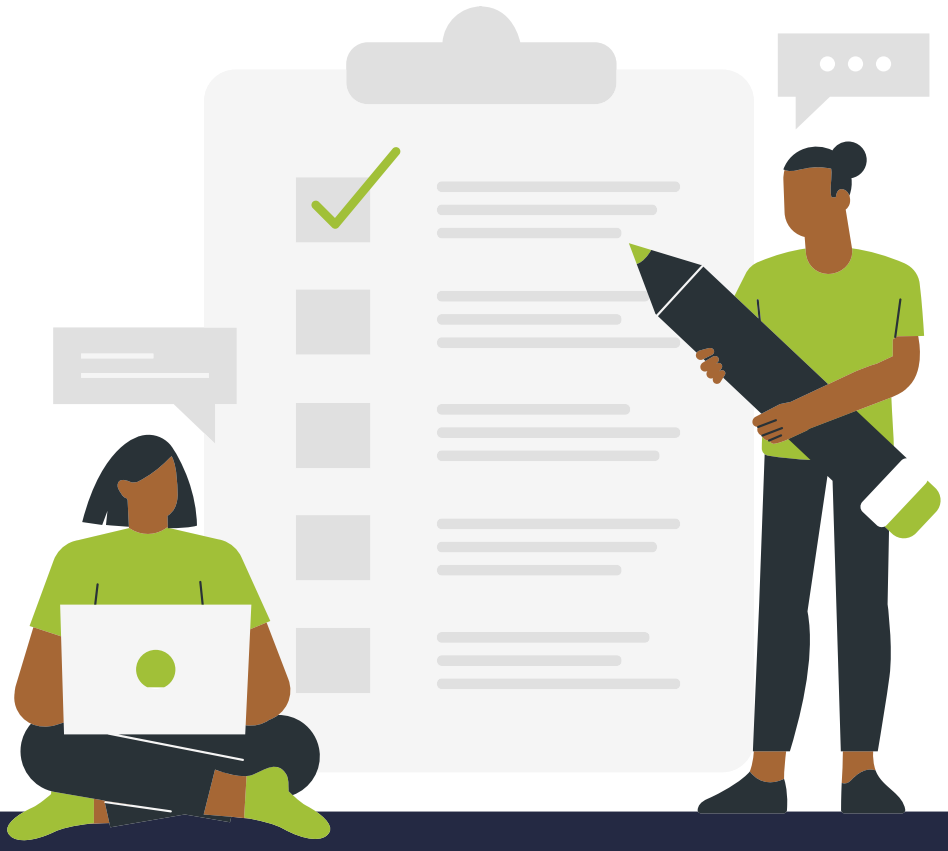
4. BE MASTER OF ADMINISTRATION!



IMPORTANT INFORMATION AND CONTACT DETAILS

- The information in this booklet is based on the **TVSZ** (Tanulmányi és Vizsgaszabályzat - Education and Exam Regulations), **and TJSZ** (Térítési Juttatási Szabályzat - Compensation and Allowance Regulations).

Please always check the latest regulation in these documents, as it contains further details and may change during your studies. You can find them on neptun.sze.hu / neptun.sze.hu/en_GB

- Please check the **messages sent to you in Neptun** regularly - English version is often at the end of the e-mails.

- The most important **websites** for you:
  - admissions.sze.hu - information for international students
  - neptun.sze.hu - latest educational information, deadlines, Neptun guide, link to Neptun, phonebook (contact details for all university employees)
  - karrier.sze.hu - information on internship
  - math.sze.hu - information on thesis and final exam
  - facebook.com/szehkb/ - information on latest events and news for international students
  - facebook.com/sze.givk.hok - Student's Council of the Faculty
- **Contact details:**

Administrator of the Department of Mathematics and Computational Science	Szilvia Hegyi szilvia.hegyi@math.sze.hu, office C605	planning the curriculum, questions about thesis and final exam...
Administrator at the Academic Registry Office (Tanulmányi Osztály, TO)	Enikő Horváth heniko@sze.hu IG ground floor	student requests, student ID card, student status...
Administrator for Stipendium Hungaricum	Márta Mészáros mmzs@sze.hu office IG 103	information on Stipendium Hungaricum
Student Committe of Foreign Affairs (Hallgatói Külügyi Bizottság)	Vályi Nagy Dávid valyi.nagy.david@ga.sze.hu	events and help for international students from fellow students

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