Modernization of Mechatronics and Robotics for bachelor's degree in Uzbekistan through Innovative Ideas and Digital Technology
(MechaUz)

609564-EPP-1-2019-1-EL-EPPKA2-CBHE-JP

MechaUz_D.2.2_Development a BSc program_V.1

Project Acronym:	MechaUZ
Grant Agreement No.	609564
Deliverable Editor(s)	TSTU
Dissemination level:	National level

REVISION HISTORY

Version	*Date*	*Organization*	*Author*	*Changes*
V 1.0	09/05/2022	TSTU	Makhmudjon Abdullayev	Developing the Report of the WP2.2

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Approval Table

Version	*Date of Approval*	*Deliverable Name*	*Approved By*
V 1.0	10/08/2022	MechaUz_D.2.2 _Development a BSc program_V.1	Vytautas Bucinskas, vytautas.bucinskas@vilniustech.lt

CURRICULUM DEVELOPMENT TEAM

Coordinator:

International Hellenic University (Thessaloniki, Greece)

European Partners:

The South-East European Research Centre (Thessaloniki, Greece),

Vilnius Gediminas Technical University (Vilnius, Lithuania),

Liepāja University (Liepāja, Latvia),

Vidzeme University of Applied Sciences (Valmiera, Latvia),

Polytechnic Institute of Viana do Castelo (Viana do Castelo, Portugal)

Partners from Uzbekistan:

Andijan machine-building institute (Andijan, Uzbekistan),

Turin Polytechnic University in Tashkent (Tashkent, Uzbekistan),

Fergana Polytechnic Institute (Fergana, Uzbekistan),

Tashkent University of Information Technology (Tashkent, Uzbekistan),

Karshi Engineering-Economic Institute (Karshi, Uzbekistan),

Tashkent State Technical University (Tashkent, Uzbekistan),

Ministry of Higher and Secondary Specialised Education System of Uzbekistan (Tashkent, Uzbekistan)

ABSTRACT

- Undergraduate study programs in the specialty "Mechatronics and Robotics" of leading universities in Europe and the other countries were studied
- TSTU analyzed the curricula of the bachelor's specialty "Mechatronics and Robotics" and developed a new curriculum, which has been introduced into the educational process since the 2022/2023 academic year at all Uzbek parners.

ABBREVIATIONS

Acronym	*Definition*
TSTU	Tashkent State Technical University
BS	Bachelor science
CITIN	Center for Industrial Technological Interaction
DoW	Description of Work
EC	European Commission
WP	Work Package
WPL	Work Package Leader
WP2	Work Package 2
MechaUz	Modernization of Mechatronics and Robotics for Bachelor degree in Uzbekistan through Innovative Ideas and Digital Technology

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PREFACE

From February 11 to February 13, 2020, representatives of the MechaUZ project team participated in the first meeting of the new CBHE project "MechaUz: Modernization of Mechatronics and Robotics for Bachelor degree in Uzbekistan through Innovative Ideas and Digital Technology" takes place in Greece. The project consortium brings together 13 higher educational institutions from 5 countries: Greece, Portugal, Latvia, Lithuania, and Uzbekistan.

During the first day meeting, presentations of the MechaUZ project were held by the Grantholder, active round-table discussions were conducted between partners. The Grant holder provided all important information about project management, recommendations for successful project implementation, and the latest news from EACEA representatives. During the meetings will be discussed also financial issues, the role of each institution of higher education in the project, work packages, the plan of upcoming events, and the importance of obtaining results.

From May 16 to May 20, 2022, representatives of the MechaUZ project team participated in the second meeting of the executors of this project at the Faculty of Mechanics of the Turin Polytechnic University in Tashkent (Uzbekistan) to discuss the summary, changes in the chronology of the project, the following actions, heard a report on the work done on development of the curriculum, review of activities and next steps, on the operation of the project website, a presentation of the iLAB, equipped within the project, on the implementation of the planned activities.

Further, a Training was organized for the participants of the inter-partnership visit, within the framework of which the participants listened to courses, in particular: an overview of the Curricula of the undergraduate direction "Mechatronics and Robotics" of the Vilnius Gediminas Technical University (VGTU) (Lithuania) and the University of Liepaja (Liepaja University) (Latvia) about the accreditation process, listened to the financial report of the project executors.

They visited higher educational institutions: Turin Polytechnic University in Tashkent and Tashkent State Technical University, INNO Technopark, Labs and production and companies that use mechatronic and robotic devices.

As part of the visit to Tashkent State Technical University, on May 18, 2022, a visit to INNO Technopark was organized, during which the project participants got acquainted with the production base, equipment and laboratories, where classes are held for undergraduate students in the direction of study "Mechatronics and Robotics" of TSTU, listened to report of the head of the department Abdullaev M.M. about the organization of the educational process, industrial practice in INNO Technopark, as well as about the projects of students of the department - winners of various competitions in robotics.

An excursion was organized in the laboratory of the Department of "Mechatronics and Robotics" of the TSTU, where the laboratory equipment of the department was presented, including equipment purchased at the expense of the MechaUZ project from Lucas Nuelle (Germany), which are used for research during laboratory classes.

In the afternoon, a visit was organized for the project participants to the base enterprises of the Mechatronics and Robotics Department of the TSTU - UzAvto Motors Powertrain JSC, where the participants got acquainted with the robotic processes for the production of internal combustion engines for cars.

From May 30 to June 3, 2022, representatives of the MechaUZ TSTU project team in the amount of 6 people participated in the third meeting of the executors of this project at the Faculty of Mechanics of Vilnius Gediminas Technical University (VGTU) (Lithuania) to discuss and develop a bachelor's curriculum in the direction " Mechatronics and Robotics".
During the visit, they listened to reports on the work of the international department of Vilnius Gediminas Technical University (VGTU), the introduction of curricula into the education system, the experience of inter-partner visits, got acquainted with international research conducted at the Faculty of Mechanics and the infrastructure of the faculty (a tour of the faculty).
We held a meeting on accreditation and certification, discussed the tasks, goals, action plan of the meeting of the project management group, heard the financial report of the project executors.
Further, a Training was organized for the participants of the inter-partnership visit, within the framework of which the participants heard courses, in particular on: primary converters, the theory of mechanisms and machines, elements of machines and mechatronics, technologies of robotic production, laboratory work on mechatronics and robotics, the implementation of the Educational process, final qualification works of bachelors and their methodological support. At the end of the Training, the participants of the inter-partner visit were awarded Certificates of successful completion of the course.
Visits were organized to factories and companies where robots and robotic systems are used.

From July 18 to July 22, 2022, representatives of the MechaUZ TSTU project team in the amount of 5 people participated in the fourth meeting of the executors of this project at the Polytechnic Institute of Viana do Castelo (Portugal) to discuss and develop the curriculum Bachelor's degree in "Mechatronics and Robotics".
During the visit, they listened to reports on the creation of laboratories, discussed organizational issues, each Uzbek university presented information and a short video on the work done, the sustainable development of the MechaUZ project, discussed joint exchange programs and projects.
We held a meeting on accreditation and certification, discussed the tasks, goals, action plan of the meeting of the project management group, heard the financial report of the project executors.
Further, a Training was organized for the participants of the inter-partner visit, during which the participants heard courses on the operation and basic programming of ABB robots: general view of the system; hand movement; definition of tools and work

objects, introduction to programming; peripherals; FAST language, robot service; operation of robot manipulators; final practice.

At the end of the Training, the participants of the inter-partner visit were awarded Certificates of successful completion of the course.

We visited the Center for Industrial Technological Interaction (CITIN), Mechanical Engineering Laboratories (IPVC), the Higher School of Agriculture (ESA - IPVC), where mechatronic and robotic systems are used, as well as ESTG, IPVC campuses.

INTRODUCTION

This work package activity will focus on the development of new bachelor's program, curriculum and teaching materials in the field of Mechatronics. Regulations on continuous education, a new generation of textbooks and manuals for Bachelor's degree in the field of Mechatronics are developed. These textbooks and manuals will be developed based on systematic teaching approach and methodology of International Labour Organization. Main outcomes of the project will be a full Bachelor of Science curriculum with 12 courses compatible with European standards.

The main tasks:

- Development of new Bachelor's program (new standards, regulations, curriculum, textbooks, manuals, soft skills and new teaching methodology) in Mechatronics.

QUALIFICATION REQUIREMENTS FOR MECHATRONIC AND ROBOTICS

Qualification requirements have been developed and officially approved within the framework of the documents "State Educational Standard of Higher Education. Basic rules" and "Classifier of areas of study and specialties of higher education".

The purpose of the qualification requirements for the direction of study 60711500 - "Mechatronics and Robotics" is to approve the state educational standard, curriculum and discipline programs, taking into account the accumulated experience in implementing the tasks of the National Training Program, as well as the global trend in the development of higher education and the establishment of requirements for the level of general education and professional readiness of the graduate of this stage of education.

Characteristics of the direction of preparation of bachelors:
Education under the undergraduate program in accordance with these qualification requirements is carried out according to the credit-module system, according to the standard terms in full-time education 4 years, in evening education 4.5 years, in correspondence and distance learning 5 years.

60711500 - Types of professional activities of bachelors in the field of mechatronics and robotics

- design and construction activities;
- installation and adjustment works;
- organizational and managerial activity;
- research activities;
- operation and maintenance activities;
- production and technological activities.

General qualification:

- understand the nature of documents and work related to their professional activities in one of the foreign languages, have special knowledge in the field of scientific sciences and be able to use them in their professional activities on a modern basis;
- be able to use information technology in their professional activities, master the methods of collecting, storing, processing and using information, be able to make informed decisions in their activities;
- has an idea about a healthy lifestyle and the need to compliance it.

Professional Qualifications:

- has the search, analysis and use of regulatory documents in their professional activities;
- has the skills to develop methods for monitoring and assessing the quality of production processes, includes the creation and application of modern mechatronic and robotic systems;
- be able to produce and calculate mathematical, informational simulation models on the topic of experimental design and practical work;
- has the skills to develop project and program documentation;
- use of modern communication, information and computer technologies;
- develop design and program documentation;
- carrying out tests on the collection of operating parameters of the actuators of mechatronic and robotic systems;
- be able to apply the formulas and professional standards of robotic technologies, tools and computing facilities in accordance with the specialty being trained;
- has the ability to manage processes in mechatronic and robotic systems;
- the ability to control compliance with the technological operation of mechatronic and robotic systems;
- be able to use and implement measures for the natural use of energy resources in mechatronic and robotic systems;
- has the skills to check the technical condition of mechatronic and robotic systems, structures and equipment and assess the residual life;
- be able to lead a team;
- has the skills to recognize the code of professional ethics;
- has the skills to work in design institutes, participation in scientific research, fairs and innovative exhibitions.

Courses of the direction of study 60711500 - "Mechatronics and Robotics" includes the following sections of subjects, which are divided into compulsory subjects and elective subjects:

1. Humanitarian and Social sciences Courses
2. Mathematical and Natural science Courses
3. General Professional Courses
4. Professional Courses
5. Professional Elective Courses.

The educational program of the direction of study 60711500 - "Mechatronics and Robotics", which is a direction in the field of science and technology, covers a set of issues related to mechatronic and robotic systems, the design of mechatronic modules

and robots, the design of their components, electronic devices, microprocessor control devices and their software , maintenance of mechatronic modules and robots, their diagnostics, testing and operation, as well as their effective use.

STANDARD TEMPLATES FOR MECHATRONICS AND ROBOTICS

Program details

Duration:	4 year
Duration:	166 weeks
Number of weeks per semester:	18 (15 for teaching and 3 for examinations)
Total number of credit hours:	240
Number of credit hours per semester:	30

Note: At the beginning of each academic semester, one additional week is allocated for the introduction of students into the credit educational system.

Subjects and courses

Subject	*Percentage of the total course modules*	*Title of courses*	*Credits Hours*	*% Subject*	*% Total*
Mechanical Engineering	16,8	1. Electromechanical systems (with term paper)	6	2,5	100
		2. Solid mechanics	4	1,7	
		3. Design of robot control systems 1,2 (with term paper)	8	3,3	
		4. Robotic technologies	4	1,7	
		5. Design of mechatronic modules 1,2 (with term paper)	8	3,3	
		6. Elective Course 1,2	10	4,3	
Electrical/ Electronic Engineering	12,6	1. Electrical Engineering and Electronics 1,2	8	3,3	
		2. Circuitry and microprocessor systems 1,2 (with course project)	10	4,3	
		3. Microcontrollers and industrial controllers 1,2	8	3,3	
		4. Power electronics	4	1,7	
Computer Science/ ICT	13,6	1. Engineering and computer graphics	4	1,7	
		2. Algorithmization and information processing	4	1,7	
		3. Programming language (C)	4	1,7	
		4. C++ programming language	4	1,7	
		5. Fundamentals of Robot Programming	6	2,5	
		6. Automatic design systems (CAD/CAM/CAE systems) 1,2	10	4,3	
Mechatronics	33,7	1. Introduction to the specialty	4	1,7	
		2. Mechatronic system drives 1,2 (with term paper)	10	4,3	
		3. Robotics	4	1,7	
		4. Automatic control systems 1,2 (with term paper)	10	4,2	

		5. Modeling mechatronic modules and robots	4	1,7	
		6. Information devices of mechatronic modules and robots 1,2	8	3,3	
		7. Artificial intelligence systems	4	1,7	
		8. Open Elective Course 1,2	8	3,3	
		9. Elective Course 1,2	10	4,3	
		10. Graduation Thesis (Thesis project)	18	7,5	
Fundamental subjects	23,3	1. Modern history of Uzbekistan	4	1,7	
		2. Physics 1.2	8	3,3	
		3. Higher Mathematics 1,2,3	14	5,8	
		4. Uzbek (Russian) language 1,2	6	2,5	
		5. Ecology	4	1,7	
		6. Academic writing	2	0,8	
		7. Foreign language	8	3,3	
		8. Metrology and standar-dization	4	1,4	
		9. Philosophy	4	1,4	
		10. Economy and management of the industry	4	1,4	

SCHEME OF STUDIES FOR BS IN MECHATRONICS AND ROBOTICS

Schedule of the learning process

Grade	Weeks																																																			The number of weeks of the learning process						Number of holiday weeks	Total
	September					October				November					December				January					February				March					April				May				June				July				August				Sub Total	Including:						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52		Theoretical and practical education	Examination	Introduction of ECTS	Internship	Final Project/Thesis		
I	K																E	H	H	E	E	H	H	H	K																E	E	I	I	I	I	H	H	H	H	H	H	41	30	5	2	4		11	52
II	K																E	H	H	E	E	H	H	H	K																E	E	I	I	I	I	I	I	H	H	H	H	43	30	5	2	6		9	52
III	K																E	H	H	E	H	H	H	K																E	E	I	I	I	I	I	I	I	H	H	H	H	43	30	4	2	7		9	52
IV	K														E	E	K	H	H														E	E	I	I	H	H	H	P	P	P	P	P	H	H	H	H					39	26	4	2	2	5	9	48
Total																																																					**166**	**116**	**18**	**8**	**19**	**5**	**38**	**204**

Note: **K**-Introduction of ECTS; **E**-Examination; **H**-holiday; **I**- Internship; **P**-Final Project/Thesis

Semesters/Contact hours

Qualification code	*Title of the course*	*Credits*	*Total Hours*	*Contact hours*					*Students' workload*
				Sub total	*Lecture*	*Practice*	*Laboratory*	*Seminars*	
1-semester									
MHUZ1104	Modern history of Uzbekistan	4	120	60	30			30	60
PHIZ1104	Physics 1	4	120	60	30	15	15		60
PRLN114	Programming language (C)	4	120	60	30	30			60
HMAT1106	Higher Mathematics 1	6	180	90	45	45			90
INTS1104	Introduction to the specialty	4	120	60	30	15	15		60
UZLN1104	Uzbek (Russian) language 1	4	120	60		60			60
ECOL1104	Ecology	4	120	60	30	15	15		60
Total for semester:		**30**	**900**	**450**	**195**	**180**	**45**	**30**	**450**
2-semester									
ECGR1204	Engineering and computer graphics	4	120	60	30	30			60
PHIZ1204	Physics 2	4	120	60	30	15	15		60
ACTS1204	Automatic control systems 1	4	120	60	30	15	15		60
HMAT1204	Higher Mathematics 2	4	120	60	30	30			60
ELST1206	Electromechanical systems (with term paper)	6	180	90	30	30	30		90
UZLN1204	Uzbek (Russian) language 2	2	60	30		30			30
ALIP1204	Algorithmization and information processing	4	120	60	30	30			60
ACWR1202	Academic writing	2	60	30		30			30
Total for semester:		**30**	**900**	**450**	**180**	**210**	**60**	**0**	**450**
Total for year:		**60**	**1800**	**900**	**375**	**390**	**105**	**30**	**900**
3-semester									
EENE2304	Electrical Engineering and Electronics 1	4	120	60	30	15	15		60
CMPS2304	Circuitry and microprocessor systems 1	4	120	60	30	15	15		60
ACTS2306	Automatic control systems 2 (with term paper)	6	180	90	30	30	30		90
HMAT2304	Higher Mathematics 3	4	120	60	30	30			60
VCIC2304	Microcontrollers and industrial controllers 1	4	120	60	30	15	15		60
SLME2304	Solid mechanics	4	120	60	30	15	15		60
FGLN2304	Foreign language	4	120	60		60			60
Total for semester:		**30**	**900**	**450**	**180**	**360**	**90**	**0**	**450**
4-semester									
EENE2404	Electrical Engineering and Electronics 2	4	120	60	30	15	15		60

CMPS2404	Circuitry and microprocessor systems 2 (with course project)	6	180	90	30	30	30		90
CPRL2404	C++ programming language	4	120	60	30		30		60
PWEL2404	Power electronics	4	120	60	30	15	15		60
VCIC2404	Microcontrollers and industrial controllers 2	4	120	60	30	15	15		60
MTST2404	Metrology and standardization	4	120	60	30	15	15		60
SFLN2404	Special foreign language	4	120	60		60			60
Total for semester:		**30**	**900**	**450**	**180**	**150**	**0**	**0**	**450**
Total for year:		**60**	**1800**	**900**	**360**	**510**	**90**	**0**	**900**
5-semester									
PHIL3504	Philosophy	4	120	60	30	30			60
MSDR3504	Mechatronic system drives 1	4	120	60	30	15	15		60
ROBT3504	Robotics	4	120	60	30	15	15		60
DSMM3504	Design of mechatronic modules 1	4	120	60	30	15	15		60
DRCS3504	Design of robot control systems 1	4	120	60	30	15	15		60
FNRP3506	Fundamentals of Robot Programming	6	180	90	30	30	30		90
OELC3504	Open Elective Course 1	4	120	60	30	15	15		60
Total for semester:		**30**	**900**	**450**	**210**	**135**	**105**	**0**	**450**
6-semester									
MMMR3604	Modeling mechatronic modules and robots	4	120	60	30	15	15		60
MSDR3606	Mechatronic system drives 2 (with term paper)	6	180	90	30	30	30		90
RBTN3604	Robotic technologies	4	120	60	30	30			60
DSMM3604	Design of mechatronic modules 2 (with coursework)	4	120	60	30	15	15		60
DRCS3604	Design of robot control systems 2 (with term paper)	4	120	60	30	15	15		60
EMIN3604	Economy and management of the industry	4	120	60	30			30	60
OELC3604	Open Elective Course 2	4	120	60	30	15	15		60
Total for semester:		**30**	**900**	**450**	**210**	**120**	**90**	**30**	**450**
Total for year:		**60**	**1800**	**900**	**420**	**255**	**195**	**30**	**900**
7-semester									
IDMM4704	Information devices of mechatronic modules and robots 1	4	120	60	30	15	15		60
ADSS4706	Automatic design systems (CAD/CAM/CAE systems) 1	6	180	90	30	30	30		90
AINS4704	Artificial intelligence systems	4	120	60	30	30			60
ELCR4704	Elective Course 1	4	120	60	30	30			60
ELCR4706	Elective Course 2	6	180	90	30	30	30		90
ELCR4706	Elective Course 2	6	180	90	30	30	30		90

Total for semester:		**30**	**900**	**450**	**180**	**165**	**75**		**450**
8-semester									
IDMM4804	Information devices of mechatronic modules and robots 2	4	120	60	30	15	15		60
ADSS4804	Automatic design systems (CAD/CAM/CAE systems) 2	4	120	60	30	15	15		60
ELCR4804	Elective Course 4	4	120	60	30	15	15		60
GRTH4818	Graduation Thesis (Thesis project)	18	540						540
Total for semester:		**30**	**900**	**180**	**90**	**45**	**45**	**0**	**720**
Total for year:		**60**	**1800**	**630**	**270**	**210**	**150**	**0**	**1170**
Total:		**240**	**7200**	**3330**	**1425**	**1365**	**540**	**60**	**3870**

Note:

Undergraduate study programs in the specialty "Mechatronics and Robotics" of leading universities in Europe and the other countries were studied

TSTU analyzed the curricula of the bachelor's specialty "Mechatronics and Robotics" and developed a new curriculum, which has been introduced into the educational process since the 2022/2023 academic year at TSTU in collaboration with AndMI, KEEI, FPI, TUIT.

DETAILS OF COURSES BS IN MECHATRONICS AND ROBOTICS

Circuitry and microprocessor systems 1,2	This course introduces students to discrete elements of electronic circuits, digital circuitry, logic elements, digital nodes and devices, the structure of microprocessor devices and the basics of their programming. he course includes the following topics: - basic terms and definitions used in circuitry and microprocessor systems; - discrete elements of electronic circuits; - generalized structure of digital systems; - logical elements and algebra of logic; - combinational digital units: adders, comparison circuits, decoders, encoders, demultiplexers, multiplexers, bus shapers, rectangular pulse generators; - memory elements, sequential digital nodes: flip-flops, registers, counters and their varieties; - analog-to-digital and digital-to-analog converters; - microprocessors, microcontrollers and their classification; - internal structure and principle of operation of single-chip microprocessors; - programming language of microprocessors and microcontrollers - Assembler; - the basics of programming in assembler and debugging programs; - generalized structure of microprocessor control systems; - design of a processor block based on serial microprocessors; - design of a memory unit based on commercially available integrated circuits; - design of operator interfaces and control object; - application of timer and interrupt controller in microprocessor control systems. Within the framework of this course, a course project is provided, where students independently design a microprocessor control system with a given amount of memory and using various interface devices. 1. Digital Design and Computer Architecture, by David Harris, Sarah Harris. 2013. P. ISBN-13: 978-0123944245 2. Circuitry and microprocessor system, by M. Abdullayev, N. Alimova. 2022. TSTU

DESIGN OF ROBOT CONTROL SYSTEMS 1,2	This course introduces students to fundamental and practical knowledge of robot control systems, their design and programming. The course includes the following topics: - Homogeneous transformations - Forward kinematics - Denavit-Hartenberg convention - Inverse kinematics - Jacobian matrix - Dynamic modeling - Dynamic modeling using the Lagrange-Euler method - Robotic control strategies - Trajectories - Drone systems - Robotic control applications 1. Robot Modeling and Control, by Mark W. Spong, Seth Hutchinson,M. Vidyasagar United States, 2020. ISBN: 9781119524045. 2. Intelligent Control of Robotic Systems, by Laxmidhar Behera, Swagat Kumar, Prem Kumar Patchaikani, Ranjith Ravindranathan Nair, Samrat Dutta, 2020. ISBN: 9781138597716
Introduction to Mechatronics and Robotics	This course introduces the students to the fundamentals of mechatronic and robotic systems. The course includes the following topics: – Overview of mechatronics and robotics – Overview microcontrollers and interfacing – Embedded systems and computers – Introduction to different types of sensors – Introduction to different types of actuators – Signal filtering and processing – Overview of computer vision – Forward and inverse kinematics. After this course students will be able to understand the software and hardware that is required to design your own control systems and robots. **TEXTBOOK:** 1. J. Craig, Introduction to Robotics Mechanics and Control, Pearson, 2018.

	2. G. Long, Fundamentals of Robot Mechanics, Quintus-Hyperion, 2015.
Engineering and computer graphics	This course introduces the students to methods of depicting objects and the general rules of drawing, including the use of computer technology. The course includes the following topics: - Development of figurative, spatial thinking, abilities to analyze and synthesize geometric shapes - Mastering methods for constructing flat projection models of three-dimensional space and methods of geometric modeling - Algorithms for transforming projection models - Algorithms for solving positional and metric problems - Development of skills to express the properties of spatial objects and relations between them by means of a geometric model - Development of design documentation using computer technology. After this course students will be able to understand the basic principles and methods of geometric modelling and methodology for developing graphic applications.
Automatic control systems	This course introduces the students to the fundamental concepts of control system design and analysis. The course reviews linear systems theory and presents how linear systems theory is used to both specify performance requirements and how to design the control system. The course includes the following topics: - Define basic concepts in automatic control - Determine relations between models of linear dynamic systems in form of differential equations, state space models, transient responses, transfer functions and frequency responses - Analyse linear systems with respect to stability, steady state properties, controllability and observability, and fastness and damping - Evaluate closed loop systems with respect to stability, as well as robustness against and sensitivity for model errors and disturbances - Interpret and apply graphical methods and tools like block diagrams, root locus, Bode and Nyquist diagrams

	- Understand the function of simple controllers (PID controllers, lead-lag filters, state feedback) and controller structures (feedforward and cascade control) - Design simple controllers from given specifications - Understand and design observers for estimating the states in state space models. After this course students will be able to fundamental concepts and tools used to model and design continuous automatic control systems and their mathematical models, and achieve required specifications.
Measurements, certification, and standardization	This course introduces the students to the theoretically and practically to measurement procedures in order to estimate the real value of electrical and non-electrical quantities. Also, course provides necessary knowledge to work in the territorial authorities and research institutions of Uzbekistan for Technical Regulation and Consumer Policy, services and bodies of standardization, metrology and certification in enterprises and organizations of IT. The course includes the following topics: - Measuring Units' Systems: - Error Analysis - Instruments and measuring devices - Basic measuring devices - Balancing Methods – Measuring Bridges - Basics and functions of Oscilloscopes - Measuring Power and energy - Certification Basics and Requirements in Uzbekistan - Standardization Basics and Requirements in Uzbekistan After this course students will be able to in-depth knowledge and understanding of the International System of units and the electrical quantities measuring standards, and can successfully convert magnitudes of measured quantities in different unit systems, will learn Certification and Standardization processes in Uzbekistan. **TEXTBOOK:** 1. Psomopoulos C.S., (2013), Electrical Measurements, Tsotras Publ, Athens, in Greek.
Digital Systems and Microprocessors	This course introduces the students to the digital systems and the building blocks that make up digital systems. The

	emphasis will be on microprocessor-based systems hardware, programming and interfacing. The course includes the following topics: - arithmetic circuits - multiplexers, demultiplexers, decoders, encoders, tri-state bus devices - DACs and ADCs - memory devices (SRAM, DRAM, Flash, PLD's, ROM) - microprocessor architecture, microcomputer architecture - I/O modes and interfacing - digital communication standards. After this course students will be learn to program an 8-bit microprocessor in assembly language, and will develop the hardware and software for microprocessor-controlled applications. The student will be introduced to a 16-bit microprocessor, major differences between 8-bit and 16-bit microprocessors.
Communication and Networking	This course introduces the students to the basic knowledge of data sharing, transmission media and their protocols, and basic knowledge of networks in the field of Mechatronics and Robotics. The course includes the following topics: - Basics of data communications - Network models and techniques - Digital and analog transmission - Multiplexing and Demultiplexing - Introduction to networks and devices - Wireless LANs for Robotics communications: GSM, BLE, Wi-Fi, ZigBee, Mesh networks: capacity, routing, and scheduling - Robotics applications and control of modern data communications networks. After this course students will be able to major knowledge wireless and wired communication technologies, network devices, networking for Robotics applications.
Mechatronics System Design 1,2	This course introduces the students to the design mechatronic systems, derive equations for electromechanical systems, identify fundamental components for a mechatronic system, and develop

	control system for mechatronic system. The course includes the following topics: - Microcontroller Math and Number Manipulation - Software Design of Mechatronics - Inter-Processor Communications - Microcontroller Peripherals - Basic Circuit Analysis and Passive Components - Semiconductors, Operational Amplifiers, Real Operational Amplifiers and Comparators - Signal Conditioning, Active and Digital Filters - Digital Inputs and Outputs, Digital Outputs and Power Drivers - Digital Logic and Integrated Circuits - A-to-D and D-to-A Converters - Voltage Regulators, Power Supplies, and Batteries - Noise, Grounding, and Isolation - Mechatronic Sensors and Actuators - Mechatronic Projects and Systems Engineering After this course students will be able to learn the different systems of Mechatronics and its design. Understanding the system includes its control mechanism and various real time interfacing techniques. Different case studies of control, drives and real time interfacing are also learnt by students so that they can design, control and interface a system off their own at the end of the course. **TEXTBOOK:** 1. J. Edward Carryer, R. Matthew Ohline, Thomas W. Kenny. Introduction to Mechatronic Design. Textbook. Mechanical Engineering, Stanford University
Electric Drive and Electromechanical Systems	This course introduces the students to the fundamental knowledge and skill on the different electric motors and its application. The course includes the following topics: - Introduction to Electrical Motors - Types of Industrial Motors: DC motors and AC motors - Stepper Motors - Servo Motors - Electromechanical system - Complete systems

	- Simulation and Practical exercises that used to Design Mechatronics and Robotics systems. After this course students will be able to incorporate the motors to the electrical drive units.
Robotic Control Systems	This course introduces the students to the fundamental knowledge in design, programming and operating industrial robots. The course includes the following topics: - Homogeneous transformations - Forward kinematics - Denavit-Hartenberg convention - Inverse kinematics - Jacobian matrix - Dynamic modeling - Dynamic modeling using the Lagrange-Euler method - Robotic control strategies - Trajectories - Drone systems - Robotic control applications After this course students will be able to industrial robots modelling, Robot control algorithms, Robot programming, Industrial applications. **TEXTBOOK:** 1. Mark W. Spong - Robot modeling and control – John Willey & Sons, 2004
Robot Operating system and programming	This course introduces the students to the environment for developing modular control software, a communication infrastructure to connect the software components and an open source library of implemented algorithms. - ROS architecture: Master, nodes, topics, messages, services, parameters and actions - Console commands: Navigating and analyzing the ROS system and the catkin workspace - Creating ROS packages: Structure, launch-files, and best practices - ROS C++ client library: Creating your own ROS C++ programs - Simulating with ROS: robot models (URDF) and simulation environments (SDF) - Manipulation and Robot Vision

	- Working with visualizations (RViz) and user interface tools (rqt) - Inside ROS: TF transformation system, time, bags. After this course students will be able to select and implement the appropriate ROS components for a robotics problem, apply algorithms for robotic perception, planning, navigation, localization, and manipulation, and implement and use algorithms for controlling mobile robots. **TEXTBOOKS:** 1. Jason M. O'Kane, A Gentle Introduction to ROS, independently published. version 2.1.3. (Electronic copies freely available from https://www.cse.sc.edu/~jokane/agitr/) 2. Programming Robots with ROS: A Practical Introduction to the Robot Operating System
CAD/CAM Systems	This course introduces the students to the computer-aided design (CAD) and computer-aided manufacturing (CAM) theory and applications. The course includes the following topics: - Introduction CAD/CAM systems - Geometric modeling - Data exchange and integration - Mechanical assembly - Mechanical tolerancing - Process planning and Tool path generation - Integration of CAD/CAM with the production machine - Computer control of machines and processes in manufacturing systems. After this course students will be able to achieve automated manufacturing CAD-CAM uses technologies like FMS, AGV, Robotics, Mechatronics, automated conveyor systems and computer aided techniques like CAD, CAM, CAE, CIM. **TEXTBOOK:** 1. Zeid Ibrahim, CAD/CAM theory and practices, McGraw Hill international edition. 2009.
Industrial Control Systems	This course introduces the students to the operating principles of electric motors and discrete control systems

	with an introduction to process control. The course includes the following topics: - Fundamental understanding of Electric Motors and their protection - Fundamental understanding of Motor Control Components - Motor Control Components: starters, sensors, timers, programmable logic controllers and analog controllers with an emphasis on industry applications - Including combination starters and motor control centres - Fundamental understanding of the application of sensors - Fundamental understanding of Digital Logic - Working knowledge of the configuration, writing of control programs for programmable logic controllers - Fundamental understanding of the operation of PID controllers. After this course students will be able to fundamental understanding of Electric Motors and Components, application of sensors, Digital Logic, the operation of PID controllers, and working knowledge of the configuration, writing of control programs for PLC. **TEXTBOOKS:** 1. D. Patrick and S.Fardo. Electrical Motor Control Systems 2. D. Geller. Programmable Controllers Using the A-B SLC500 Family
Artificial Intelligence and Robotics	This course introduces the students to consider the main issues that arise when creating software for intelligent robots - knowledge representation, learning, behaviour planning, etc. - Introduction to AI and Problem Representation - Heuristic Search Techniques and Game Playing - Logic and Knowledge Representation - Knowledge Acquisition and Expert System - Core of AI - AI in Robotics and its application After this course students will be able to know the basics of building intelligent control systems for various robotic

	devices, programmatically implement individual modules of such systems (trajectory planning, behavior planning, training, etc.) using the most relevant and well-known practices and algorithms in robotics.
Industrial Electronics	The subject of industrial electronics is electronics, and it is different in industry technological necessary in the development of various products and services used to perform processes. This is a different type of electronics, technique and How does it differ from electronics used in technology? In industry the electronics used range from DC circuits to control systems uses concepts covered in various electrical and electronics courses. The entire set of electronic elements is considered in the manual. Basic the focus is on the suitability of these elements for industrial use. In the manual, direct and alternating current motors, production processes discrete and analog control issues, switches and sensors, and control systems and production automation are considered.
Fundamentals of modeling and optimization of technological processes	**Course Description, Aim and Content** In today's economy, business professionals make decisions which may prescribe the course of actions whose extent may vary from day-to-day operations to strategies that influence the future of their companies. Although analytical modeling tools have been out there a very long time, they were typically judged to be useless and cumbersome in the past in the context of business decision making processes. With the advances in computing power, information collection and data processing technologies, analytics has become of very critical interest in this context, and modeling tools have turned out to be essential in implementing analytics. In this course, we cover various analytical modeling tools with a focus on optimization models. Each tool is to be covered to an extent where decision makers will be able to • identify the necessity of analytical modeling • realize the use of optimization models in data analytics • distinguish the type of models that could be used for a decision problem • lead/participate in a team of problem solvers • understand the underlying in the course of business decision making processes. Examples of modeling and optimization techniques from other courses will be covered. Case studies from real-life

	businesses will be delivered by professionals who are employing such tools and techniques. **Recommend or Required Reading** • Model Building in Mathematical Programming, H. P. Williams, 4th edition, John Wiley & Sons, 1999. ISBN-13: 978-0471997887 • Operations Research: Applications and Algorithms, W. L. Winston, 4th edition, Cengage Learning, 2003. ISBN-13: 978-0534380588 • Optimization Models For Decision Making: Volume 1, Katta G. Murty, Internet Edition
Mechatronic modules and information devices of robots	In this course, general information about information devices and systems used in mechatronic modules and robots, metrological support, design issues, widely used automated design systems, technical vision systems are covered in detail. serves to form skills and acquire the skills of designing high-efficiency mechatronic and robotic systems. The introduction of control questions at the end of each chapter increases the effectiveness of learning science in the process of self-control by students and raises the level of the course. 1. Robot control devices: Circuit design and programming. Predko M. 2014, 402p. 2. Robotics Experiments for the Evil Genius (TAB Robotics) 1st Edition. by Myke Predko. 2008. - 296p. ISBN-10: 0071413588. 3. Yusupbekov N.R., Aliev R.A., Aliev R.R., Yusupbekov A.N. Boshqarishning intellectual tizimlari va qaror qabul qilish. –Toshkent: “O’zbekiston milliy ensiklopediyasi” DIN, 2015. -572b. 4. Гребнев В.В. Микроконтроллеры семейства AVR фирмы Atmel. Москва, ИП Радиософт, 2002. -176с. 5. Программирование на языке С для AVR и PIC микроконтроллеров./Сост. Ю.А.Шпак. -Киев. МК-пресс, 2006. -400с. Labs: Getting to know the laboratory stand for the research of sensors used in mechatronic modules and robots Laboratory work 1. Ultrasonic Proximity Sensor Research Laboratory work 2. Research of contactless proximity sensor

	Laboratory work 3. Investigation of a digital angular velocity sensor Laboratory work 4. Research of pressure, temperature and humidity sensors Laboratory work 5. Study of the strain gauge Laboratory work 6. Investigating the TSS230 Color Sensor Laboratory work 7. Absolute Encoder Research
Basics of automation of production processes	The goal of studying science is production in mechanical engineering the basics of knowledge in general issues of process automation is to increase. Tasks of studying science in mechanical engineering and its components automation to form the structure of the production process level and level detection, flexible automatic collection systems design and perform calculations. As a result of studying the discipline, the student is formed at several levels should master the basics of knowledge. To have an opinion: - about the current state of the engineering industry; - prospects for the development of mechanical engineering technology; - automation tools at all levels of production and management technologies. 1. Капустин, Н.М. Комплексная автоматизация в машиностроении: учебник для вузов /Н.М. Капустин, П.М. Кузнецов, Н.П. Дьяконова; под ред. Н.М. Капустина. – М.: Академия, 2005. — 364 с. 2. Автоматизация производственных процессов в машиностроении: учебник для вузов / Н.М. Капустин [и др.] – М.: Высш. шк., 2004. – 414 с. 3. Инструментальное обеспечение автоматизированного производства: учебник для вузов / В.А. Гречишников [и др.] – М.: Станкин, 2000.–204 с. 4. M.P. Groover, “Automation, Production Systems, and Computer Integrated Manufacturing”, Pearson; 5. H. Jack, “Automating Manufacturing Systems with PLCs”, free download at http://claymore.engineer.gvsu.edu/~jackh/books.html.
Basics of machine elements and automatic design	Getting to know general information about the course. A history of machine detailing science, learning the main requirements for the task and details of the machine. Machine details study of workability and calculation criteria and affecting details loading, getting to know the voltages generated in them.

	1. Shoobidov Sh.A. Mashina detallari: Texnika oliy o‘quv yurtlari uchun darslik.- Toshkent: “O’zbekiston ensiklopediyasi”, 2014.- 444 b. 2. Kurganbekov M.M., Moydinov A. Mashina detallari: O’quv qo’llanma. I va II qismlar.–Toshkent: “O’zbekiston ensiklopediyasi”, 2014.- 384 b. 3. Шообидов Ш.А. Машина деталлари. Ўқув қўлланма.–Тошкент: 2004.-120 б. 4. Шообидов Ш. А., Мусаев С. У. Юритмалар. Тасмали ва занжирли узатмаларни лойиҳалаш. Ўқув қўлланма.–Тошкент: 2000.-82 б. 5. Шообидов Ш. А., Мусаев С. У. Тишли ва червякли узатмаларни лойиҳалаш. Ўқув қўлланма.–Тошкент: 2005.-80 б. 6. Shoobidov Sh. A., Musayev S.O’. Ko’tarish, transport mashinalari. O’quv qo’llanma.–T.: «SHARQ», 2007.-192 b. 7. Richard G. Budynas., J. Keith Nisbett. Shigley’s mechanical engineering design. Published by McGraw-Hill Education, 2 Penn Plaza, New York, 2015.
Embedded systems	This course covers the broad range of foundational skills that apply across all embedded computer system application areas, from thermostats to self-driving vehicles. The emphasis is at the layer where hardware meets software. Topics include microcontroller hardware, assembly language, embedded C++ programming, analog I/O, timers, code optimization, interrupts, and concurrency. Real world engineering practices, constraints, and example applications are integrated throughout the course. Weekly hands-on hardware and software experiences with an industry-strength automotive embedded controller are coordinated with the lecture content to reinforce core skills The mission of course is to those who study it: - Understand what is a microcontroller, microcomputer, embedded system; - Understand different components of a micro-controller and their interactions; - Become familiar with programming environment used to develop embedded systems; - Understand key concepts of embedded systems like IO, timers, interrupts, interaction with peripheral devices; - Learn debugging techniques for an embedded system; - Design embedded systems based on releated tolls and applications.

	1. Embedded Systems Architecture A Comprehensive Guide for Engineers and Programmers By Tammy Noergaard 2012. 2. Real-Time Concepts for Embedded Systems by Qing Li and Carolyn Yao ISBN:1578201241. 3. Dr. K.V.K.K. Prasad “Embedded/Real-time systems: Concepts, design and Programming”. 4. Wolf, Wayne Hendrix. Computers as components: principles of embedded computing system design /byWayneWolf – 2nd ed. ELSEVIER 2008. 5. M.M.Мусаев. Компьютер тизимлари ва тармоқлари. Т.: «Алоқачи» 2013б 394 б.
Computer programming	The purpose of teaching science is to learn the basic principles of information collection, storage and processing, transmission through the C++ programming language. Also, to create modern information systems and study the methods and technologies of their creation. The essence of computer programming 1 subject, its main principles and tasks is to develop students' algorithmic knowledge. To achieve this, modern programming language (C++) capabilities are used. The mission of science is to those who study it: - fields of application of programming languages; - program structure and alphabet; - use of constants and variables, data types; - methods of applying mathematical and logical operations; - methods of using input - output operators; - creating algorithms and programs for branching and repetitive processes; - creation of functions and libraries and their use; - work with arrays, strings and characters; - work with static structure and dynamic structure of data; - graphic programming capabilities; - working with files; - methods of applying class, object-oriented programming capabilities in various fields; - consists of teaching theoretical and practical knowledge of visual programming elements on the basis of coherence and continuity. 1. Bjarne Stroustrup. Programming: Principles and Practice Using C++ (2nd Edition). Person Education, Inc. 2014. second printing, January 2015. 2. Harry Hariom Choudhary, Bjarne M Stroustrup. C++ Programming Professional.: Sixth Best Selling Edition for Beginner's & Expert's 2014.

	3. Bjarne Stroustrup. The C++ Programming Language, 4th Edition. Person Education, Inc. 2013. Third printing, April 2014. 4. Nazirov Sh.A., Qobulov R.V., Bobojanov M.R., Raxmanov Q.S. C va C++ tili. “Voris nashriyot” MCHJ, Toshkent 2013. 488 b. 5. Horstmann, Cay S. C++ for everyone / Cay S. Horstmann. Printed in the United States of America - 2nd ed. 2010. – P. 562. 6. Horton I. - Beginning Visual C++ 2012 / I.Horton. Published simultaneously in Canada. – 2012. –P. 988

CURRICULUMS

Based on the developed Qualification requirements, standards the curriculums and teaching programs were developed by each partner HEIs in Uzbekistan. There are 5 versions of curriculums were modernized by AndMI, TUIT, TSTU, KEII and FPI in collaboration with VGTU.

The curriculum of Andijan machine-building institute was approved by the scientific council of the institute on 31st of August, 2022 and started to implement from educational year of 2022/2023.

The curriculum of Fergana Polytechnic Institute was approved by the scientific council of the institute on 30th of August, 2022 and started to implement from educational year of 2022/2023.

The curriculum of Tashkent University of Information Technology was approved by the scientific council of the university on 25th of August, 2022 and started to implement from educational year of 2022/2023.

The curriculum of Tashkent State Technical University was approved by the scientific council of the university on 19th of July, 2022 and started to implement from educational year of 2022/2023.

The curriculum of Karshi Engineering-Economic Institute was approved by the scientific council of the institute on 28th of June, 2022 and started to implement from educational year of 2022/2023.