Study plan

Name of study plan: Cybernetics and Robotics

Faculty/Institute/Others: Faculty of Electrical Engineering

Department:

Branch of study guaranteed by the department: Welcome page

Garantor of the study branch:

Program of study: Cybernetics and Robotics Type of study: Follow-up master full-time

Required credits: 102
Elective courses credits: 18
Sum of credits in the plan: 120

Note on the plan:

Name of the block: Compulsory courses in the program

Minimal number of credits of the block: 60

The role of the block: P

Code of the group: 2021_MKYRDIP Name of the group: Diploma Thesis

Requirement credits in the group: In this group you have to gain 30 credits Requirement courses in the group: In this group you have to complete 1 course

Credits in the group: 30 Note on the group:

Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) Tutors, authors and guarantors (gar.)	Completion	Credits	Scope	Semester	Role
BDIP30	Diploma Thesis	Z	30	22s	L	Р

Characteristics of the courses of this group of Study Plan: Code=2021_MKYRDIP Name=Diploma Thesis

BDIP30	Diploma Thesis	Z	30			
Independent final comprehensive work for the Master's degree study programme. A student will choose a topic from a range of topics related to his or her branch of study, which will						
be enecified by branch	department or branch departments. The diploma thesis will be defended in front of the heard of examiners for the comprehen	scive final examina	ation			

Code of the group: 2021_MKYRP

Name of the group: Compulsory subjects of the programme

Requirement credits in the group: In this group you have to gain 30 credits

Requirement courses in the group: In this group you have to complete 5 courses

Credits in the group: 30

vote on the gi						
Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) Tutors, authors and guarantors (gar.)	Completion	Credits	Scope	Semester	Role
B3M33ARO1	Autonomous Robotics Karel Zimmermann, Vojt ch Vonásek Karel Zimmermann Karel Zimmermann (Gar.)	Z,ZK	6	2P+2L	L	Р
B3M38DIT1	Diagnostics and Testing Radislav Šmíd Radislav Šmíd (Gar.)	Z,ZK	6	2P+2L	Z	Р
B3M35LSY1	Linear Systems Petr Hušek Petr Hušek (Gar.)	Z,ZK	6	4P+2C	Z	Р
B3MPVTY1	Team project Petr Drábek, Tomáš Drábek, Ond ej Drbohlav, Martin Hlinovský, Pavel Mužák, Martin Šipoš Ond ej Drbohlav Tomáš Drábek (Gar.)	Z	6	0P+4C	L	Р
B3MPROJ6	Project Tomáš Drábek, Martin Hlinovský, Kamila Krupková, Petr Pošík, Jana Zichová, Šárka Heitmanová. Drahomíra Heitmanová	Z	6	0p+6s	Z	Р

Characteristics of the courses of this group of Study Plan: Code=2021_MKYRP Name=Compulsory subjects of the programme

B3M33ARO1 **Autonomous Robotics** The Autonomous robotics course will explain the principles needed to develop algorithms for intelligent mobile robots such as algorithms for: (1) Mapping and localization (SLAM) sensors calibration (lidar or camera). (2) Planning the path in the existing map or planning the exploration in a partially unknown map and performing the plan in the world. IMPORTANT: It is assumed that students of this course have a working knowledge of optimization (Gauss-Newton method, Levenberg Marquardt method, full Newton method), mathematical analysis (gradient, Jacobian, Hessian), linear algebra (least-squares method), probability theory (multivariate gaussian probability), statistics (maximum likelihood and maximum aposteriori estimate), python programming and machine learning algorithms. This course is also part of the inter-university programme prg.ai Minor. It pools the best of Al education in Prague to provide students with a deeper and broader insight into the field of artificial intelligence. More information is available at https://prg.ai/minor. B3M38DIT1 Diagnostics and Testing Z,ZK The course aims to introduce students to the problems of modelling and fault detection, ensuring fault tolerance, monitoring the operational status of complex industrial components and autonomous systems, non-destructive testing and diagnostics of electronic devices with analogue and digital circuits. Linear Systems Z,ZK The purpose of this course is to introduce mathematical tools for the description, analysis, and partly also synthesis, of dynamical systems. The focus will be on linear time-invariant controllers will be explained in detail. Partially covered will be also time-varying and nonlinear systems. Some of the tools introduced in this course are readily applicable to engineering

The purpose of this course is to introduce mathematical tools for the description, analysis, and partly also synthesis, of dynamical systems. The focus will be on linear time-invariant multi-input multi-output systems and their properties such as stability, controllability, observability and state realization. State feedback, state estimation, and the design of stabilizing controllers will be explained in detail. Partially covered will be also time-varying and nonlinear systems. Some of the tools introduced in this course are readily applicable to engineering problems such as the analysis of controllability and observability in the design of flexible space structures, the design of state feedback in aircraft control, and the estimation of state variables. The main motivation, however, is to pave the way for the advanced courses of the study program. The prerequsites for this course include undergraduate level linear algebra, differential equations, and Laplace and z transforms.

B3MPVTY1 Team project Z 6
Teamwork is the basis of most of the activities that people perform in companies and their personal lives. In this course, students can try how to solve a technical task in a team, how to cooperate, how to communicate together and how to solve problems such as project delays, how to include external influences in the plan, etc.

B3MPROJ6 Project Z 6

Name of the block: Compulsory elective courses

Minimal number of credits of the block: 42

The role of the block: PV

Code of the group: 2021_MKYRPV1

Name of the group: Compulsory elective subjects of the programme - Group 1

Requirement credits in the group: In this group you have to gain at least 18 credits (at most 36)

Requirement courses in the group: In this group you have to complete at least 3 courses (at most 6)

Credits in the group: 18

Note on the group:

~Podmínka pro splnění této skupiny předmětů: Studenti musí absolvovat nejméně 3

povinně-volitelné předměty ze skupiny 1.\\

Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) Tutors, authors and guarantors (gar.)	Completion	Credits	Scope	Semester	Role
B4M33MPV	Computer Vision Methods Ond ej Drbohlav, Georgios Tolias, Ji í Matas, Jan ech, Dmytro Mishkin Ond ej Drbohlav Ji í Matas (Gar.)	Z,ZK	6	2P+2C	L	PV
B3M35OFD	Estimation, filtering and detection Vladimír Havlena Vladimír Havlena (Gar.)	Z,ZK	6	2P+2C	Z	PV
B3M35ORR	Optimal and robust control Zden k Hurák Zden k Hurák Zden k Hurák (Gar.)	Z,ZK	6	2P+2C	L	PV
B3M38SPD1	Data Acquisition and Transfer Radislav Šmíd Radislav Šmíd Radislav Šmíd (Gar.)	Z,ZK	6	2P+2L	L	PV
BE4M33SSU	Statistical Machine Learning Jan Drchal, Vojt ch Franc, Boris Flach (Gar.)	Z,ZK	6	2P+2C	Z	PV
B3M38ZDS1	Analog Signal Processing and Digitalization Josef Vedral, Michal Janošek Josef Vedral Josef Vedral (Gar.)	Z,ZK	6	2P+2L	Z	PV

Characteristics of the courses of this group of Study Plan: Code=2021_MKYRPV1 Name=Compulsory elective subjects of the programme

- Group 1

B4M33MPV	Computer Vision Methods	Z,ZK	6
The course covers select	cted computer vision problems: search for correspondences between images via interest point detection, description and ma	tching, image stite	ching, detection
recention and common	tation of chicate in images and videos, image retrieval from large databases and tracking of chicate in video convenees. This		art of the

recognition and segmentation of objects in images and videos, image retrieval from large databases and tracking of objects in video sequences. This course is also part of the inter-university programme prg.ai Minor. It pools the best of AI education in Prague to provide students with a deeper and broader insight into the field of artificial intelligence. More information is available at https://prg.ai/minor.

B3M35OFD Estimation, filtering and detection

This course will cover description of the uncertainty of hidden variables (parameters and state of a dynamic system) using the probability language and methods for their estimation. Based on bayesian problem formulation principles of rational behavior under uncertainty will be analyzed and used to develop algorithms for parameter estimations (ARX models, Gaussian process regression), filtering (Kalman filter) and detection (likelihood ratio theory) . We will demonstrate numerically robust implementation of the algorithms applicable in real life problems for the areas of industrial process control, robotics and avionics.

B3M35ORR	Optimal and robust control	Z,ZK	6
B3M38SPD1	Data Acquisition and Transfer	Z,ZK	6
BE4M33SSU	Statistical Machine Learning	Z,ZK	6

The aim of statistical machine learning is to develop systems (models and algorithms) for learning to solve tasks given a set of examples and some prior knowledge about the task. This includes typical tasks in speech and image recognition. The course has the following two main objectives 1. to present fundamental learning concepts such as risk minimisation, maximum likelihood estimation and Bayesian learning including their theoretical aspects, 2. to consider important state-of-the-art models for classification and regression and to show how they can be learned by those concepts.

Code of the group: 2021_MKYRPV2

Name of the group: Compulsory elective subjects of the programme - Group 2

Requirement credits in the group: In this group you have to gain at least 24 credits (at most 114)

Requirement courses in the group: In this group you have to complete at least 4 courses (at most 19)

Credits in the group: 24

Note on the group:

B3M38ZDS1

~Podmínka pro splnění této skupiny předmětů: Studenti musí absolvovat celkem 7 povinně volitelných předmětů v součtu ze skupiny 1 a skupiny 2 za splnění podmínky na minimálně 3

absolvované předměty ze skupiny 1.\\

Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) Tutors, authors and guarantors (gar.)	Completion	Credits	Scope	Semester	Role
B3M38ASE	Automotive Sensors and Networks Antonín Platil, Ji í Novák Ji í Novák Ji í Novák (Gar.)	Z,ZK	6	2P+2L	L	PV
B3M35DRS	Dynamics and Control Networks Kristian Hengster-Movric Kristian Hengster-Movric	Z,ZK	6	2P+2C	Z	PV
B3M33HRO	Humanoid robots Mat j Hoffmann Mat j Hoffmann (Gar.)	Z,ZK	6	2P+2C	L	PV
B3M35HYS	Hybrid Systems Zden k Hurák Zden k Hurák (Gar.)	Z,ZK	6	2P+2C		PV
B3M38INA1	Integrated Avionics Martin Šipoš, Jan Rohá Martin Šipoš Jan Rohá (Gar.)	Z,ZK	6	2P+2L	L	PV
B3M35KOA	Combinatorial Algorithms Zden k Hanzálek Zden k Hanzálek (Gar.)	Z,ZK	6	2P+2C	L	PV
B2M32MKSA	Mobile Networks Zden k Be vá, Robert Bešák, Pavel Mach Pavel Mach Zden k Be vá (Gar.)	Z,ZK	6	2P + 2L	Z	PV
B3M33MRS	Multi-robot aerial systems Robert P ni ka, Tomáš Bá a, Martin Saska Martin Saska (Gar.)	Z,ZK	6	2P+2L	Z	PV
B3M35NES	Nonlinear Systems and Chaos Sergej elikovský Sergej elikovský (Gar.)	Z,ZK	6	2P+2C	Z	PV
B3M33PKR	Advanced robot kinematics Viktor Korotynskiy, Tomáš Pajdla Tomáš Pajdla Tomáš Pajdla (Gar.)	Z,ZK	6	2P+2C	Z	PV
B3M38POS	Advanced Sensors Michal Janošek, Antonín Platil Antonín Platil (Gar.)	Z,ZK	6	2P+2L	Z	PV
B3M35PSR	Real -Time Systems Programming Michal Sojka Michal Sojka Michal Sojka (Gar.)	Z,ZK	6	2P+2C	Z	PV
B3M38PSL1	Aircraft Avionics Martin Šipoš, Jan Rohá Jan Rohá (Gar.)	Z,ZK	6	2P+2L	Z	PV
B3M35RSA	Automotive Control Systems Denis Efremov, Tomáš Haniš, David Vošahlík Tomáš Haniš Tomáš Haniš (Gar.)	Z,ZK	6	2P+2S		PV
B3M35SRL	Flight Control Systems Martin Hrom ik Martin Hrom ik (Gar.)	Z,ZK	6	2P+2L	Z	PV
B4M33TDV	Three-dimensional Computer Vision Radim Šára Radim Šára (Gar.)	Z,ZK	6	2P+2C	Z	PV
B4M36UIR	Artificial Intelligence in Robotics Stefan Edelkamp, Tomáš Kroupa, Jan Faigl Jan Faigl (Gar.)	Z,ZK	6	2P+2C	Z	PV
B3M38VBM1	Videometry and Contactless Measurement Radislav Šmíd, Jan Fischer Radislav Šmíd Radislav Šmíd (Gar.)	Z,ZK	6	2P+2L	Z	PV
B3M38VIN1	Virtual Instrumentation Antonín Platil, Jaroslav Rozto il Antonín Platil Antonín Platil (Gar.)	Z,ZK	6	2P+2L	L	PV

Characteristics of the courses of this group of Study Plan: Code=2021_MKYRPV2 Name=Compulsory elective subjects of the programme - Group 2

B3M38ASE Automotive Sensors and Networks

The course provides students with a deeper insight into the functional principles of advanced sensor systems in cars, methods of signal processing in sensors and explains how to use them in vehicle subsystems. It also deals with distributed vehicle systems for real-time control and methods of their testing. Theoretical lectures are complemented by practical laboratory teaching with real elements (ECUs, sensors) of modern vehicles.

B3M35DRS

Dynamics and Control Networks

Z,ZK 6

This course responds to an ever-increasing demand for understanding contemporary networks – large-scale complex systems composed of many components and subsystems interconnected into a single distributed entity. Herein, we will consider fundamental similarities between diverse areas such as e.g. forecasting the spread of global pandemics, public opinion dynamics and manipulation of communities through social media, formation controls for unmanned vehicles, energy generation and distribution in power grids, etc. Understanding such compelling issues goes far beyond the boundaries of any single physical, technological or scientific domain. Therefore, we will analyze phenomena across different domains, involving societal, economic and biological networks. For such networked systems, the resulting behavior depends not only on the characteristics of their individual components and details of their physical or logical interactions, but also on a precise way those components are interconnected – the detailed interconnection topology. For that reason, the first part of the course introduces fundamental theoretical and abstract computational network analysis concepts; in particular, the algebraic graph theory, network measures and metrics and fundamental network algorithms. The second part of the course subsequently views networks as dynamical systems, studies their properties and ways in which these are controlled, using mainly methods of automatic control theory.

B3M33HRO	Humanoid robots	Z,ZK	6
	'human-centered robotics": humanoid robots and human-robot interaction. Motivated by the vision of robot companions in ou		
	ogy and its specific challenges and opportunities: (i) design, kinematics and inverse kinematics of humanoids, (ii) multimodal	•	
) walking and balancing, and (ii) grasping. The second part of the course centers on human-robot interaction (HRI), which includ cognitive/social HRI - how to design robots and behaviors to be acceptable for people.	udes priysicai riki	(Salety aspects,
B3M35HYS	Hybrid Systems	Z,ZK	6
B3M38INA1	Integrated Avionics	z,zk	6
	Modular Avionics (IMA) focuses on a modern concept of the approach to the development and design of aircraft electronics (a		e transition from
	to SW blocks. They use high-speed connections to exchange data in applications related to paid air transport. The existing r		-
	rements for the accuracy, reliability, and functionality of electronic systems even in the event of a failure. In the course, studel ed safety-critical multi-sensor systems, methods of data processing from predetermined systems, fault detection methods, so		
· ·	ed salety-critical multi-sensor systems, methods of data processing from predetermined systems, radiit detection methods, so el architectures, bus technology, and methods of testing/certification of aircraft instruments.	election of primary	y computer and
B3M35KOA	Combinatorial Algorithms	Z,ZK	6
	problems and algorithms of combinatorial optimization (often called discrete optimization; there is a strong overlap with the ter		
	gebra, graph theory, and basics of optimization, we show optimization techniques based on graphs, integer linear programmi		
	ace search methods. We focus on application of optimization in stores, ground transportation, flight transportation, logistics, particles, processes routing, schooling in parallel computers.	olanning of humar	resources,
B2M32MKSA	n lines, message routing, scheduling in parallel computers. Mobile Networks	Z,ZK	6
	principles and functionalities of mobile networks with special focus on currently deployed technologies and future mobile netwo		_
	oles of GSM, UMTS, LTE/LTE-A, and 5G will be explained. Then, selected key technologies for future mobile networks (6G) will be explained.		o, a.oo.a.o
B3M33MRS	Multi-robot aerial systems	Z,ZK	6
The course offers the in	troduction to multirotor autonomous aerial systems (UAV). Standard senzors and principles of estimate and control of UAV w	vill be introduced.	The problems of
	lanning, localization, mapping and exploration will be discussed for sigle moving UAV as well as multiple UAVs moving in a fo		
B3M35NES	Nonlinear Systems and Chaos	Z,ZK	6
_	s to introduce basics of the modern approaches to the theory and applications of nonlinear control. Fundamental difference wh near case is that the state space approach prevails. Indeed, the frequency response approach is almost useless in nonlinear	-	-
•	y differential equations, therefore, an introduction to solving these equations is part of the course. More importantly, the qualitati	•	
equations will be preser	sted, among them Lyapunov stability theory is crucial. More specifically, the focus will be on Lyapunov function method enabli	ng to analyse stab	oility of nonlinear
	f linear ones. Furthemore, stabilization desing methods will be studied in detail, among them the so-called control Lyapunov	•	
	special stress will be, nevertheless, given by this course to introduce and study methods how to transform complex nonlinear ethods would be applicable. Such an approach is usually refered to as the so-called exact nonlinearity compensation. Contra	=	
	d does not ignore nonlinearities but compensates them up to the best possible extent. The course introduces some interestin	-	
	and landing plane ("planar VTOL"), or a simple 2-dimensional model of the walking robot.		, 0
B3M33PKR	Advanced robot kinematics	Z,ZK	6
-	onstrate techniques for modelling, analyzing and identifying robot kinematics. We will explain more advanced principles of the	-	-
· ·	ns suitable for identification of kinematic parameters from measured data. We will explain how to solve the inverse kinematic	task of 6DOF ser	ial manipulators
and now it can be used	to identify its kinematic parameters. Theory will be demonstrated on simulated tasks and verified on a real industrial robot.		
R3M38POS	Advanced Sensors	7 7K	6
B3M38POS B3M35PSR	Advanced Sensors Real -Time Systems Programming	Z,ZK Z ZK	6
B3M35PSR	Advanced Sensors Real -Time Systems Programming is to provide students with basic knowledge about software development for real-time systems, for example in control and en	Z,ZK	6
B3M35PSR The goal of this course	Real -Time Systems Programming	Z,ZK nbedded application	6 ons. The focus
B3M35PSR The goal of this course is on embedded system such systems. Another	Real -Time Systems Programming is to provide students with basic knowledge about software development for real-time systems, for example in control and en s equipped with a real-time operating system (RTOS). Lectures will cover real-time systems theory, which can be used to for set of lectures will introduce methods and techniques used for development of safety-critical systems, whose failure may have	Z,ZK hbedded application mally verify timing e catastrophic cor	6 ons. The focus g correctness of nsequences.
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B3M35PSR The goal of this course is on embedded system such systems. Another During labs, students w The obtained metrics re	Real -Time Systems Programming is to provide students with basic knowledge about software development for real-time systems, for example in control and en s equipped with a real-time operating system (RTOS). Lectures will cover real-time systems theory, which can be used to for set of lectures will introduce methods and techniques used for development of safety-critical systems, whose failure may hav ill first solve a few simple tasks to familiarize themselves with basic components of VxWorks RTOS and to benchmark the use present the typical criteria for assessing the suitability of a given platform for the given application. After the simple tasks, stu	Z,ZK nbedded application mally verify timing e catastrophic core ad OS and hardwa udents will solve a	6 ons. The focus g correctness of nsequences. are (Xilinx Zynq).
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B3M35PSR The goal of this course is on embedded system such systems. Another During labs, students w The obtained metrics retime-critical motion cont B3M38PSL1	Real -Time Systems Programming is to provide students with basic knowledge about software development for real-time systems, for example in control and en s equipped with a real-time operating system (RTOS). Lectures will cover real-time systems theory, which can be used to for set of lectures will introduce methods and techniques used for development of safety-critical systems, whose failure may hav ill first solve a few simple tasks to familiarize themselves with basic components of VxWorks RTOS and to benchmark the use present the typical criteria for assessing the suitability of a given platform for the given application. After the simple tasks, stu	Z,ZK nbedded application mally verify timing e catastrophic core ed OS and hardwa idents will solve a anguage. Z,ZK	6 ons. The focus g correctness of nsequences. are (Xilinx Zynq). complex task of
B3M35PSR The goal of this course is on embedded system such systems. Another During labs, students w The obtained metrics retime-critical motion cont B3M38PSL1 The course acquaints symethods used to process	Real -Time Systems Programming is to provide students with basic knowledge about software development for real-time systems, for example in control and en is equipped with a real-time operating system (RTOS). Lectures will cover real-time systems theory, which can be used to for set of lectures will introduce methods and techniques used for development of safety-critical systems, whose failure may have a few simple tasks to familiarize themselves with basic components of VxWorks RTOS and to benchmark the use present the typical criteria for assessing the suitability of a given platform for the given application. After the simple tasks, sturol application which will require full utilization of RTOS features. All the tasks at the labs will be implemented in C (or C++) laterial for a system and sensors work is their data. The course includes a detailed description of aircraft instrumentation and its resistance to external influences, a de	Z,ZK nbedded application mally verify timing e catastrophic core ed OS and hardwa idents will solve a anguage. Z,ZK ng in the low frequiscription of aircraf	6 ons. The focus g correctness of nsequences. are (Xilinx Zynq). complex task of 6 uency range and t power sources,
B3M35PSR The goal of this course is on embedded system such systems. Another During labs, students w The obtained metrics retime-critical motion cont B3M38PSL1 The course acquaints somethods used to process analysis of instruments	Real -Time Systems Programming is to provide students with basic knowledge about software development for real-time systems, for example in control and en is equipped with a real-time operating system (RTOS). Lectures will cover real-time systems theory, which can be used to for set of lectures will introduce methods and techniques used for development of safety-critical systems, whose failure may have a few simple tasks to familiarize themselves with basic components of VxWorks RTOS and to benchmark the use present the typical criteria for assessing the suitability of a given platform for the given application. After the simple tasks, sturol application which will require full utilization of RTOS features. All the tasks at the labs will be implemented in C (or C++) to Aircraft Avionics and the current technology used in aircraft instruments and unmanned aerial vehicles, ie systems and sensors work is their data. The course includes a detailed description of aircraft instrumentation and its resistance to external influences, a deand systems for measuring engine and aerometric quantities, and a description of emergency and operational diagnostics. T	Z,ZK nbedded application mally verify timing e catastrophic core and OS and hardwa idents will solve a anguage. Z,ZK ng in the low frequiscription of aircraf he course also de	6 ons. The focus g correctness of nsequences. are (Xilinx Zynq). complex task of 6 uency range and t power sources, als with the field
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B3M38VIN1 Virtual Instrumentation Z,ZK 6

Name of the block: Elective courses Minimal number of credits of the block: 0

The role of the block: V

Code of the group: 2021_MKYRH

Name of the group: Humanities subjects

Requirement credits in the group: Requirement courses in the group:

Credits in the group: 0 Note on the group:

Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) Tutors, authors and guarantors (gar.)	Completion	Credits	Scope	Semester	Role
B0M16FIL	Peter Zamarovský Peter Zamarovský Peter Zamarovský (Gar.)	Z,ZK	5	2P+2S	Z,L	V
B0M16HVT	History of science and technology 2 Marcela Efmertová, Jan Mikeš Marcela Efmertová (Gar.)	Z,ZK	5	2P+2S	Z,L	V
B0M16HSD1	History of economy and social studies Marcela Efmertová	Z,ZK	5	2P+2S	Z,L	V
B0M16PSM	Psychology Jan Fiala Jan Fiala (Gar.)	Z,ZK	5	2P+2S	Z,L	V
A003TV	Physical Education	Z	2	0+2	L,Z	V
B0M16TEO	Theology Vladimír Sláme ka Vladimír Sláme ka (Gar.)	Z,ZK	5	2P+2S	Z,L	V

Characteristics of the courses of this group of Study Plan: Code=2021_MKYRH Name=Humanities subjects

	<u> </u>		
B0M16FIL		Z,ZK	5
B0M16HVT	History of science and technology 2	Z,ZK	5

This subject traces historical developments in electrical engineering branches in the world and in the Czech Lands. Its ultimate goal is to stimulate students' interest in the history and traditions of the subject, while highlighting the developments in technical education and professional organizations, the process of shaping scientific life and the influence of technical engineers

B0M16HSD1 History of economy and social studies

This subject deals with the history of the Czech society in the 19th - 21th centuries. It follows the forming of the Czech political representation, its aims and achieved results as well as the social and cultural development and coexistence of the various ethnical groups in the Czech countries.

B0M16PSM	Psychology	Z,ZK	5
A003TV	Physical Education	Z	2
B0M16TEO	Theology	Z,ZK	5

This subject provides to students the basic orientation in christian theology and requires no special previous education. After short philosophic lecture the basic theologic disciplines are gone through. The subject is determined not only to believer students who want to know the reliable theologic grounding but also above all to ones who want to get know Christianity - religion from which graws our civilization up.

Code of the group: 2021_MKYRVOL Name of the group: Elective subjects Requirement credits in the group: Requirement courses in the group:

Credits in the group: 0

Note on the group: ~Nabídku volitelných předmětů uspořádaných podle kateder najdete na webových stránkách

http://www.fel.cvut.cz/cz/education/volitelne-predmety.html\\

List of courses of this pass:

Code	Name of the course	Completion	Credits
A003TV	Physical Education	Z	2
B0M16FIL		Z,ZK	5
B0M16HSD1	History of economy and social studies	Z,ZK	5

This subject deals with the history of the Czech society in the 19th - 21th centuries. It follows the forming of the Czech political representation, its aims and achieved results as well as the social and cultural development and coexistence of the various ethnical groups in the Czech countries.

B0M16HVT History of science and technology 2 Z,ZK 5 This subject traces historical developments in electrical engineering branches in the world and in the Czech Lands. Its ultimate goal is to stimulate students' interest in the history and traditions of the subject, while highlighting the developments in technical education and professional organizations, the process of shaping scientific life and the influence of technical engineers B0M16PSM Z,ZK Psychology 5 Theology B0M16TEO 5 Z,ZK This subject provides to students the basic orientation in christian theology and requires no special previous education. After short philosophic lecture the basic theologic disciplines are gone through. The subject is determined not only to believer students who want to know the reliable theologic grounding but also above all to ones who want to get know Christianity - religion from which graws our civilization up. B2M32MKSA Mobile Networks The lectures introduce principles and functionalities of mobile networks with special focus on currently deployed technologies and future mobile networks. Furthermore, architecture and fundamental principles of GSM, UMTS, LTE/LTE-A, and 5G will be explained. Then, selected key technologies for future mobile networks (6G) will be explained. B3M33ARO1 **Autonomous Robotics** The Autonomous robotics course will explain the principles needed to develop algorithms for intelligent mobile robots such as algorithms for: (1) Mapping and localization (SLAM) sensors calibration (lidar or camera). (2) Planning the path in the existing map or planning the exploration in a partially unknown map and performing the plan in the world. IMPORTANT: It is assumed that students of this course have a working knowledge of optimization (Gauss-Newton method, Levenberg Marguardt method, full Newton method), mathematical analysis (gradient, Jacobian, Hessian), linear algebra (least-squares method), probability theory (multivariate gaussian probability), statistics (maximum likelihood and maximum aposteriori estimate), python programming and machine learning algorithms. This course is also part of the inter-university programme prg.ai Minor. It pools the best of Al education in Prague to provide students with a deeper and broader insight into the field of artificial intelligence. More information is available at https://prg.ai/minor. B3M33HRO Humanoid robots 6 The course focuses on "human-centered robotics": humanoid robots and human-robot interaction. Motivated by the vision of robot companions in our homes, this course introduces humanoid robot technology and its specific challenges and opportunities: (i) design, kinematics and inverse kinematics of humanoids, (ii) multimodal sensing - vision, touch, hearing, inertial sensing, etc., (iii) walking and balancing, and (ii) grasping. The second part of the course centers on human-robot interaction (HRI), which includes physical HRI (safety aspects, collaborative robots) and cognitive/social HRI - how to design robots and behaviors to be acceptable for people. B3M33MRS Multi-robot aerial systems The course offers the introduction to multirotor autonomous aerial systems (UAV). Standard senzors and principles of estimate and control of UAV will be introduced. The problems of motion planning, path planning, localization, mapping and exploration will be discussed for sigle moving UAV as well as multiple UAVs moving in a formation B3M33PKR Advanced robot kinematics We will explain and demonstrate techniques for modelling, analyzing and identifying robot kinematics. We will explain more advanced principles of the representation of motion in space and the robot descriptions suitable for identification of kinematic parameters from measured data. We will explain how to solve the inverse kinematic task of 6DOF serial manipulators and how it can be used to identify its kinematic parameters. Theory will be demonstrated on simulated tasks and verified on a real industrial robot. B3M35DRS **Dynamics and Control Networks** This course responds to an ever-increasing demand for understanding contemporary networks - large-scale complex systems composed of many components and subsystems interconnected into a single distributed entity. Herein, we will consider fundamental similarities between diverse areas such as e.g. forecasting the spread of global pandemics, public opinion dynamics and manipulation of communities through social media, formation controls for unmanned vehicles, energy generation and distribution in power grids, etc. Understanding such compelling issues goes far beyond the boundaries of any single physical, technological or scientific domain. Therefore, we will analyze phenomena across different domains, involving societal, economic and biological networks. For such networked systems, the resulting behavior depends not only on the characteristics of their individual components and details of their physical or logical interactions, but also on a precise way those components are interconnected – the detailed interconnection topology. For that reason, the first part of the course introduces fundamental theoretical and abstract computational network analysis concepts; in particular, the algebraic graph theory, network measures and metrics and fundamental network algorithms. The second part of the course subsequently views networks as dynamical systems, studies their properties and ways in which these are controlled, using mainly methods of automatic control theory. B3M35HYS Hybrid Systems Z,ZK 6 B3M35KOA Combinatorial Algorithms Z,ZK 6 The goal is to show the problems and algorithms of combinatorial optimization (often called discrete optimization; there is a strong overlap with the term operations research). Following the courses on linear algebra, graph theory, and basics of optimization, we show optimization techniques based on graphs, integer linear programming, heuristics, approximation algorithms and state space search methods. We focus on application of optimization in stores, ground transportation, flight transportation, logistics, planning of human resources, scheduling in production lines, message routing, scheduling in parallel computers. B3M35LSY1 **Linear Systems** The purpose of this course is to introduce mathematical tools for the description, analysis, and partly also synthesis, of dynamical systems. The focus will be on linear time-invariant multi-input multi-output systems and their properties such as stability, controllability, observability and state realization. State feedback, state estimation, and the design of stabilizing controllers will be explained in detail. Partially covered will be also time-varying and nonlinear systems. Some of the tools introduced in this course are readily applicable to engineering problems such as the analysis of controllability and observability in the design of flexible space structures, the design of state feedback in aircraft control, and the estimation of state variables. The main motivation, however, is to pave the way for the advanced courses of the study program. The prerequsites for this course include undergraduate level linear algebra, differential equations, and Laplace and z transforms. B3M35NES Nonlinear Systems and Chaos The goal of this course is to introduce basics of the modern approaches to the theory and applications of nonlinear control. Fundamental difference when dealing with nonlinear systems control compared with linear case is that the state space approach prevails. Indeed, the frequency response approach is almost useless in nonlinear control. State space models are based mainly on ordinary differential equations, therefore, an introduction to solving these equations is part of the course. More importantly, the qualitative methods for ordinary differential equations will be presented, among them Lyapunov stability theory is crucial. More specifically, the focus will be on Lyapunov function method enabling to analyse stability of nonlinear systems, not only that of linear ones. Furthemore, stabilization desing methods will be studied in detail, among them the so-called control Lyapunov function concept and related backstepping method. Special stress will be, nevertheless, given by this course to introduce and study methods how to transform complex nonlinear models to simpler forms where more standard linear methods would be applicable. Such an approach is usually refered to as the so-called exact nonlinearity compensation. Contrary to the well-known approximate linearization this method does not ignore nonlinearities but compensates them up to the best possible extent. The course introduces some interesting case studies as well, e.g. the planar vertical take off and landing plane ("planar VTOL"), or a simple 2-dimensional model of the walking robot. B3M35OFD Estimation, filtering and detection Z,ZK This course will cover description of the uncertainty of hidden variables (parameters and state of a dynamic system) using the probability language and methods for their estimation. Based on bayesian problem formulation principles of rational behavior under uncertainty will be analyzed and used to develop algorithms for parameter estimations (ARX models. Gaussian process regression), filtering (Kalman filter) and detection (likelihood ratio theory). We will demonstrate numerically robust implementation of the algorithms applicable in real life problems for the areas of industrial process control, robotics and avionics. B3M35ORR Z,ZK Optimal and robust control

The goal of this course is to provide students with basis knowledge about a software development for real-time systems, for example in counted and embedded applications. The focus on embedded systems exceptioned that is explored to the course of the course and the systems of the students with formation processors of such systems. Another set of because will include methods and eschriques used for development of adely-critical systems, whose failure may have obtained with grant grant grant and the students of the students				
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or updated information see http://bilakniha.cvut.cz/en/f3.html				

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