Budapest University of Technology and Economics
Faculty of Transportation Engineering
and Vehicle Engineering

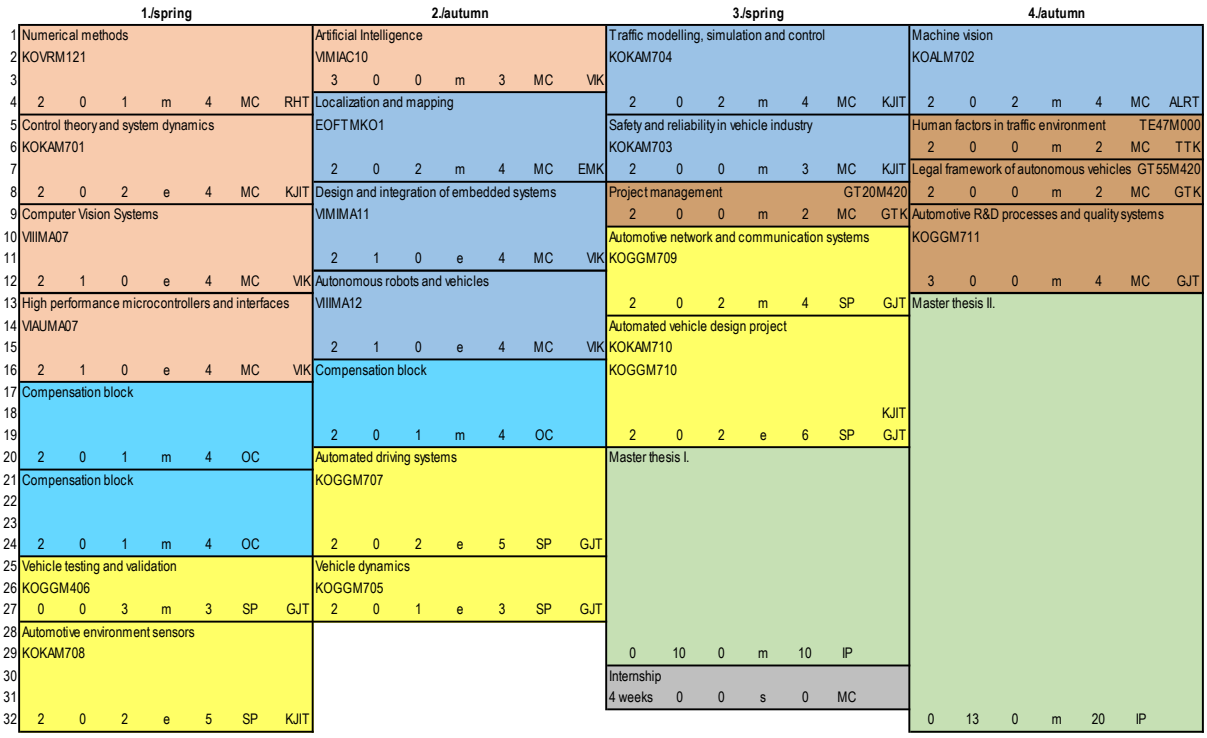
Autonomous Vehicle Control Engineering Master Programme

Curriculum

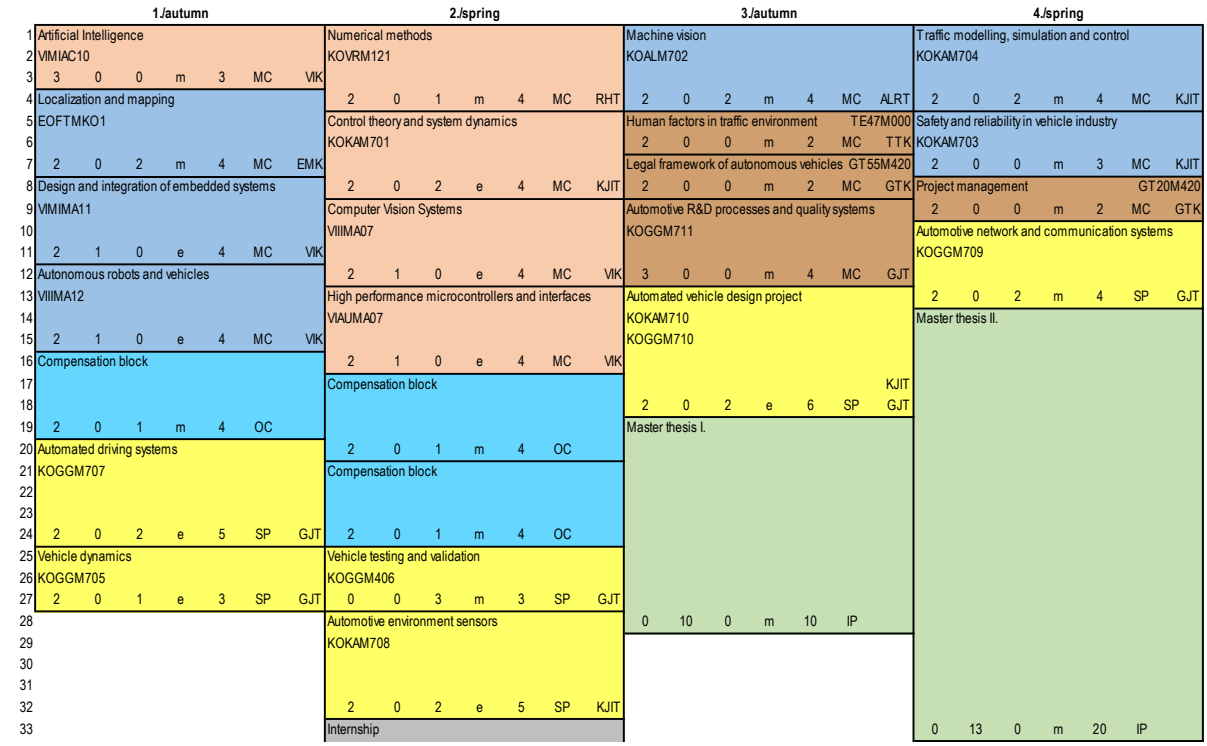
Valid from February 2024

Code
6-MA_közös_2024_O
6-MA_közös_2024_T

Autonomous Vehicle Control Engineering Master Programme start in February



Autonomous Vehicle Control Engineering Master Programme start in September



Recommendation examples of compensation subjects

For vehicle engineer BSc

Programming in C- and Matlab KOKAM603						
2	0	1	m	4	OC	KJIT
Software Development Methods and Paradigms VIAUMA00						
2	1	0	e	4	OC	VIK
Optional course						
2	0	0	m	2	OC	any
Optional course						
2	1	0	e	4	OC	any

For mechanical/mechatronics engineer BSc

Software Development Methods and Paradigms VIAUMA00						
2	1	0	e	4	OC	VIK
Automotive vehicle systems KOGGM712						
2	0	1	m	4	OC	GJT
Optional course						
2	0	0	m	2	OC	any
Optional course						
2	1	0	e	4	OC	any

For electrical engineer / informatics BSc

Vehicle operation KOGGM174						
2	0	1	e	4	OC	GJT
Automotive vehicle systems KOGGM712						
2	0	1	m	4	OC	GJT
Vehicle mechanics fundamentals KOGGM713						
2	0	1	e	4	OC	GJT

Course description explanation

1. Subject name	official name of the subject
2. Subject name in Hungarian	official name of the subject in Hungarian
3. Role	role of the subject in the curriculum, MC - mandatory; SP - specialization; EC - elective economics; OC - optional compensation
4. Code	Neptun code of the subject (with BME prefix)
5. Evaluation type	type of academic performance assessment, e - exam grade; m - mid-term grade
6. Credits	credit value of the subject
7. Weekly contact hours	number of weekly (term-based) teaching hours for students by lecture, practice and lab
8. Curriculum	master programs related to the subject,: A - Autonomous Vehicle Control Engineering J - Vehicle Engineering K - Transportation Engineering L - Logistics Engineering
9. Working hours for fulfilling the requirements of the subject	contact hours – personal appearance at classes in a university preparation for seminars – preparation at home for the classes homework – preparation of homework and other assignments for the classes reading written materials – reviewing and understanding the taken lessons at home midterm preparation – recommended preparation time at home for the midterm test during the semester exam preparation – recommended preparation time at home for the exam
10. Department	name of responsible department for managing the subject
11. Responsible lecturer	name of the person in charge of the subject (subject coordinator)
12. Lecturers	name of all lecturers of the subject
13. Prerequisites	predefined criteria for registering the subject
14. Desciption of lectures	detailed content of the lecture type course
15. Description of practices	detailed content of the practice type course
16. Description of laboratory practices	detailed content of the laboratory practice type course
17. Learning outcomes	results to achieve at the end of the learning process, grouped by competence
18. Requirements	requirements for passing the subject, aspects of performance evaluation, way to determine a grade (obtain a signature)
19. Retake and delayed completion	opportunity for repeat/retake and delayed completion
20. Learning materials	notes, textbooks, suggested literature, recommended learning support materials in printed or electronic form

Curriculum Supplement

All questions and conditions that regulate the study progress should be defined in this Supplement to the Curriculum. Thus, the Curriculum Supplement (curriculum appendix) contains **the system of subject prerequisites**, the rules for the selecting specializations, the description of the conditions for the **preparation of the Master thesis and the final examination**, as well as the order of the final exam.

The subject prerequisite system expresses the connections between the subjects. The specific subject prerequisites are included in the subject datasheets.

In the absence of a *strong* or a *weak* prerequisite, it is not possible to enroll in the subject, and no exceptions can be given, as it reflects the professional conditions of effective education. In the case of *co-requisite* subjects (simultaneous enrollment of two subjects in prerequisite connection), if the subject having a co-requisite subject is not fulfilled in the given semester, consequently the co-requisite subject also cannot be completed in that semester. In the absence of the *recommended* prerequisite, the course can be enrolled, but it should be noted that the course is preferably assumes knowledge from the recommended prerequisite subject.

2. There are no general rules for the selection of specialization and for specialization subjects.

3. Enrollment rules for the Master thesis subjects in all specializations:

The **prerequisite for enrollment in the Master thesis I. course** are the completion of compulsory courses covering all the basic natural scientific knowledge in the recommended curriculum (i.e. mandatory courses marked with pink background) and the collection of a minimum of 56 credits.

The **prerequisite for enrollment in the Master thesis II. course** are the completion of compulsory courses covering all the basic natural scientific knowledge included in the recommended curriculum (i.e. mandatory courses marked with pink background) and the collection of a minimum of 84 credits. The Master thesis I. course can be enrolled simultaneously as co-requisite, in which case the above cumulative acquired credits must be achieved by completing another subjects according to the recommended curriculum. A further condition is the completion of the 4-week internship in case of full time master study.

4. Criteria for taking the final examination:

Completion of all subjects included in the recommended curriculum, including optional subjects (all together at least 120 credits), submitting the Master thesis and, in the case of a full-time master study, fulfillment of all criterion requirements in the curriculum (4 weeks of internship).

5. Final examination order:

The final examination in front of the Final Examination Board consists of **defending the Master thesis** and **passing oral final exams from three subjects** (or subject groups). The final exam subjects (or subject groups) are assigned by the Department responsible for the specialization. The subjects must be selected partly from the professional core subjects, and from the specialization subjects, so that each subject has a minimum credit value of 3 and the knowledge of the three subjects (or subject groups) is **at least 15 credits in total.**

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Artificial Intelligence**				
2. Subject name in Hungarian	Mesterséges intelligencia			**3. Role**	.
4. Code	**VIMIAC10**	**5. Evaluation type**	**m**	**6. Credits**	**3**
7. Weekly contact hours	**3 lecture**	**0 practice**	**0 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**90 hours**
Contact hours	42 hours	**Preparation for seminars**	14 hours	**Homework**	22 hours
Reading written materials	0 hours	**Midterm preparation**	12 hours	**Exam preparation**	0 hours

10. Department	Department of Measurement and Information Systems
11. Responsible lecturer	Dr. Pataki Béla
12. Lecturers	Dr. Pataki Béla, Dr. Hullám Gábor

13. Prerequisites	- (-), -; - (-), -; - (-), -

14. Description of lectures

The aim of the subject is a short, yet substantial presentation of the field of artificial intelligence. The principal presented topics are (1) expressing intelligent behavior with computational models, (2) analysis and application of the formal and heuristic methods of artificial intelligence, (3) methods and problems of practical implementations. The subject is intended to develop the abilities and skills of the students of informatics in the area of:

- studying novel applications of the computing,
- developing effective methods to solve computational problems,
- understanding the technological and conceptual limits of the computer science,
- intellectual understanding of the central role of the algorithm in information systems.

15. Description of practices

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16. Description of laboratory practices

-

17. Learning outcomes

a) knowledge:
- knows the possibilities of artificial intelligence and its limitations,
- knows the basic conceptual and mathematical foundations of intelligent systems,
- know the methods of intelligent system design,
- knows the formalization techniques of information,

b) skills:
- is able to design an independent information processing architecture,
- is able to understand, model and implement learning processes

c) attitude:
- strives to understand the technological / conceptual constraints of computing / science
- strives to understand the central role of the algorithm in IT systems.

d) autonomy and responsibility:
- can independently develop effective methods for solving computational problems

18. Requirements, way to determine a grade (obtain a signature)

Two midterm exams, with the minimum-level of 40%. The midterm result is the sum of the exams and the homework
The overall sum must reach the 40% of the maximum.

19. Opportunity for repeat/retake and delayed completion

One Midterm exam can be retried

20. Learning materials

Stuart Russell és Peter Norvig: Artificial Intelligence: A Modern Approach

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Automated driving systems**				
2. Subject name in Hungarian	Automatizált járműirányítási rendszerek			**3. Role**	.
4. Code	**KOGGM707**	**5. Evaluation type**	**e**	**6. Credits**	**5**
7. Weekly contact hours	**2 lecture**	**0 practice**	**2 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**150 hours**
Contact hours	56 hours	**Preparation for seminars**	0 hours	**Homework**	50 hours
Reading written materials	24 hours	**Midterm preparation**	0 hours	**Exam preparation**	20 hours

10. Department	Department of Automotive Technologies
11. Responsible lecturer	Dr. Szalay Zsolt
12. Lecturers	Fodor Károly

13. Prerequisites	- (-), -

14. Description of lectures

The aim of the course is to introduce the communication systems of classic and highly automated vehicles. ECU level communication, and in-vehicle communication protocols like CAN, LIN, MOST, FlexRay and Automotive Ethernet. Inter-vehicle communication, V2X. Communication protocols. Automotive cybersecurity issues. Electromagnetic compatibility. Testing and validation of communication systems. Vehicle diagnostics. Intelligent transport systems, implementation. Computer network basics, protocols.

Introduction to vehicle communication (V2X communication). Vehicle to vehicle communication (V2V), vehicle to infrastructure communication (V2I). V2X architectures and protocols. Standard V2X security and privacy. Electronic Control Units (ECUs) and ECU level communication (UART, SPI, I2C). Automotive in-vehicle communication protocols and their applications (CAN, LIN, FlexRay, MOST, Automotive Ethernet) Cybersecurity of in-vehicle communication systems. Electromagnetic compatibility of communication systems. Diagnostic capabilities of communication systems.Testing and validation of vehicle communication systems.

15. Description of practices

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16. Description of laboratory practices

The lab enables the practical implementation of individual student work. Some of the systems presented in the presentation are also presented in practice.

17. Learning outcomes

a) knowledge:
- knows the automotive communication systems,
- knows the communication technologies of the automotive industry,
- is familiar with the communication security issues of automotive systems,
- knows electromagnetic compatibility issues of communication systems, their testing and validation

b) skills:
- is able to use in-vehicle communication protocols,
- is capable of designing appropriate communication interfaces
- can select a protocol for a particular autonomous vehicle function,

c) attitude:
- responsive to understanding new communication solutions

d) autonomy and responsibility:
- takes responsibility of the work done

18. Requirements, way to determine a grade (obtain a signature)

Successful completion of 2 midterm exams and laboratories and submission of the laboratory assignment.

19. Opportunity for repeat/retake and delayed completion

Delayed completion of individual homework.

20. Learning materials

Slides and lecture notes

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Automated vehicle design project**				
2. Subject name in Hungarian	Autonóm jármű projektfeladat			**3. Role**	.
4. Code	**KOGGM710**	**5. Evaluation type**	**e**	**6. Credits**	**6**
7. Weekly contact hours	**2 lecture**	**0 practice**	**2 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**180 hours**
Contact hours	56 hours	**Preparation for seminars**	0 hours	**Homework**	64 hours
Reading written materials	40 hours	**Midterm preparation**	0 hours	**Exam preparation**	20 hours

10. Department	Department of Automotive Technologies
11. Responsible lecturer	Dr. Szalay Zsolt
12. Lecturers	Dr. Szalay Zsolt, Dr. Bécsi Tamás, Dr. Aradi Szilárd

13. Prerequisites	- (-), -; - (-), -; - (-), -

14. Description of lectures

The aim of the course is to apply the knowledge gained by the previous courses through the elaboration of an individual or group project. The students choose from an well described problem group of the automated vehicles, and after studying the problem, they design a solution for it. The elaboration of the task goes through the stages of specification, state of the art study, algorithm design, implementation, documentation and end-semester presentation. The classes of the projects aim the elaboration of the project, the supervision of the progress, and consultation.

15. Description of practices

-

16. Description of laboratory practices

During the lab exercises, the task is to consult with the instructor and check the progress.

17. Learning outcomes

a) knowledge:
b) skills:
- capable of breaking down a project task into elements based on specification,
- is able to design a development process,
- is able to track and document a development process

c) attitude:
- open to self-development tasks

d) autonomy and responsibility:
- is able to make responsible decisions in a development project

18. Requirements, way to determine a grade (obtain a signature)

The completed and documented work will be presented by the student at the end of the semester. The prerequisite of the exam is the succesful fulfilment of the individual task.

19. Opportunity for repeat/retake and delayed completion

The individual task cannot be delayed completed.

20. Learning materials

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BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Automated vehicle design project**				
2. Subject name in Hungarian	Autonóm jármű projektfeladat			**3. Role**	.
4. Code	**KOKAM710**	**5. Evaluation type**	**e**	**6. Credits**	**6**
7. Weekly contact hours	**2 lecture**	**0 practice**	**2 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**180 hours**
Contact hours	56 hours	**Preparation for seminars**	0 hours	**Homework**	64 hours
Reading written materials	40 hours	**Midterm preparation**	0 hours	**Exam preparation**	20 hours

10. Department	Department of Control for Transportation and Vehicle Systems
11. Responsible lecturer	Dr. Gáspár Péter
12. Lecturers	Dr. Szalay Zsolt, Dr. Bécsi Tamás, Dr. Aradi Szilárd

13. Prerequisites	- (-), -; - (-), -; - (-), -

14. Description of lectures

The aim of the course is to apply the knowledge gained by the previous courses through the elaboration of an individual or group project. The students choose from an well described problem group of the automated vehicles, and after studying the problem, they design a solution for it. The elaboration of the task goes through the stages of specification, state of the art study, algorithm design, implementation, documentation and end-semester presentation. The classes of the projects aim the elaboration of the project, the supervision of the progress, and consultation.

15. Description of practices

-

16. Description of laboratory practices

During the lab exercises, the task is to consult with the instructor and check the progress.

17. Learning outcomes

a) knowledge:
b) skills:
- capable of breaking down a project task into elements based on specification,
- is able to design a development process,
- is able to track and document a development process

c) attitude:
- open to self-development tasks

d) autonomy and responsibility:
- is able to make responsible decisions in a development project

18. Requirements, way to determine a grade (obtain a signature)

The completed and documented work will be presented by the student at the end of the semester. The prerequisite of the exam is the succesful fulfilment of the individual task.

19. Opportunity for repeat/retake and delayed completion

The individual task cannot be delayed completed.

20. Learning materials

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BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Automotive environment sensors**				
2. Subject name in Hungarian	Járműipari környezetérzékelés			**3. Role**	.
4. Code	**KOKAM708**	**5. Evaluation type**	**e**	**6. Credits**	**5**
7. Weekly contact hours	**2 lecture**	**0 practice**	**2 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**150 hours**
Contact hours	56 hours	**Preparation for seminars**	18 hours	**Homework**	0 hours
Reading written materials	20 hours	**Midterm preparation**	20 hours	**Exam preparation**	36 hours

10. Department	Department of Control for Transportation and Vehicle Systems
11. Responsible lecturer	Dr. Bécsi Tamás
12. Lecturers	Dr. Bécsi Tamás, Dr. Aradi Szilárd

13. Prerequisites	- (-), -

14. Description of lectures

The perception of the environment and the understanding of the situation is of high importance for the development of modern driver assistance systems as well as for the development of autonomous vehicle systems. To do this, one has to know the physical background, possibilities and limitations of the existing environmental sensors.

The course aims the studying of the technologies developed for the tasks of environment sensing of an automated vehicle, the currently available technologies and the corresponding signal processing techniques.

First, the course introduces the inner sensors of the vehicles, such as position, velocity, translation or rotation, basics of their physical operation and their limitations. After this, the main principles of environment sensing, such as ultrasonic, radar, lidar and machine vision systems are introduced through application examples. To strengthen the robustness of the collected data, several typical sensor fusion techniques are also studied.

15. Description of practices

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16. Description of laboratory practices

The aim of the laboratory practice is to develop different measurements and software processing tasks.

17. Learning outcomes

a) knowledge:

- is familiar with the sensors for measuring vehicle status, their operating principles,
- is familiar with the sensors and possibilities and limitations of environmental sensors used today (Radar, Lidar, Ultrasound, Camera Systems),
- is familiar with the sensory fusion techniques used in environmental sensing,
- is familiar with the methods of processing the data of environmental sensors,

b) skills:

- can interpret the data of different sensors,
- is able to design an algorithm for simple determination of the environmental situation based on sensor data,
- is able to select an appropriate sensor architecture for the implementation of a designated driving support / autonomous vehicle function

c) attitude:

- is interested in the latest trends of automotive sensors
- is interested in the algorithmization aspect of the sensor information processing tasks

d) autonomy and responsibility:

- Being able to work in a team responsibly to design an autonomous vehicle function

18. Requirements, way to determine a grade (obtain a signature)

For signature: succesful fulfilment of two midterm exams. Final grade is the average of the two midterm tests (25-25%) and the exam (50%).

19. Opportunity for repeat/retake and delayed completion

One Midterm exam can be retried

20. Learning materials

Lecture Notes

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Automotive network and communication systems**				
2. Subject name in Hungarian	Autóipari hálózati és kommunikációs rendszerek			**3. Role**	.
4. Code	**KOGGM709**	**5. Evaluation type**	**m**	**6. Credits**	**4**
7. Weekly contact hours	**2 lecture**	**0 practice**	**2 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**120 hours**
Contact hours	56 hours	**Preparation for seminars**	10 hours	**Homework**	20 hours
Reading written materials	34 hours	**Midterm preparation**	0 hours	**Exam preparation**	0 hours

10. Department	Department of Automotive Technologies
11. Responsible lecturer	Dr. Szalay Zsolt
12. Lecturers	Dr. Török Árpád, Pethő Zsombor, Bokor László (VIK)

13. Prerequisites	- (-), -

14. Description of lectures

The aim of the course is to introduce the communication systems of classic and highly automated vehicles. ECU level communication, and in-vehicle communication protocols like CAN, LIN, MOST, FlexRay and Automotive Ethernet. Inter-vehicle communication, V2X. Communication protocols. Automotive cybersecurity issues. Electromagnetic compatibility. Testing and validation of communication systems. Vehicle diagnostics. Intelligent transport systems, implementation. Computer network basics, protocols. Introduction to vehicle communication (V2X communication). Vehicle to vehicle communication (V2V), vehicle to infrastructure communication (V2I). V2X architectures and protocols. Standard V2X security and privacy. Electronic Control Units (ECUs) and ECU level communication (UART, SPI, I2C). Automotive in-vehicle communication protocols and their applications (CAN, LIN, FlexRay, MOST, Automotive Ethernet) Cybersecurity of in-vehicle communication systems. Electromagnetic compatibility of communication systems. Diagnostic capabilities of communication systems. Testing and validation of vehicle communication systems.

15. Description of practices

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16. Description of laboratory practices

The lab enables the practical implementation of individual student work. Some of the systems presented in the presentation are also presented in practice.

17. Learning outcomes

a) knowledge:
- knows the automotive communication systems,
- knows the communication technologies of the automotive industry,
- is familiar with the communication security issues of automotive systems,
- knows electromagnetic compatibility issues of communication systems, their testing and validation

b) skills:
- is able to use in-vehicle communication protocols,
- is capable of designing appropriate communication interfaces
- can select a protocol for a particular autonomous vehicle function,

c) attitude:
- responsive to understanding new communication solutions

d) autonomy and responsibility:
- takes responsibility of the work done

18. Requirements, way to determine a grade (obtain a signature)

Successful completion of 2 midterm exams and laboratories and submission of the laboratory assignment.

19. Opportunity for repeat/retake and delayed completion

Delayed completion of individual homework.

20. Learning materials

Slides and lecture notes

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Automotive R&D processes and quality systems**				
2. Subject name in Hungarian	Autóipari K+F folyamatok és minőségügyi rendszerek			**3. Role**	.
4. Code	**KOGGM711**	**5. Evaluation type**	**m**	**6. Credits**	**4**
7. Weekly contact hours	**3 lecture**	**0 practice**	**0 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**120 hours**
Contact hours	42 hours	**Preparation for seminars**	20 hours	**Homework**	0 hours
Reading written materials	38 hours	**Midterm preparation**	20 hours	**Exam preparation**	0 hours

10. Department	Department of Automotive Technologies
11. Responsible lecturer	Dr. Szalay Zsolt
12. Lecturers	Domina Ádám, Wahl István

13. Prerequisites	- (-), -

14. Description of lectures

The aim of the course is to familiarize students with the processes used in the automotive industry, research and development, and the relevant regulations. Students will gain insight into the standards and process models required by the automotive industry for development processes. Within the framework of the course, students can get acquainted with the individual elements of the flow, their structure and their relationships. In addition, students can learn about quality methods that support development. Presentation of the life cycle of vehicle development. Quality assurance during vehicle development, control points and models. Product and process testing.

Automotive Qualification Management Standards, Audits (IATF16949) Software Development Processes, Graduation Models (Automotive SPICE). Manage your requirements. Application of FMEA in product design. Project management. Change management. Software development processes. Testing processes. Supplier quality control. Configuration management.

15. Description of practices

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16. Description of laboratory practices

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17. Learning outcomes

a) knowledge:

- is familiar with standard solutions for automotive research development processes, taking into account life cycle planning and quality assurance aspects,
- knows the automotive quality management standards
- know project and change management processes,
- is familiar with testing and supplier control processes

b) skills:

- is able to engage in automotive development, understand its project structure,
- is able to design and implement a project management project for automotive development

c) attitude:

- open to work on a project-based approach
- open to work in team

d) autonomy and responsibility:

- responsible for the work done

18. Requirements, way to determine a grade (obtain a signature)

One midterm exam, which determines the final grade.

19. Opportunity for repeat/retake and delayed completion

The midterm exam can be retried once

20. Learning materials

Lecture Notes

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Automotive vehicle systems**				
2. Subject name in Hungarian	Közúti járművek szerkezettana			**3. Role**	.
4. Code	**KOGGM712**	**5. Evaluation type**	**m**	**6. Credits**	**4**
7. Weekly contact hours	**2 lecture**	**0 practice**	**1 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**120 hours**
Contact hours	42 hours	**Preparation for seminars**	10 hours	**Homework**	20 hours
Reading written materials	28 hours	**Midterm preparation**	20 hours	**Exam preparation**	0 hours

10. Department	Department of Automotive Technologies
11. Responsible lecturer	Dr. Zöldy Máté
12. Lecturers	Nyerges Ádám, Mahmoud Jneid

13. Prerequisites	- (-), -; - (-), -; - (-), -

14. Description of lectures

The target of the subject is to present the vehicle systems and structures. Within the framework of the subject the vehicle engines, transmissions, suspension systems, brake systems and frame structures are teached. In the Autonomous Vehicle Control Enginees MSc tematics, the target of the subject is to caught up the students, who do not have vehicle engineer BSc. By the subject the students are able to recognise the important parts and systems of road vehicles, they know their function and operatation.

Structures of road vehicles, vehicle categories according to UN, elements and orientation of the transmission system.

The types and the operation of internal combustion engines, fuels, emission.

The geometry of the cranktrain, the indicator diagram, the power, the torque, the efficiency and the fuel consumption of the internal combustion engines.

Structure of internal combustion engines, lubrication system, cooling system.

Fuel systems and charging of internal combustion engines.

Wheel dimensions, tyre parameters, suspension geometry, Ackermann governing.

Structure an operation of clutches and manual transmissions.

Dual clutch transmissions, hydrodinamical clutch and gearboxes.

Planetary gear. Automatized and automatic transmission systems.

Final gears, differentials, wheel bearings.

Types of suspension systems, shock absorbers.

Hydraulic brake systems, ABS.

Air brake systems.

Frameworks and structures of road vehicles, passive safety systems.

15. Description of practices

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16. Description of laboratory practices

Vehicle presentation: cross-engine front-wheel drive vehicle.

Vehicle presentation: long-wheel-drive rear-wheel drive vehicle.

Vehicle Show: Bus.

Engine Assembly.

Brake pad measurement of internal combustion engine characteristics.

Measuring and controlling the brake booster of an internal combustion engine.

Mounting of manual transmissions.

Clutch and differential assembly.

Brake System Presentation.

17. Learning outcomes

a) knowledge:

- knows the basic structure of road vehicles,
- knows the operation of the internal combustion engine, its lubrication and cooling systems, and processes,
- knows the indicator diagram, performance and efficiency of internal combustion engines
- knows the basic wheel models and the Ackermann steering,
- is familiar with the basic structure and operating principles of knobs and transmissions,

- knows the types and operating principles of automated transmissions,
- is familiar with the models describing the types of running gear and their general operation,
- is familiar with the principles and operation of braking systems,
- knows the basic passive safety solutions.

b) skills:
- is able to test and evaluate the basic systems of vehicles,
- is able to perform simple vehicle diagnostic tasks in case of appropriate model-specific further education
- is capable of creating the operating models of various vehicle elements,
- is capable of jointly examining vehicle structure models, modeling a complete drive chain,

c) attitude:
- strives to better understand vehicle structures, research and explore new solutions
- open to technical approaches to problems and tasks raised by new systems
- is able to carry out the assigned tasks in a team

d) autonomy and responsibility:
- is able to independently model an unknown vehicle structure solution
- can independently process vehicle diagnostic results
- is responsible for evaluating a diagnostic measurement task.

18. Requirements, way to determine a grade (obtain a signature)

The semester mark reflects the results of the two midterm tests and the homework (1/3-1/3-1/3 weight). Participation in the lab, the two successful midterm tests and the accepted homework are the prerequisite for fulfilling the subject.

19. Opportunity for repeat/retake and delayed completion

One midterm test can be retried, tasks must be given accurately.

20. Learning materials

Automotive Engines and Testing note
Automotive Engines I-II. note
Vehicle Power Transmission Note I.
Vehicle Suspension I-II. note

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Autonomous robots and vehicles**				
2. Subject name in Hungarian	Autonóm robotok és járművek			**3. Role**	.
4. Code	**VIIIMA12**	**5. Evaluation type**	**e**	**6. Credits**	**4**
7. Weekly contact hours	**2 lecture**	**1 practice**	**0 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**120 hours**
Contact hours	42 hours	**Preparation for seminars**	15 hours	**Homework**	0 hours
Reading written materials	0 hours	**Midterm preparation**	15 hours	**Exam preparation**	48 hours

10. Department	Department of Control Engineering and Information Technology
11. Responsible lecturer	Dr. Kiss Bálint
12. Lecturers	Dr. Lantos Béla, Dr. Harmati István

13. Prerequisites	- (-), -

14. Description of lectures

The subject summarizes the theoretical and practical fundamentals of the modeling, control and intelligent architectural realization methods of robotic and autonomous systems. The subject provides concepts and system engineering background for maintenance and development engineers of such systems. Robotized manufacturing cells, widely used robot structures and the typical programming methodology of robotic arms are presented. Robot modeling, navigation and motion planning methods are studied. Special emphasis is put on the real-time control methods of robot arms and mobile platforms. Possibilities of the cooperation of wheeled and legged mobile robots are enumerated. Current control end navigation challenges are overviewed. Students successfully completed the course requirements will have an in-depth understanding of the modelling, real-time control and navigation solutions employed in robotics so that he or she can can creatively employ and complement them as necessary in the case industrial applications (e.g. automotive and robotics).

15. Description of practices

Classroom exercises demonstrate the application of theoretical material through case studies.

16. Description of laboratory practices

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17. Learning outcomes

a) knowledge: - is familiar with the theoretical and practical foundations of modeling, control and intelligent system engineering of robotic and autonomous systems
- knows the dynamic models of mechatronic systems,
- knows the robotic and kinematic models of robots,
- knows robot programming and robot control systems,
- is familiar with intelligent actuators and their use in vehicle control
b) skills: - is able to design and implement robot control on the systems it knows
- is able to design and implement trajectory planning and execution tasks,
- capable of mathematical and physical modeling of robot and autonomous vehicle systems
c) attitude: - is interested in novel solutions for autonomous movements and controls
d) autonomy and responsibility: - independently capable of performing mechatronic design tasks,
- is able to get to know an unknown system, acquires robot programming environments in autodidact

18. Requirements, way to determine a grade (obtain a signature)

a. During the period of classes: successful midterm exam (at least pass grade). The result of the midterm exam count for the exam grade with up to 20%. Requirement for signature: the result of the midterm exam is at least 2 (pass).
b. During the period of exams: no exam is possible without the signature. The exam is written composed of theoretical questions and exercises.

19. Opportunity for repeat/retake and delayed completion

The mid-term can be repeated once during the period of classes and once during the repeat period.

20. Learning materials

Lantos-Kiss-Harmati: Autonomous robots and vehicles handouts (electronically)
Lantos-Márton: Nonlinear Control of Vehicles and Robots (Springer, 2011)
Somló-Lantos-Cat: Advanced robot control (Akadémiai Kiadó, 1997)

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Computer Vision Systems**				
2. Subject name in Hungarian	Számítógépes látórendszerek			**3. Role**	.
4. Code	**VIIIMA07**	**5. Evaluation type**	**e**	**6. Credits**	**4**
7. Weekly contact hours	**2 lecture**	**1 practice**	**0 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**120 hours**
Contact hours	42 hours	**Preparation for seminars**	10 hours	**Homework**	0 hours
Reading written materials	0 hours	**Midterm preparation**	20 hours	**Exam preparation**	48 hours

10. Department	Department of Control Engineering and Information Technology
11. Responsible lecturer	Dr. Vajta László
12. Lecturers	Dr. Vajta László, Szemenyei Márton

13. Prerequisites	- (-), -; - (-), -; - (-), -

14. Description of lectures

Along with the development of computer technologies, automatic evaluation of visual content became a daily practice on areas of quality control, process control, navigation, security systems, medical diagnostics, and many more. The aim of the course is to provide an introduction of the principles and applications of advanced computer image processing and visualisation, covering virtual technologies which are playing a key role in the management of supervised autonomous industrial processes.

15. Description of practices

In the exercises, examples and case studies are deepened into the theoretical curriculum of the lectures.

16. Description of laboratory practices

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17. Learning outcomes

a) knowledge:
- is familiar with the mathematical and physical descriptive theories and practical implementations of image recognition and imaging,
- knows the tools of the description, the methods of geometric description of the image details,
- know basic image processing algorithms,
- is familiar with image filtering technologies, segmentation and object recognition methods

b) skills:
- can independently design image processing algorithms,
- be able to apply the development environments used in industry,
- is capable of performing object recognition and tracking tasks

c) attitude:
- motivated to learn new results in the ever-developing field of image processing,
- is motivated to apply the acquired knowledge to the development of advanced automated vehicle functions

d) autonomy and responsibility:
- can independently interpret and learn new results of image processing,
- is able to independently use the use of a visual system development environment

18. Requirements, way to determine a grade (obtain a signature)

One midterm exam with the minimum requirement of 40%. The midterm gives 20% of the final grade

19. Opportunity for repeat/retake and delayed completion

The midterm exam can be retried once

20. Learning materials

Lecture Notes
John C. Russ: The Image Processing Handbook
Besl, P.J.: "Surfaces in range image understanding", Springer, 1988
Computer Vision online tananyag: http://www.dai.ed.ac.uk/CVonline/

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Control theory and system dynamics**				
2. Subject name in Hungarian	Irányításelmélet és rendszerdinamika			**3. Role**	.
4. Code	**KOKAM701**	**5. Evaluation type**	**e**	**6. Credits**	**4**
7. Weekly contact hours	**2 lecture**	**0 practice**	**2 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**120 hours**
Contact hours	56 hours	**Preparation for seminars**	10 hours	**Homework**	0 hours
Reading written materials	27 hours	**Midterm preparation**	12 hours	**Exam preparation**	15 hours

10. Department	Department of Control for Transportation and Vehicle Systems
11. Responsible lecturer	Dr. Gáspár Péter
12. Lecturers	Dr. Gáspár Péter, Dr. Németh Balázs

13. Prerequisites	- (-), -

14. Description of lectures

The course aims the study of the analytical and control design methods of electromechanical systems. First, the modeling paradigms and state space representations are outlined. After this, system analysis is presented, such as controllability, observability and stability, Through the control design problem, the course examines the different qualitative properties, and the consideration techniques of system uncertainties and disturbances. From the classical methods, the pole allocation and the quadratic linear control is presented. The course focuses on the interpretation of the observer design and the separation principle. Course thematic: - System modeling based on physical principles - Analysis in time and frequency domain - State space of dynamic systems - Quantitative properties and stability analysis of closed loop systems - Properties of state space representations - Controllability and observability of state space representations - Compensator design - Full state feedback with pole allocation - Controller design with linear quadratic method - Separation principle and observer design

15. Description of practices

-

16. Description of laboratory practices

In the laboratory practice the computerized implementation and evaluation of the known control theory models and algorithms is performed.

17. Learning outcomes

a) knowledge: - knows the basic dynamic system modeling paradigms, their mathematical background,
- knows the time and frequency domain description of linear time-variant systems,
- knows the principles of feedback control, and the quantitative and qualitative criteria,
- knows the state space of theory,
- is familiar with various simple feedback control methods,
- knows the basics of modern control theory, the principle of quadratic regulation,
- knows the methods of observer design,
b) skills: - is able to independently design a specific system model,
- be able to apply the control design methods independently,
- is able to use the most popular softwares on the field
c) attitude: - is interested in a mathematical solution to control problems,
- acquires system-level thinking
d) autonomy and responsibility: - can independently provide quality and quantity parameters for a system's performance, enabling them to make decisions about system redesign,
- can independently describe a particular system, use the appropriate mathematical formalisms,
- is able to make decisions on the appropriate methods of solving the control task

18. Requirements, way to determine a grade (obtain a signature)

One midterm exam, which is successfull if 50% of its points are reached. The mark of the course depends on the result of the midterm exam (50%) and on the result of the successful written final exam (50%). The final exam is successfull, if 50% of its points are reached.

19. Opportunity for repeat/retake and delayed completion

The midterm exam can be retried once

20. Learning materials

Lecture Notes

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Design and integration of embedded systems**				
2. Subject name in Hungarian	Rendszertervezés és -integráció			**3. Role**	.
4. Code	**VIMIMA11**	**5. Evaluation type**	**e**	**6. Credits**	**4**
7. Weekly contact hours	**2 lecture**	**1 practice**	**0 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**120 hours**
Contact hours	42 hours	**Preparation for seminars**	14 hours	**Homework**	24 hours
Reading written materials	0 hours	**Midterm preparation**	0 hours	**Exam preparation**	40 hours

10. Department	Department of Measurement and Information Systems
11. Responsible lecturer	Dr. Majzik István
12. Lecturers	Scherer Balázs

13. Prerequisites	- (-), -; - (-), -; - (-), -

14. Description of lectures

The aim of the subject is the presentation of the basic methods that are needed for the systematic development of embedded systems. First the following topics are discussed: development life cycle models (e.g., V-model, iterative models), quality assurance, project planning, requirements traceability, version control and configuration control methods. Among system development methods, the subject presents the hardware-software co-design and component integration techniques, based on the previously studied technologies and building blocks, emphasizing also the model-based design approaches.

The subject also covers the specific design methods for safety-critical embedded systems in which the malfunctions may lead to hazards, or in case of given environmental conditions even to accidents or damages. Such safety-critical systems are used for example in transportation, vehicles, medical equipment or process control systems. The students will be familiar with the architectural concepts (that are often referred in related standards), the techniques of safety and dependability analysis (that are needed to assess the design decisions), as well as the techniques of systematic verification. The exercises present concrete tools and techniques to support the typical tasks in requirement management, configuration control, source code analysis, unit testing, integration testing, system testing, hazard analysis and model based design.

- The role of development processes, life cycle models, and quality assurance in system design. The basics of CMMI.
- Project planning. Management of requirements, versions, and configurations. Exercise: Requirements management and traceability, configuration and version control systems (e.g., DOORS, SVN, Trac).
- The steps of the development process according to the V-model. Requirement analysis.
- Design of logical and technical architectures. Hardware-software co-design. Model based design (e.g., Simulink, Stateflow). Specification, design, implementation and integration of hardware and software components. Peculiarities and constraints that characterise the design of embedded systems.
- Checking of requirements and designs: General expectations, the basic criteria for completeness, consistency and testability. Source code analysis (searching for fault patterns, checking of coding rules). Exercise: Source code checking by static analysis. Generation of documentation (e.g., DoxyGen).
- Overview of the basic concepts of testing (the ISTQB recommendations). Unit testing using specification based (functional, black-box) and structure based (white-box) testing methods. Test coverage metrics and test quality characteristics. The model based testing approach. Exercise: Unit testing. Measuring of the test coverage.
- Integration and system testing: Bottom-up and top-down incremental testing. The typical methods of system testing and validation testing. Monitoring and debugging.
- Integration testing using model-, software-, processor-, and hardware-in-the-loop (MIL, SIL, PIL, HIL) methods. Exercise: Construction of a HIL testing environment. Application of a typical HIL testing framework (e.g., NI VeriStand).
- The basic concepts of system and software safety: Accident, risk, safety, the safety integrity level (SIL). The definitions and attributes of reliability, availability and safety. Exercise: Specification of safety requirements. The development standards for safety critical systems (based on IEC 61508).
- The principles and typical solutions of architecture design in safety critical systems: The general conditions of safe behaviour in case of faults. Architecture design patterns in case of fail-stop and fail-operational behaviour.
- Fault tolerance in case of transient and permanent hardware faults (TMR, NMR, software based solutions for error detection and recovery). Fault tolerance in case of software design faults (N-version programming, recovery blocks). The time and resource needs of the different solutions. Exercise: The application of architecture design patterns. Architecture design using modelling tools. The architecture of a SCADA system (case study).
- Hazard analysis methods for the assessment of design decisions: The overview of the typical techniques for hazard analysis. Qualitative and quantitative techniques: Fault tree, event tree, cause-consequence analysis, FMEA, FMECA. Construction of a risk matrix on the basis of the hazard analysis. Overview of the generic risk reduction techniques.
- Dependability analysis methods for the assessment of the satisfaction of dependability related requirements: Application of combinatorial techniques in case of independent failures of components. The construction of reliability block diagrams: serial, parallel

and voting architectures. Exercise: Construction of fault tree and event tree diagrams, analysis on the basis of reliability block diagrams. Reliability analysis of a SCADA system (case study).

- Design, verification and source code synthesis on the basis of formal models: Formal models for real-time embedded controllers. Formalization of requirements using temporal logics. Formal verification with model checking (examples). Source code generation on the basis of timed automata models. Monitor synthesis for the runtime verification of safety requirements.

15. Description of practices

The lab presents the material of lectures through specific tools.

16. Description of laboratory practices

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17. Learning outcomes

a) knowledge:
- knows the methods of systematic planning of embedded systems,
- knows the methods of model-based beating,
- knows the basic principles of safety critical systems,
- is familiar with the security and reliability analysis of design decisions and the methods of systematic verification

b) skills:
- capable of using model-based design software,
- is able to use architectural design patterns,
- capable of source code verification by static analysis

c) attitude:
- Open to implement secure software acquisition tasks

d) autonomy and responsibility:
- can independently design safety-critical embedded software

18. Requirements, way to determine a grade (obtain a signature)

During the semester: Solution of an assigned homework, applying the system design and verification methods presented during the lectures. The successful completion of the homework is required for the signature.

19. Opportunity for repeat/retake and delayed completion

The homework can be submitted during the repetition period. The submission of the homework cannot be replaced by a midterm exam.

20. Learning materials

Frank Vahid, Tony d. Givargis: Embedded System Design: A Unified Hardware/Software Introduction. John Wiley & Sons, 200- ISBN: 0471386782
Neil Storey: Safety-Critical Computer Systems. Addison-Wesley, 199- ISBN: 0201427877

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Embedded Operating Systems and Client Applications**				
2. Subject name in Hungarian	Beágyazott operációs rendszerek és kliens alkalmazások			**3. Role**	.
4. Code	**VIAUAC07**	**5. Evaluation type**	**e**	**6. Credits**	**4**
7. Weekly contact hours	**2 lecture**	**1 practice**	**0 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**120 hours**
Contact hours	42 hours	**Preparation for seminars**	14 hours	**Homework**	0 hours
Reading written materials	0 hours	**Midterm preparation**	16 hours	**Exam preparation**	48 hours

10. Department	Department of Automation and Applied Informatics
11. Responsible lecturer	Dr. Tevesz Gábor
12. Lecturers	Dr. Tevesz Gábor, Benedek Zoltán, Szabó Zoltán

13. Prerequisites	- (-), -

14. Description of lectures

The students will be able to understand and make use of the basic concepts of embedded operating systems. The objective of the course is to present platforms, techniques and tools which are required to create and run both application and system level software for embedded systems. After creating the hardware unit and embedded programs for it, the next natural step is the implementation of a desktop or web application that enables monitoring and parameterizing the hardware unit from a standard PC. Mobile applications are becoming more widely used as well. The course presents the programming of desktop and web based client applications, focusing on user interfaces, graphics drawing tools, multithreaded and network programming. Most modern development platforms follow object-oriented concepts. Consequently, the course provides introduction to object-oriented design, basic UML and a few architectural and design patterns. Students will be able to develop desktop and thin client applications to access hardware units from PCs, and to create user friendly user interfaces for different client types. Network programming also gets an important role. The topics covered are illustrated by case studies and demo applications.

15. Description of practices

In the exercises, examples and case studies are deepened into the theoretical curriculum of the lectures.

16. Description of laboratory practices

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17. Learning outcomes

a) knowledge: - is familiar with the basic concepts and paradigms of basic embedded operating systems, - know the programming methods for thick and thin clients, - knows the basics of mobile client development - knows the steps of object-oriented software design and modeling, - knows architectural and design patterns

b) skills: - can produce thin and thin client applications, - can create mobile client applications - can create a user interface for these platforms, - can use known and well-established communication solutions

c) attitude: - is interested in client programming solutions

d) autonomy and responsibility: - able to learn independently on new platforms, - is capable of independently performing software engineering tasks to communicate with embedded operating systems

18. Requirements, way to determine a grade (obtain a signature)

In lecture term: An in-class term test

In examination period: Written exam

Pre-exam: upon request

The requisite of the mid-term signature is to attend at the in-class term test and have at least satisfactory result. The requisite of attending at an exam is having the mid-term signature. The credits can be obtained by reaching at least satisfactory result at the exam. The grade consists of two parts: the grade of the mid-term test (25%) and the grade of the exam (75%).

19. Opportunity for repeat/retake and delayed completion

One Midterm exam can be retried

20. Learning materials

Labrosse, J.J.: MicroC/OS-II The Real-Time Kernel (Second edition). CMP Books
Michael J. Donahoo and Kenneth L. Calvert: TCP/IP Sockets in C: Practical Guide for Programmers
MSDN: .NET Framework Programming

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**High performance microcontrollers and interfaces**				
2. Subject name in Hungarian	Nagyteljesítményű mikrokontrollerek és interfészek			**3. Role**	.
4. Code	**VIAUMA07**	**5. Evaluation type**	**e**	**6. Credits**	**4**
7. Weekly contact hours	**2 lecture**	**1 practice**	**0 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**120 hours**
Contact hours	42 hours	**Preparation for seminars**	15 hours	**Homework**	0 hours
Reading written materials	0 hours	**Midterm preparation**	15 hours	**Exam preparation**	48 hours

10. Department	Department of Automation and Applied Informatics
11. Responsible lecturer	Dr.Tevesz Gábor
12. Lecturers	Dr. Gál Tibor, Kiss Domokos

13. Prerequisites	- (-), -; - (-), -; - (-), -

14. Description of lectures

Wide inside is given of the computer system architectures, high performance microcontroller architectures and their building blocks. Convectional architectures are analyzed then special architectures (ARM, DSP, network and graphic processors, GPGPU) are dealt with and compared with the SoC devices with soft and hard processors. Methods increasing the performance, security and reliability, decreasing power consumption are treated. Mechanical, electrical and logical aspects of bus systems connecting parts of control systems are treated in detail. Diagnostic methods of WEB, mobile, etc. based control systems are also introduced.

Modern processor and computer architectures (2 weeks)

Instruction set, micro and computer architectures. General characteristics, characteristics of a good architecture, aims of architecture development, design levels, virtual machines. Decreasing conception gap, high level languages. Computer and processor generations. Increasing the performance: conventional, pipelined, superpipelined, superscalar and VLIW architectures. Parallel processor performance. Performance of scalar and superscalar pipelined processors. Arithmetic and instruction pipelines. Data and control dependencies, branch prediction. Advanced technologies (multiple threads and cores, virtualization, advanced configuration and power management, reliable execution environment, client diagnose and repair, advanced vector supplement, etc.)

Special purpose processors (2 weeks)

ARM, signal, network, graphics, media, cell processors and general purpose graphics processor units. ARM micro and instruction set architectures, architecture specific profiles, CPU operating modes, coprocessors, ISA and micro architecture types (DSP and SIMD extentions, Jazelle, Thumb, Thumb-2, VFP, NEON, TrustZone, virtualization).

Characteristics of signal processing, appropriate ISA and micro architectures. Tasks of network processors, RTC and pipelined model.

Graphics display resolution, color depth, speed, functionality. 2D and 3D graphics, graphics pipeline.

General characteristics of media processors, the Texas TMS320DM6467 digital media processor.

Microarchitectures, programming models and application areas of cellprocessors.

GPGPU programming principles, GPGPU methods (mapping, reduction, distribution, collection, searching, etc.) and principles.

Multiprocessor systems (1 week)

Classification and typical examples. Control-flow, data-flow, demand driven and pattern driven mechanisms. Communicating networks. Cache coherency, SW and HW methods, directory based and snooping protocols, MESI protocol. Vector computer ISA and micro architectures. Systolic array processors.

Interfaces and busses (3 weeks)

Classification, mechanical, electrical and logical characteristics. Transaction, arbitration, data transfer and addressing. Synchronous, semi synchronous and asynchronous busses. Asymmetric and symmetric signaling systems and circuits. Reflections, metastability and live insertion. Widely used bus systems: PCI, PCIe, SATA, USB, Thunderbolt.

RTL based synthesis (1 week)

Survey of Verilog. Synthesisable and non-sythesisable RTL. Comparing RTL and SW. Implementation of simple handshaking and LocalLink protocol (Xilinx), Verilog description of data source and data sink. Classical and Verilog based design of a combined arbiter. Verilog based design of a graphics display using FPGA-RAM hardware.

Programmable logic devices (1 week)

Main characteristics of Xilinx, Altera és Cypress programmable logic devices.

System on Chip (SoC) (2 weeks)

Classification: programmable/non-programmable devices, soft and hard processor cores. Methods and devices of development, IP devices with fix and variable parameters. Components of SoC, block diagram/logic circuit diagram/Verilog description: switches, LEDs, programmable IO, IO blocks, IO networks, RAM blocks, counter/timer blocks, interrupt controllers, arbiters, DMA controllers, simple processors, canonical D8/A16 microcomputer, basic microcontroller and standard SoC busses.

WEB, mobil, etc. based control and diagnostics (1 week)

Connection methods with WEB and mobile. Remote control and diagnostics.

15. Description of practices

The exercises will be exemplified in the form of examples and case studies in the theoretical curriculum of the lectures.

16. Description of laboratory practices

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17. Learning outcomes

a) knowledge:
- knows modern processor architectures,
- is familiar with modern microcontroller interfaces and bus networks
- knows the programmable logic tools,
- knows integrated and embedded systems,

b) skills:
- is able to select a system with the right performance, consumption and proper interfaces for a given task,
- can design and implement communication structures on microcontrollers,
- can design and implement simple functions in a microcontroller environment

c) attitude:
- open to new processor technologies and communication interfaces,
- endeavor to select the appropriate tools and program design at a high level,

d) autonomy and responsibility:
- independently learn how to operate, develop and program an unknown processor family,
- is able to view, test and improve software implemented by others

18. Requirements, way to determine a grade (obtain a signature)

In lecture term: An in-class term test
In examination period: Written exam
Pre-exam: upon request
The requisite of the mid-term signature is to attend at the in-class term test and have at least satisfactory result. The requisite of attending at an exam is having the mid-term signature. The credits can be obtained by reaching at least satisfactory result at the exam.

19. Opportunity for repeat/retake and delayed completion

The midterm exam can be retried once

20. Learning materials

Gál T.: Interfésztechnikák. SZAK Kiadó, 20-
Gál T.: Nagyteljesítményű mikrokontrollerek (Electronis textbook - in Hungarian). BME AUT, 20-

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Human factors in traffic environment**				
2. Subject name in Hungarian	Emberi tényezők a közlekedési környezetben			**3. Role**	.
4. Code	**TE47M000**	**5. Evaluation type**	**m**	**6. Credits**	**2**
7. Weekly contact hours	**2 lecture**	**0 practice**	**0 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**60 hours**
Contact hours	28 hours	**Preparation for seminars**	16 hours	**Homework**	0 hours
Reading written materials	0 hours	**Midterm preparation**	16 hours	**Exam preparation**	0 hours

10. Department	Department of Cognitive Science
11. Responsible lecturer	Dr. Németh Kornél
12. Lecturers	Dr. Polner Bertalan, Dr. Demeter Gyula

13. Prerequisites	- (-), -

14. Description of lectures

The purpose of the subject is to present the human factors involved in transport. The following topics are of the utmost importance: Overview of human risk factors, basic concepts of transport, presentation of the test methodology of vehicle driving behavior and description of its models. Overview of human visibility, visual attention and search processes, in particular the overhead resulting from parallel processing. Human-specific aspects of spatial navigation. Factors permanently influencing information processing and decision-making mechanisms, eg. age and experience, personality traits, circumstance evaluation, driving style, and factors with a temporary effect, eg. substance abuse, distraction stimuli, tools, and tiredness psychological mechanisms. Psychological, cause analysis of traffic accidents. Describe the direct and associated human factors of accidents. The possibility of reducing the risk of accidents in human-machine interactions, avoidance, precautionary measures, and psychological aspects of safe driving. An overview of safety-relevant psychological studies.

15. Description of practices

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16. Description of laboratory practices

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17. Learning outcomes

a) knowledge: - knows the basic human psychological concepts relevant to road traffic, - is familiar with the methodology and models of human-machine interactions, especially human behavior-related behavioral behavior, - knows the relevant physiological and psychophysical qualities and laws of human vision, - possesses basic psychological knowledge of attention, - is familiar with the human-specific psychological factors that are related or fundamentally affect the evaluation and decision-making mechanisms while driving, - knows the human psychological qualities that are decisive for behavior even in the social sphere, if we are part of the transport, - is familiar with the behavioral characteristics of other human agents involved in transport (not just the driver), their impact on road safety, - is familiar with the human aspects of basic traffic safety principles and the human-specific background factors of traffic accidents.

b) skills: - in engineering, always keeps in mind that the device / system you are working with will work under the partial / full control of another person whose innumerable predictable and even more unknown parameters may affect the use of the device and the effectiveness of the device. - is able to use the psychological literature of human-machine interactions with the appropriate expertise and critical. - is able to design a human experimental methodology that may be relevant in its engineering field, to design the experimental design - uses sophisticated human-specific psychological knowledge when designing and testing operational processes and tools.

c) attitude: - strives for a better understanding of the human factors relevant to transport, especially driving, researching and researching new solutions - open to a human approach to the problems and tasks raised by new systems

d) autonomy:

18. Requirements, way to determine a grade (obtain a signature)

Successful completion of two midterm test. The final grade is the average of the two test results.

19. Opportunity for repeat/retake and delayed completion

Both midterm exams can be retried once.

20. Learning materials

Campbell és mtsai. (2012). Human Factors Guidelines for Road Systems (2nd ed.), TRB, Washington, ISBN 978-0-309-25816-6
Castro, C. (2009). HUMAN FACTORS OF VISUAL AND COGNITIVE PERFORMANCE IN DRIVING. CRC Press, FL, ISBN 13: 978-1-4200-5530-6
Fuller, R., & Santos, J.A. (2002). HUMAN FACTORS FOR HIGHWAY ENGINEERS, PERGAMON, ISBN-13: 978-0080434124
Shinar D., (2007). Traffic Safety and Human Behavior, Elsevier, ISBN: 978-0-08-045029-2

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Legal framework of autonomous vehicles**				
2. Subject name in Hungarian	Autonóm járművek jogi keretei			**3. Role**	.
4. Code	**GT55M420**	**5. Evaluation type**	**m**	**6. Credits**	**2**
7. Weekly contact hours	**2 lecture**	**0 practice**	**0 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**60 hours**
Contact hours	28 hours	**Preparation for seminars**	0 hours	**Homework**	0 hours
Reading written materials	8 hours	**Midterm preparation**	24 hours	**Exam preparation**	0 hours

10. Department	Department of Business Law
11. Responsible lecturer	Dr. Grad-Gyenge Anikó
12. Lecturers	Dr. Grad-Gyenge Anikó

13. Prerequisites	- (-), -

14. Description of lectures

The objective of the course is to introduce the students into the legal environment of the autonomous vehicles, including especially the basic principles and guidelines and the present and possible future framework of these laws. - Autonomous vehicles in the recent legal environment, esp. a) public law and private law questions. Autonomous vehicles in the private and public laws, legal frameworks of administrative laws, registrations, torts and product liability, warranty, software-law issues, risk-management, contract-management, insurance issues, b) Data protection (privacy) and data safety issues c) relevant criminal law issues. Autonomous vehicles in the recent legal environment. Criminal issues, and criminal liability - Autonomous vehicles in the Future. a) Types and definitions of autonomous and automated cars. Minimum requirements, technical compliance standards. b) Future use of autonomous cars and its possible effects on law - use in controlled environments, ride services, etc. c) Human - machine interface and its legal problems; new requirements - e.g. driving licence standards for the human "element" of the system.

15. Description of practices

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16. Description of laboratory practices

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17. Learning outcomes

a) knowledge: - knows the basic directions of the autonomous regulatory environment of autonomous vehicles
- knows the basic administrative requirements of the legal environment
- is familiar with the fundamental private law (liability and contract law) related to autonomous vehicles
- is familiar with the fundamental data-law context of autonomous vehicles
- is familiar with the fundamental criminal relations related to autonomous vehicles
b) skills: - be able to navigate the regulatory context of autonomous vehicles, identify the main directions of the current legal environment
- is able to identify legal issues related to autonomous vehicles and to identify possible relationships
c) attitude: - endeavor to take account of the legal context of autonomous vehicles, to identify legal risks and to determine compliance points for normative subsystems;
- open to regulatory approaches to problems and tasks raised by new systems
- is able to perform the assigned tasks in a team
d) autonomy and responsibility: - Is able to independently model a related legal problem
- is responsible for performing a legal analysis, taking into account the basic questions of the regulatory environment
- in the performance of its tasks, strives for technical activity that meets the normative requirements

18. Requirements, way to determine a grade (obtain a signature)

Successful completion of two midterm test. The final grade is the average of the two test results.

19. Opportunity for repeat/retake and delayed completion

Both midterm exams can be retried once.

20. Learning materials

Lecture Notes
Verebics János – PéterváriKinga – Pázmándi Kinga: Law of Contracts (in Hungarian) (Budapest, February 2018)
Pétervári Kinga-Pázmándi Kinga - Ződi Zsolt: Autonóm járművek jogi keretei (in Hungarian) note, February 2018)
Pétervári Kinga: A kereskedelmi szerződések joga (in Hungarian) (Typotex, 2015)

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Localization and mapping**				
2. Subject name in Hungarian	Helymeghatározás és térképezés			**3. Role**	.
4. Code	**EOFTMKO1**	**5. Evaluation type**	**m**	**6. Credits**	**4**
7. Weekly contact hours	**2 lecture**	**0 practice**	**2 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**120 hours**
Contact hours	56 hours	**Preparation for seminars**	11 hours	**Homework**	20 hours
Reading written materials	21 hours	**Midterm preparation**	12 hours	**Exam preparation**	0 hours

10. Department	Department of Photogrammetry and Geoinformatics
11. Responsible lecturer	Dr. Barsi Árpád
12. Lecturers	Dr. Barsi Árpád

13. Prerequisites	- (-), -

14. Description of lectures

Goal of the subject is to present the basics of positioning and localization, the map making procedure, the requirements against the maps, as well as the use of maps. During the semester the surveying methods, the basics of geoinformatics (GIS) and the modern map making is demonstrated. The students get knowledge about positioning and its accuracy measures by own conducted measurements. The latest map standards, the newest research results and the future trends are also presented. Semester requirements. History, grouping and goals of geodesy, surveying and cartography. Basic terms. Figure of the Earth and its approximations. Measurement methods. Reference surfaces and their fitting. Map projection systems, map series. Surveying methods, map making techniques, photogrammetry, map update. Groups of positioning methods, basics of global positioning. Satellite based positioning: basics, measurement methods, instruments, corrections, software. Augmentation system for global positioning methods, instruments, error sources, accuracy measures. Terrestrial positioning techniques, indoor solutions, instruments, accuracy measures. Navigation: basics, methods, map matching. Geoinformatics (GIS): systems, standards, data bases, analyzing possibilities, visualizations. Online GIS, crowd-sourcing in GIS, web cartography, change detection, HD map, SLAM. Map as a database, update, query, data exchange, LDM

15. Description of practices

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16. Description of laboratory practices

Individual laboratory measurements are performed by the students using different positioning tools, and after processing their measurement results, mapping is performed. Laboratory measurements include the evaluation of the results aquired and the determination of their accuracy characteristics.

17. Learning outcomes

a) knowledge:
- knows the introductory basics of cartography,
- know the common positioning technology,
- knows the principles of satellite positioning,
- knows the basic principles of anvigation,

b) skills:
- is able to perform measurements with various positioning devices and evaluate them,
- is able to use mapping method from positioning data

c) attitude:
- open to new mapping and positioning methods
- open for use in positioning in technical tasks

18. Requirements, way to determine a grade (obtain a signature)

Two midterm tests and an individual homework.
Final grade is calculated as: 35% of the two tests and 30% of the homework.

19. Opportunity for repeat/retake and delayed completion

One midterm test can be retaken, final deadline for the homework is the end of the delayed completion period.

20. Learning materials

Lecture Notes

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Machine vision**				
2. Subject name in Hungarian	Gépi látás			**3. Role**	.
4. Code	**KOALM702**	**5. Evaluation type**	**m**	**6. Credits**	**4**
7. Weekly contact hours	**2 lecture**	**0 practice**	**2 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**120 hours**
Contact hours	56 hours	**Preparation for seminars**	16 hours	**Homework**	20 hours
Reading written materials	18 hours	**Midterm preparation**	10 hours	**Exam preparation**	0 hours

10. Department	Department of Material Handling and Logistics Systems
11. Responsible lecturer	Dr. Rózsa Zoltán
12. Lecturers	Dr. Rózsa Zoltán, Gazdag Sándor, Golarits Marcell

13. Prerequisites	- (-), -; - (-), -; - (-), -

14. Description of lectures

Machine vision is the most important measure of intelligent road transport. Allows you to track the complex movement and traffic participants, continuously analyze situations and locations. The processing and semantic evaluation of the video stream extracted through the camera gives basic information to the autonomous driving. The subject is about capturing, analyzing and interpreting visual information: extracting high-level image descriptors from lower-level visual characteristics.

- Machine vision in the society of autonomous robots (e.g. autonomous driving): technology, devices, system requirements, software tools and environment; overview of main tasks and related mathematical and algorithmic background; summary of basic image processing methods applied in the following.
- Shape representation and description (regions, active contours, shape description, region decomposition, superpixel); definitions of shapes in 2D, 3D and 3D point-clouds.
- Scale Space axioms of image understanding (Lindeberg's edge/ridge definition: multiscale segmentation and sceletonization, SIFT and similar feature detectors, anisotropic diffusion, RANSAC fitting)
- Energy optimization based image analysis (Markov Random Field, simulated annealing, region segmentation) for remote sensing and change detection; MRF as preprocessing in motion segmentation and active layer in Deep Convolutional Neural Nets.
- Deconvolution: Wiener filter, iteration based deconvolution, and Bayesian-based Lucy-Richardson blind-deconvolution, super-resolution.
- Video processing and analysis; Background/ foreground/ Shadow segmentation (mixture of Gaussian models, shadow models, foreground fitting); Motion Analysis (Optical flow, interest point detection and tracking, video tracking);
- Pattern recognition in 2D and 3D (Statistical-, Neural-, Syntactic- pattern recognition, graph based comparison); Principal Component Analysis; Kernel Methods;
- Biometrical personal identification for human-computer interactions: face-, hand-, finger-, and gesture-recognition; camera-based eye-tracking and saliency definitions, attention detection in short;
- Image- and video-features; Generating and using annotated data sets: training-, test-and validation-sets. Content based image- and video-analysis, -indexing and –retrieval; the curse of dimensionality;
- Reconstruction of the scanned environment from monocular and multiple-view vision; Image based Simultaneous Localization and Mapping (I-SLAM) for automatic driving localization.
- Multimodal/multiview fusion: fusion of sensors and cameras of different positions and spectra: optical-, infra- and depth-cameras. Motion tracking in multiple-view; Traffic surveillance and control from street cameras and on-board moving devices.
- Hidden Markov Models: speech and motion based recognition; pedestrian- and vehicle- detection and tracking; event detection: behaviour of the surrounding pedestrians and vehicles.
- Deep learning structures for image based driving assistance: Recurrent neural networks; Ways to make neural networks generalize better. Combining multiple neural networks to improve generalization. Learning issues.
- Novel pattern recognition structures: Convolutional Neural Networks, Hopfield nets, Boltzmann machines, Deep Neural Networks with generative pre-training. Modeling hierarchical structures with neural nets. Examples: pedestrian detection and vehicle analysis.
- Demonstration of the participants' project development during the semester.

15. Description of practices

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16. Description of laboratory practices

Computer exercises; MATLAB programming

17. Learning outcomes

a) knowledge:

- knows advanced image processing algorithms,
- knows three-dimensional shape recognition methods,
- is familiar with environmental reconstruction technologies,
- is familiar with modern, neural network-based approaches to image processing

b) skills:

- design of image object and shape recognition algorithm,
- can see the architectural issues of a machine vision system,
- is able to select a suitable tool and algorithm for a given task.

c) attitude:

- open to learn about modern vision systems
- open to automatic use of machine vision in vehicle control

d) autonomy and responsibility:

- can participate in image processing projects independently or in a team,
- is able to design a vision system that meets the given task and safety requirements

18. Requirements, way to determine a grade (obtain a signature)

Requirements: continuous comletion of lab tasks, two successful midterm tests and an accepted individual homework. Final grade is the average of the two midterm tests.

19. Opportunity for repeat/retake and delayed completion

One midterm test can be retried, the homework can be delayed completed.

20. Learning materials

Lecture Notes

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Numerical methods**				
2. Subject name in Hungarian	Numerikus módszerek			**3. Role**	k
4. Code	**KOVRM121**	**5. Evaluation type**	**m**	**6. Credits**	**4**
7. Weekly contact hours	**2 lecture**	**0 practice**	**1 lab**	**8. Curriculum**	**AJK**

9. Working hours for fulfilling the requirements of the subject					**120 hours**
Contact hours	42 hours	**Preparation for seminars**	11 hours	**Homework**	20 hours
Reading written materials	35 hours	**Midterm preparation**	12 hours	**Exam preparation**	0 hours

10. Department	Department of Aeronautics and Naval Architecture
11. Responsible lecturer	Dr. Rohács József
12. Lecturers	Dr. Bicsák György

13. Prerequisites	- (-), -

14. Description of lectures

Introduction: scope of lectures, content and requirements. System analysis, model generation, modelling and simulation. General models, simplifications. Source of errors, model types and solution possibilities. Analytic, geometric and numerical solutions. Functions, vectors, matrices, basic operations. Classical and floating-point error-calculation. Sensitivity and numerical stability. Investigation of solution technics. Representing the solutions, evaluation. Solution of system of equations. Single variable, non-linear equations. Successive approximation, Newton iteration and secant method. Solution of polynomial equation. Horner method and Newton-method. Numerical solution of linear system of equations. Gauss-elimination and LU decomposition. Numerical solution of Eigenvalue problem. Extremum problems, optimization. Linear programming, simplex method. Optimization of non-linear functions. Non-linear programming. Gradient method. Functions, series of functions, approximation. Taylor series, MacLaurin series, Fourier series. Polynomial-interpolation, Newton, Lagrange and Hermite interpolation. Application of Splines. Generating curves and surfaces with using Splines. Bezier polynomials, NURBS surfaces. Approximation, Chebyshev and Padé approximation. Harmonical analysis, fast Fourier transformation (FFT). Numerical differentiation, integration. Approximation of derivatives using finite difference method. Approximation of derivatives using Lagrange and Newton interpolation formulas. Numerical integration, general quadrature formula. Trapezoidal and Simpson formula. Romberg iteration. Initial value problems, ordinary differential equations. Explicit formulas: Euler method, 4th order Runge-Kutta method. Implicit formulas, predictor-corrector methods. Approximation of partial differential equations. Boundary conditions, finite difference method, finite volume method, finite element method. Stochastic process modelling. System input data generation. Monte-Carlo simulation.

15. Description of practices

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16. Description of laboratory practices

MATLAB application of the introduced methods.

17. Learning outcomes

a) knowledge: knowing the fundamentals of numerical approximation methods used in engineering instead of analytic algorithms. Knowing to find and apply the most suitable numerical method for a certain problem.

b) skills: can implement different algorithms to a programming language and to find the best approximation method for a given mathematical problem.

c) attitude: interested, responsive

d) autonomy and responsibility: can work individually and in teamwork

18. Requirements, way to determine a grade (obtain a signature)

2 midterm exams from the theoretical part, 50 points / exam. 1 project work for a group of 4-5 students, for n*100 points (n is the number of students). The points can be divided between the group members according to their whish. Grade calculation: summing all the points, the total points gives the final grade as follows: 0 – 79 - 1; 80 – 109 - 2; 110 – 139 - 3; 140 – 169 - 4; 170 – 5

19. Opportunity for repeat/retake and delayed completion

Because of the point-collection system, no minimum points are determined for the midterm exams or for the project work. The retake possibilities are the following: on the replacement week the 1st midterm exam, or the 2nd midterm exam can be tried again for 50 points, or a combined 1st+2nd midterm exam retake for 100 points.

20. Learning materials

Examples, documents and training materials, given out during lectures, presentations.
György Bicsák, Dávid Sziroczák, Aaron Latty: Numerical Methods
Ramin S. Esfandiari: Numerical methods for engineers and scientists using MATLAB, ISBN 978-1-4665-8570-6
Erwin Kreyszig: Advanced engineering mathematics, 10th edition, ISBN 978-0-470-45836-5

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Programming in C and Matlab**				
2. Subject name in Hungarian	Programozás C- és Matlab nyelven			**3. Role**	k
4. Code	**KOKAM603**	**5. Evaluation type**	**m**	**6. Credits**	**4**
7. Weekly contact hours	**1 lecture**	**0 practice**	**2 lab**	**8. Curriculum**	**AJ**

9. Working hours for fulfilling the requirements of the subject					**120 hours**
Contact hours	42 hours	**Preparation for seminars**	0 hours	**Homework**	0 hours
Reading written materials	24 hours	**Midterm preparation**	54 hours	**Exam preparation**	0 hours

10. Department	Department of Control for Transportation and Vehicle Systems
11. Responsible lecturer	Dr. Bécsi Tamás
12. Lecturers	Dr. Bécsi Tamás, Dr. Aradi Szilárd, Törő Olivér

13. Prerequisites	- (-), -; - (-), -; - (-), -

14. Description of lectures

The subject aims the learning of the C and Matlab programming languages and environments. These tools aim the students in the implementation tasks required by other courses.

The goal on one hand is the introduction of the syntax of the two languages: Types, variables, data structures. Flow control, if-then, loops, functions, complex types and data structures. On the other hand, through the learning of syntax, the design and application of basic algorithm design paradigms is also studied.

15. Description of practices

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16. Description of laboratory practices

In the laboratory practice, the goal is to learn the independent use of the syntactic and algorithmic design skills that are known at the lecture. In doing so, students learn the programming of languages through prepared examples in their development environments.

17. Learning outcomes

a) knowledge:
- knows the basic syntax and structure of the two programming environments
- knows how the types, operators, and basic instructions work,
- is familiar with the process control principles and syntax of structured programs, branches, sequences, cycles,
- know the complex data structures, their use,
- knows the basic algorithm design paradigms

b) skills:
- can write simple standalone programs in the two program languages concerned;
- can implement informally or formally specified algorithms,
- can program source code interpretation, error correction,
- is able to test and optimize ready-made programs and modules

c) attitude:
- is interested in modern IT solutions
- capable of algorithmic thinking that can be applied in other areas,

d) autonomy and responsibility:
- in addition to known environments, it is able to acquire other unknown program languages and development tools in autodidact,
- capable of designing and implementing software modules alone, responsibly,
- is able to consult in a team in algorithmic and programming tasks, to make independent decisions

18. Requirements, way to determine a grade (obtain a signature)

Two midterm exams. The final grade is the rounded average of the exams.

19. Opportunity for repeat/retake and delayed completion

One midterm exam can be retried in the delayed completion period.

20. Learning materials

Lecture Notes, Dennis Ritchie: The C programming language, Matlab help

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Project management**				
2. Subject name in Hungarian	Projektmenedzsment			**3. Role**	.
4. Code	**GT20M420**	**5. Evaluation type**	**m**	**6. Credits**	**2**
7. Weekly contact hours	**2 lecture**	**0 practice**	**0 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**60 hours**
Contact hours	28 hours	**Preparation for seminars**	0 hours	**Homework**	0 hours
Reading written materials	8 hours	**Midterm preparation**	24 hours	**Exam preparation**	0 hours

10. Department	Department of Management and Business Economics
11. Responsible lecturer	Dr. Sebestyén Zoltán
12. Lecturers	Dr. Sebestyén Zoltán

13. Prerequisites	- (-), -

14. Description of lectures

The subject introduces students with the terminology, basic tools and techniques related to project management. The curriculum briefly summarizes the basic knowledge needed to manage a project, in a structured way, to the extent of the subject. Thematics: Introduction, Project Definition. Performers, contributors. Creating a demolition hierarchy. Application and transformation of direct and indirect prevention and follow-up lists. Draw a net. Implementation time and labor expense. Bandwidth, cyclogram. Milestones. Activities appearances. Analysis of activity-based nets, calculation of total project time. Activity and event times. Activity and event reserve times: full and spare time, calculation modes. Analysis of activity node nets, calculation of total project time. Activity and event reserve times: full and spare time. Rules for calculating reserve times. Multiple dependency relationships. There are four basic connections. Methods to reduce total project implementation time. Track time and money flow. Projects Risk Management Steps. Risk Resources. Risk mitigation options. Basic organizational forms of projects. Responsibility, responsibility, decision-making. Select project team members: use skill knowledge database. Responsible selection, assignment to activity: Activity-Assignment Matrix. Fundamental contract types, settlement methods.

15. Description of practices

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16. Description of laboratory practices

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17. Learning outcomes

a) knowledge: - knows the phases of projects. actors, contributors - knows how to create a breakdown hierarchy - is familiar with the application and conversion of direct and indirect prevention and tracking lists. - is familiar with drawing and dynamically analyzing the net, analyzing its basic data, and using it - know the methods of reducing the total project implementation time - knows the steps of project risk management

b) skills: - is able to design and evaluate projects, - is able to analyze, allocate resources in case of appropriate industry-specific further education, - is able to manage different fields of expertise

c) attitude: - strives for cost-effective planning and follow-up of the project - open and endeavor to approach the problems and tasks raised during the project management from a multidisciplinary perspective - is able to carry out tasks in a team

d) autonomy and responsibility: - is able to independently produce the project's web design, its dynamics and analysis - is able to coordinate human resources responsibly to achieve the goal of the project

18. Requirements, way to determine a grade (obtain a signature)

Successful completion of two midterm test. The final grade is the average of the two test results.

19. Opportunity for repeat/retake and delayed completion

Both midterm exams can be retried once.

20. Learning materials

Anderson, D. R.-Sweeney, D.J., Williams, T.A. An Introduction to Management Science, West Publishing Company, 1994
Project Management Body of Knowledge (PMBOK), PMI Standards Committe, 2013
Waters, C. D. J. Operations Management, Addison-Wesley Publishing Company, 1991
Lockyer, K., Gordon, J. Project Management and Project Network Techniques, Prentice Hall, 2005

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Safety and reliability in vehicle industry**				
2. Subject name in Hungarian	Biztonság és megbízhatóság a járműiparban			**3. Role**	.
4. Code	**KOKAM703**	**5. Evaluation type**	**m**	**6. Credits**	**3**
7. Weekly contact hours	**2 lecture**	**0 practice**	**0 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**90 hours**
Contact hours	28 hours	**Preparation for seminars**	28 hours	**Homework**	19 hours
Reading written materials	0 hours	**Midterm preparation**	15 hours	**Exam preparation**	0 hours

10. Department	Department of Control for Transportation and Vehicle Systems
11. Responsible lecturer	Dr. Bécsi Tamás
12. Lecturers	Dr. Bécsi Tamás, Dr. Török Árpád

13. Prerequisites	- (-), -; - (-), -; - (-), -

14. Description of lectures

The aim of the course is to provide the students with theoretical and practical knowledge about the approach and methods for designing reliable, safe and secure vehicle systems. The task is to review the safety and reliability analysis methods used in the vehicle industry and to describe the safety standards for the automotive industry. The curriculum includes the introduction of the concepts of risk and risk analysis, basic concepts of safety and reliability, as well as an overview of reliability modeling techniques used in the vehicle industry, as well as a set of best practices for reliability and safety analysis. During the processing of the subject we pay attention to ISO 26262 for vehicle safety.

15. Description of practices

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16. Description of laboratory practices

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17. Learning outcomes

a) knowledge:
- knows the guidelines of the ISO 26262 standard for the automotive industry
- is familiar with the concepts and mathematical apparatus of basic safety, risk and risk analysis,
- is familiar with the development methods of security-critical systems and security architectures,
- is familiar with the numerical descriptive tools of reliability and the related calculation methods

b) skills:
- capable of performing safety calculations based on a specific specification,
- can perform risk analysis calculations

c) attitude:
- is interested in the safety and risk issues of autonomous vehicles

d) autonomy and responsibility:
- does its work in autonomous and responsible way

18. Requirements, way to determine a grade (obtain a signature)

Two midsemester exams (40-40%) and an individual homework (20%) and the final grade is the mean of the grades of the tasks.

19. Opportunity for repeat/retake and delayed completion

Both midsemester exams can be retried once. The individual task cannot be delayed completed.

20. Learning materials

Lecture Notes

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Software Development Methods and Paradigms**				
2. Subject name in Hungarian	Szoftverfejlesztési módszerek és paradigmák			**3. Role**	.
4. Code	**VIAUMA00**	**5. Evaluation type**	**e**	**6. Credits**	**4**
7. Weekly contact hours	**2 lecture**	**1 practice**	**0 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**120 hours**
Contact hours	42 hours	**Preparation for seminars**	14 hours	**Homework**	0 hours
Reading written materials	6 hours	**Midterm preparation**	10 hours	**Exam preparation**	48 hours

10. Department	Department of Automation and Applied Informatics
11. Responsible lecturer	Dr. Lengyel László
12. Lecturers	Dr. Lengyel László, Albert István

13. Prerequisites	- (-), -; - (-), -; - (-), -

14. Description of lectures

The goal of this course is to teach the software development methodologies, their application possibilities and conditions, practices and tools required and preferred for the design and development of methods. Students become practiced in treating issues of common software architectures and software systems, furthermore, they will have a good knowledge related to software development methods.

The course discusses the software development methodologies, the methods and techniques supporting methodologies and development processes, furthermore, practices, architectural requirements and solutions related to software systems.

- Effective use of development tools, learn best practices, build a variety of devices, major development, debugging, testing, mapping processes.
- Typical architectural expectations and possible solutions related to the project management methodologies, showing the advantages and difficulties in each direction.
- The manual application testing processes, methods, presentation of some assets. Guidelines for the preparation of unit tests, the conditions for the application, advantages and disadvantages.
- Source code management methods, widespread source code management tools, branching strategies, introduction of best practice guidelines for effective teamwork.
- Specification and business analysis methods: Structured Systems Analysis and Design Method (SSADM), requirements analysis, requirements specification, logical and physical planning, types of requirements, measurable objectives, prototypes, business analysis techniques, business processes and documentation requirements.
- Software Design methods: software design, UML, UML profile, description and communication of user requirements, architecture, design, Domain Driven Design, Model Driven Development
- User Experience design, typical process steps and best practices, role in the software development process, the user testing methods.
- Methodologies, classic methodologies: the software development process, software development models, Rational Unified Process (RUP), Capability Maturity Model Integration (CMMI)
- Agile development methods 1 (Agile values and principles) Why do we need methodologies?, managing change in the software industry, agile methods, values, principles, agile manifesto, agile practices.
- Agile development methods 2 (supporting the implementation practice): agile design, goals of design, levels of design, vision, release planning, iteration planning, stand-up. User stories, estimates, iteration, "done, done", Agile modeling.
- Agile development methods 3 (Agile methodologies): eXtreme Programming (XP), Scrum, Microsoft Solution Framework (MSF), characteristics of methodologies, their use in everyday life.
- Project management methods and tools 1: general project management principles, constraints, resources and competence matrices, tasks, dependencies. General description of project design tools.
- Project management methods and tools 2: specific characteristics of IT projects, agile and classic methodologies, resource and task management, monitoring, device support.
- Case studies: concrete case studies demonstrate the effective use of development tools, testing, source code management practices, collaboration tools. Experiences, best practices.

15. Description of practices

#NAME?

16. Description of laboratory practices

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17. Learning outcomes

a) knowledge:

- knows the architectural expectations and framework of software design,

- know the basic methods of software testing and source code management,
- knows the agile development methods,
- knows project management methods and tools, their specific IT features,

b) skills:

- can handle common architectural issues related to software systems
- is able to select the appropriate methods and solutions to follow the task,
- capable of performing software testing tasks,

c) attitude:

- Open to learning new development methods and environments
- Suitable to work with the selected frames when working in different projects for different projects
- Open for project-specific best practice

d) autonomy and responsibility:

- can independently design a process,
- can coordinate the work of a team and lead the development process

18. Requirements, way to determine a grade (obtain a signature)

During the semester: one midterm exam

In the exam period: written exam.

The midterm exam yields 40%, and the exam yields 60% of the final grade.

19. Opportunity for repeat/retake and delayed completion

The midterm exam can be repeated during the repeat period in accordance with the Code of Studies and Exams.

20. Learning materials

James Shore: The Art of Agile Development, O'Reilly Media, 200-
Martin Fowler with Kent Beck, John Brant, William Opdyke, and Don Roberts: Refactoring (Improving the Design of Existing Code), Addison-Wesley, 199-
Kent Beck et al.: Manifesto for Agile Software Development, Agile Alliance, 200-
Kent Beck: Test Driven Development: By Example, Addison-Wesley, 200-
Martin Fowler: Domain-Specific Languages, Addison-Wesley Professional, 20-
Martin Fowler: Using an Agile Software Process with Offshore Development, Martinfowler.com
James Shore: The Art of Agile Development: Refactoring.

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Traffic modelling, simulation and control**				
2. Subject name in Hungarian	Járműforgalom modellezése, szimulációja és irányítása			**3. Role**	.
4. Code	**KOKAM704**	**5. Evaluation type**	**m**	**6. Credits**	**4**
7. Weekly contact hours	**2 lecture**	**0 practice**	**2 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**120 hours**
Contact hours	56 hours	**Preparation for seminars**	14 hours	**Homework**	19 hours
Reading written materials	16 hours	**Midterm preparation**	15 hours	**Exam preparation**	0 hours

10. Department	Department of Control for Transportation and Vehicle Systems
11. Responsible lecturer	Dr. Varga István
12. Lecturers	Dr. Tettamanti Tamás, Dr. Luspay Tamás

13. Prerequisites	- (-), -; - (-), -; - (-), -

14. Description of lectures

This subject gives a state-of-the-art introduction to road traffic automation and control. Students become familiar with the basic notions and theories, and get acquainted with the hardware/software architectures of road traffic control systems. Traffic detection technologies, road traffic controllers, as well as traffic control centers and monitoring systems are introduced. An introduction to the traffic modeling and traffic control theories are also provided. The students practice the basics of the traffic modeling through Matlab/Simulink and SUMO traffic simulator.

15. Description of practices

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16. Description of laboratory practices

Computer lab practices: micro. and macroscopic traffic modeling (MATLAB, SUMO).

Laboratory exercises: estimation of road parameters (smoothing, Recursive Least Square Estimator, Kalman Filter, MHE), model based control design (PID, LQ, MPC).

17. Learning outcomes

a) knowledge:
- is familiar with the structure and operation of traffic control systems,
- knows the levels and methods of traffic modeling,
- know the traffic management strategies, tools and software for urban transport,
- knows the management solutions of public transport and highway systems

b) skills:
- capable of modeling traffic on a given network,
- is able to control a given subnet,
- is able to use and design a form for measuring and estimating systems

c) attitude:
- open to research on the joint system of traffic management and autonomous vehicles

d) autonomy and responsibility:
- can independently design node controls

18. Requirements, way to determine a grade (obtain a signature)

Requirements: successful completion (min. 50%) of the midterm and submission of one homework. Weights of requirements in the mid-term grade: homework (1/3), midterm (2/3).

19. Opportunity for repeat/retake and delayed completion

There is a retake option for the midterm and the homework can resubmitted upon request till the end of delayed completion period.

20. Learning materials

Tettamanti, T. ; Luspay, T. ; Varga, I. Road Traffic Modeling and Simulation Budapest, Magyarország : Akadémiai Kiadó (2019) ISBN: 9789634542957

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Vehicle dynamics**				
2. Subject name in Hungarian	Járműdinamika			**3. Role**	.
4. Code	**KOGGM705**	**5. Evaluation type**	**e**	**6. Credits**	**3**
7. Weekly contact hours	**2 lecture**	**0 practice**	**1 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**90 hours**
Contact hours	42 hours	**Preparation for seminars**	0 hours	**Homework**	20 hours
Reading written materials	10 hours	**Midterm preparation**	8 hours	**Exam preparation**	10 hours

10. Department	Department of Automotive Technologies
11. Responsible lecturer	Dr. Szalay Zsolt
12. Lecturers	Domina Ádám, Nyerges Ádám, Dr. Szabó Bálint

13. Prerequisites	- (-), -

14. Description of lectures

The aim of the course is to familiarize students with the dynamic models of road vehicles. Within the scope of the course, students will be able to familiarize themselves with the various combined longitudinal and transverse vehicle dynamics models of vehicle and vehicle combinations, including tire models. The subject assumes basic mechanical mechanics of the vehicle. Vehicle behavior and stability issues. Modeling Basics. Modeling solo vehicles with a bike model. Modeling trailers with a bike model. Two-gauge four-wheeled vehicle model. Two-gauge four-wheeled vehicle model with trailer. Basic rubber modeling considerations. Tire brush model. The "Magic Formula" tire model. The "tight string" tire model. Analysis of three modern tire models. (RMOD-K, Ftire, MF-Swift)

15. Description of practices

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16. Description of laboratory practices

Computer exercises; MATLAB and SIMULINK programming, implementation of vehicle models presented in lectures.

17. Learning outcomes

a) knowledge: - knows the basic vehicle dynamics modeling paradigms, - is familiar with the dynamic behavior of vehicles, the terms used to describe them and their meaning, - knows different vehicle models, - knows the so-called bicycle model and bicycle model for trailer vehicles, - is familiar with two-track vehicle models and their trailer description, - is aware of the basic problems of vehicle-track connection - knows the different wheel models, the Magic formula, the tight string, and the modern tire models.

b) skills: - is capable of creating a vehicle dynamics model based on a specified vehicle description, - is able to apply vehicle dynamics models in design, - is able to select a model suitable for the specified vehicle control task, - is able to understand and use other vehicle models based on their knowledge, - capable of modeling the vehicle-track connection in a special environment,

c) attitude: - open to the use of new vehicle dynamics models, - open to the combined use of vehicle dynamics and other knowledge

- collaborates with student peers and trainers to address various issues

d) autonomy and responsibility: - independently expand its knowledge in modeling IT solutions, - examines technical tasks in system-level thinking, - is responsible for performing a dynamic task entrusted to it, which provides support to its staff.

18. Requirements, way to determine a grade (obtain a signature)

One midterm exam and one individual homework. Final grade comes from the result of exam.

19. Opportunity for repeat/retake and delayed completion

The midterm exam can be retried once or the individual homework can be delayed completed.

20. Learning materials

Hans Pacejka: Tire and Vehicle Dinamics, Elsevier, Oxford, 2012

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Vehicle mechanics fundamentals**				
2. Subject name in Hungarian	Járműmechanikai alapok			**3. Role**	.
4. Code	**KOGGM713**	**5. Evaluation type**	**e**	**6. Credits**	**4**
7. Weekly contact hours	**2 lecture**	**0 practice**	**1 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**120 hours**
Contact hours	42 hours	**Preparation for seminars**	0 hours	**Homework**	20 hours
Reading written materials	18 hours	**Midterm preparation**	20 hours	**Exam preparation**	20 hours

10. Department	Department of Automotive Technologies
11. Responsible lecturer	Dr. Zöldy Máté
12. Lecturers	Sipos Gábor

13. Prerequisites	- (-), -

14. Description of lectures

Introduction into the basics of vehicle dynamics. Description of motion equation of vehicles. Longitudinal, lateral and vertical dynamics of road vehicles. In the Autonomous Vehicle Control Enginees MSc tematics, the target of the subject is to caught up the students, who do not have vehicle engineer BSc. By the subject the students are able to analyse and modelling the dynamics of a vehicle. The course starts with the basic definitions of vehicle dynamics, coordinate systems, simple vehicle motions. Starting with tyre dynamics the longitudinal and lateral slip conditions will be presented. The vehicle dynamics are separated to longitudnial, lateral and vertical behaviour. The longitudinal motion consists the acceleration performance and the brake dynamics. In lateral direction the low speed turning, the steady state cornering. As the vertical motion of the vehicle the ride behaviour is demonstrated as well. Motion equation are set up to describe the vehicle behaviour under different circumstances. Vehicle stability aspects.

15. Description of practices

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16. Description of laboratory practices

In laboratory exercises, the theoretical background is studied through various models and its practical aspects.

17. Learning outcomes

a) knowledge:
- is familiar with the mathematical basis for vehicle dimensional modeling,
- is familiar with simple description paradigms, coordinate systems, and descriptions of simple vehicle movements,
- is familiar with basic length and transverse vehicle behavior,
- knows the basics of vertical vehicle dynamics,
- knows wheel models at an introductory level,
- knows the limitations of modeling,

b) skills:
- is able to understand more complex vehicle dynamics models in later studies,
- capable of modeling simple vehicle movements,
- is able to systematically view a vehicle dynamics model,

c) attitude:
- is interested in a more detailed description of vehicle movements,
- endeavor to embrace technical approaches and thinking,
- continually expanding its mathematical and modeling skills,

d) autonomy and responsibility:
- independently fulfils the responsible task

18. Requirements, way to determine a grade (obtain a signature)

The prerequisite for obtaining the signature is the successful completion of the midterm test and individual student work. The final mark is determined by the written exam.

19. Opportunity for repeat/retake and delayed completion

The midterm test can be retried once, tasks must be given accurately.

20. Learning materials

Lecture Notes

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Vehicle operation**				
2. Subject name in Hungarian	Gépjárművek üzeme			**3. Role**	.
4. Code	**KOGGM174**	**5. Evaluation type**	**e**	**6. Credits**	**4**
7. Weekly contact hours	**2 lecture**	**0 practice**	**1 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**120 hours**
Contact hours	42 hours	**Preparation for seminars**	28 hours	**Homework**	0 hours
Reading written materials	12 hours	**Midterm preparation**	10 hours	**Exam preparation**	28 hours

10. Department	Department of Automotive Technologies
11. Responsible lecturer	Dr. Szalay Zsolt
12. Lecturers	Dr. Török Árpád

13. Prerequisites	- (-), -

14. Description of lectures

Time frame, maintenance, energy-, material and information technological environment of the vehicle operation. Characteristic uncertainties in the vehicle operation and vehicle dimensioning. Basics of probability analysis. Practical methods of reliability analysis: block -diagram method and fault-tree analysis. Random faults and defects in vehicle operation. Methods of determining reliabilty and availability. Availability definitions. Renewal processes. Modelling of operation processes by semi-Markovian approach. Application of the theory of mass service systems. Queueing problem. Optimum storing processes. Elements of material damages, leading to component failures. General approach to system diagnosis. Vehicle diagnosis based on dynamical simulation for ensureing the criteria presribed by transportation safety rules. Identification of the weak-spots using diagnostic tests.

15. Description of practices

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16. Description of laboratory practices

Vehicle Damage, Slip Brake Brake Test, Chassis Control, Adjustment, Wheel Balancing, Shock Diagnostic Methods, Engine Mechanical Status Diagnostics, Accident Data Recording Equipment (UDS) Data Processing, Presentation of Modern Diagnostic Station, where students become familiar with Periodic Technical Review Technology as described below : Identification, Testing of accessories, Checking of traction conditions, Devices for measuring noise and used diagnostic tests for establishing conditions of circulation.

17. Learning outcomes

a) knowledge: - is familiar with the basic tasks, principles and methods of vehicle operation - is familiar with the maintenance, repair and wear and tear of the entire vehicle life cycle, - knows vehicle diagnostic processes, methods, protocols, - is familiar with modern testing methods, environmental compliance principles and regulations, - acquire knowledge in various repair technologies,

b) skills: - is able to interpret the results of different test methods, - is familiar with the process of recording accident data and the associated processing process to perform such a task, - is able to consult a specialist on various maintenance processes, to consider the risks, - is able to participate in the design of a modern maintenance process, - is able to perform planning tasks related to vehicle life cycle

c) attitude: - Interested in vehicle operation - Suitable for taking environmental concerns into account when designing, - Suitable for participating in a multi-field team

d) autonomy and responsibility: - Can assess the vehicle diagnostic results responsibly, - Can independently make decisions in vehicle maintenance decisions.

18. Requirements, way to determine a grade (obtain a signature)

One midterm exam and individual lab works. The final grade is the result of the exam.

19. Opportunity for repeat/retake and delayed completion

In the delayed completion period the midterm exam can be retaken or one of the individual lab works can be completed.

20. Learning materials

Lecture Notes

BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
Faculty of Transportation Engineering and Vehicle Engineering

Subject description

1. Subject name	**Vehicle testing and validation**				
2. Subject name in Hungarian	Közúti járművek tesztelése és validációja			**3. Role**	.
4. Code	**KOGGM406**	**5. Evaluation type**	**m**	**6. Credits**	**3**
7. Weekly contact hours	**0 lecture**	**0 practice**	**3 lab**	**8. Curriculum**	**A**

9. Working hours for fulfilling the requirements of the subject					**90 hours**
Contact hours	42 hours	**Preparation for seminars**	18 hours	**Homework**	0 hours
Reading written materials	20 hours	**Midterm preparation**	10 hours	**Exam preparation**	0 hours

10. Department	Department of Automotive Technologies
11. Responsible lecturer	Dr. Zöldy Máté
12. Lecturers	Dr. Török Árpád

13. Prerequisites	- (-), -

14. Description of lectures

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15. Description of practices

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16. Description of laboratory practices

Introduction into the modern instrumental vehicle measurements. Acquirement of the usage of instruments, testing methods, and application of vehicle testing processes. In the Autonomous Vehicle Control Enginees MSc tematics, the target of the subject is to present to the students the testing procedures and possibilities of vehicle and software testing. By the subject the students are able to coordinate tests in simulation, laboratory and open road environment. Introduction of the basic measurement methods and instruments. Demonstration of different vehicle testing instruments. The subject goes through on the testing methods and tools different vehicle subsystem. Engine and driveline testing on modern engine test rigs demonstrates the dynamics, efficiency and emission of the powertrain. Brake system testing will be performed on both test benches and on a test track using a real vehicle according to the ECE directives. Suspension testing introduces both the passanger car suspension measurement methods, and the air spring system testing for heavy duty vehicles. Steering system testing is demontrated as well. This course also shows different levels of testing: like laboratory tests on a subsystem of a vehicle, laboratory tests in simulation environment (HIL), laboratory tests on a real vehicle, and testing on test track. In addition the testing as a part of the V-model based development is also explained during this course. This course consists of laboratory exercises only, and is held at companies with th eprofile of modern development and testing.

17. Learning outcomes

a) knowledge: - is familiar with the operation of the dynamometer and the procedure for measuring it, - is familiar with the principles of measuring the performance, dynamics and emissions of internal combustion engines and the standardized process of measurements, - knows the methods of measuring the suspension of passenger cars and commercial vehicles, - knows the different levels of vehicle system testing, laboratory, simulation, and test track measurements, - is familiar with the V model-based development principles applied in the automotive industry

b) skills: - is capable of performing individual test tasks after obtaining type knowledge, - can take into account different expectations while planning - is able to evaluate diagnostic results - is able to interpret the standards of international standards, to transpose them into practice,

c) attitude: - is interested in different testing processes, - is able to work in a team, in relation to the different automotive design paradigms,

d) autonomy and responsibility: - the choice of self-diagnosing diagnostic methods for their application, - the results obtained can be interpreted independently, responsibly, summarized and passed on - is able to make repair and improvement decisions based on the interpreted results

18. Requirements, way to determine a grade (obtain a signature)

The prerequisite for the completion of the subject is the successful completion of the midterm test and all laboratory requirements. Final mark reflects the result of the midterm test.

19. Opportunity for repeat/retake and delayed completion

The midterm test can be retried once, tasks must be given accurately.

20. Learning materials

Lecture Notes